Operationalizing trapped populations

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Abstract

The concept of *trapped populations* was introduced in a 2011 Foresight Report by the UK Government Office for Science. Trapped populations were conceptualized as the most vulnerable to climate variability and environmental change given very low levels of economic, social, and political resources. This vulnerability impedes the capacity to adapt by migrating, which entails considerable costs. That the most vulnerable are trapped in place raises concerns about the potential for large-scale humanitarian emergencies. Given these high stakes, it is surprising that prior research has yet to operationalize the concept of trapped populations to guide empirical efforts to identify those most at risk of being trapped in place and intervene accordingly. This paper breaks new ground toward helping to remedy this oversight by providing the first operational definition of trapped populations and a corresponding set of empirical steps that can be used and adapted by researchers, policymakers, and practitioners to identify people and populations most likely to be trapped in place under climate variability. We also provide an illustrative example focused on identifying those most likely to be trapped in place in rural areas in Mexico in the presence of heat and drought shocks. By helping to spur the development of approaches to identify those trapped in place under climate variability and environmental change, we hope to draw greater attention the risks and obligations associated with non-migrants—the bulk of the world's population—trapped in place.

Introduction

> *"Consequently, in the decades ahead, millions of people will be unable to move away from locations in which they are extremely vulnerable to environmental change. To the international community, this 'trapped' population is likely to represent just as important a policy concern as those who do migrate."*

This key conclusion from a Foresight (2011) report by the UK Government Office for Science has been all but ignored in policy and public dialogue. Instead, with origins in the coining of the term "environmental refugees" in 1985 (El-Hinnawi 1985), the prospect of climate and environmental migration has captured far greater attention and generated more concern (Barnett 2003; Biermann and Boas 2010; Milman et al. 2018; Myers 2002; Kelley et al. 2015). For example, according to the Rigaud et al. (2018), more than 140 million people are projected to move within their country of residence due to climate variability and environmental change by 2050. Some of this movement will reflect forced displacement and managed relocation as livelihoods in vulnerable places become untenable (Ferris 2017; IDMC 2018). Another portion of this movement will reflect adaptation as households send members to work elsewhere to generate incomes and remittances to offset livelihood disturbances at home (Hunter et al. 2015). In both instances, these movements have potentially profound demographic, economic, geopolitical, and sociocultural implications for the places of and populations in the origin and destination, as well as for those who move.

The importance of climate and environmental migration notwithstanding, non-migrants comprise the vast majority of the world's population. The total stock of persons living outside of their country of birth is consistently about three percent, and, while current rates of international and internal migration flows vary by country, immobility is the norm (Abel and Sander 2014; Bell et al. 2015; UN 2017). A subset of non-migrants, trapped populations are the most vulnerable to climate variability and environmental change given extremely low levels of economic, social, and political resources (Black et al. 2011; Foresight 2011). Identifying people and populations most likely to be trapped in place is important for anticipating, intervening in, and ultimately preventing large-scale humanitarian emergencies (e.g., starvation) under climate variability and environmental change (Martin et al. 2014; Nawrotzki and DeWaard 2018). Presently, however, there is no agreed upon, data-driven approach to distinguish people and populations most likely to be trapped in place from other non-migrants. Such a preventive approach is needed given the inherent difficulties and costs of doing so *ex post facto*.

Toward helping to remedy this oversight, this paper provides the first operational definition of trapped populations. This is followed by describing a corresponding set of empirical steps to identify people and populations most likely to be trapped in place under climate variability and environmental change. Perhaps most importantly, these steps can be used and adapted by researchers, policymakers, and practitioners with different skill sets and at all levels, from global to local. We then provide an illustrative example focusing on identifying those most likely to be trapped in place in rural areas in Mexico, a country with a rich migration history, a known climate hotspot, and highly vulnerable to climate variability given widespread reliance on rain fed agriculture in rural areas (Aguayo-Téllez and Martínez-Navarro 2013; Arenas et al. 2008;

Conde et al. 2006; Karmalkar et al. 2011; Massey 1987; Massey and Espinosa 1997; McSweeney et al. 2008; Wehner et al. 2011; Wiggins et al. 2002).

The overarching aim of this paper is to spur the development of innovative, accessible, and useable approaches to identify those trapped in place under climate variability and environmental change. In doing so, we seek to encourage researchers, policymakers, and practitioners to go beyond the myopic and often sensationalized focus on climate and environmental migration to consider the risks and obligations associated with non-migrants—the bulk of the world's population—who are trapped in place.

Conceptualizing trapped populations

Migration—a term that the International Organization for Migration (IOM 2014) uses to refer to both involuntary, or forced, and voluntary movement—is one of many possible adaptations to climate variability and environmental change (McLeman 2014). Rich theoretical and empirical literatures on migration, including a growing body of work on climate and environmental migration, describe four classes of factors that can operate at different spatial and temporal scales involved in migration decisions and behaviors (Black et al. 2011; Bodvarsson and Van den Berg 2013; Castles et al. 2014; Hunter et al. 2015; Lee 1966; Massey et al. 1998). These include *push factors* in places of origin, *pull factors* in places of destination, *bilateral connections and dependencies* between origins and destinations and people living in them, and the *costs* (economic, psychological, etc.) of migrating. Climate variability and environmental change are typically discussed under the banner of push factors in places of origin, and are frequently prioritized in policy and public discussions of climate and environmental migration and migrants (Hunter et al. 2015; IDMC 2018; IOM 2014; Rigaud et al. 2018).

The Foresight (2011) report adopted the same starting point in conceptualizing trapped populations, and went further to highlight the inability of those involved to offset the costs of migrating despite the harms that would be mitigated and the benefits that would be accrued by doing so. Migration requires economic resources to cover the often substantial costs of relocating (travel, settlement, etc.) (Bodvarsson and Van den Berg 2013). Social resources (e.g., family and friendship networks that can help to lower the costs of migration) are also important (Massey 1990). Finally, political resources matter in incentivizing or discouraging migration (Hollifield 2015). Given very low levels of economic, social, and political resources, trapped populations are thus the most vulnerable to climate variability and environmental change, which, in turn, impedes their capacity to adapt by migrating (see Figure 1) (Black et al. 2011; Foresight 2011). Further calling attention to the agency of those involved (Adams 2016), Ayeb-Karlsson et al. (2018:557) used the phrase "involuntary immobility" to characterize those trapped in place.

Operationalizing trapped populations

With respect to where prior research ends and the work of this paper begins, "[d]istinguishing between those who choose to stay and those who are forced to stay is essential if the notion of trapped populations is to have anything other than a very broad conceptual application" (Black and Collyer 2014:54). Guided by this call to action and leveraging insights from prior research, operationalizing the concept of trapped populations can be reduced to two basic steps. First, the focus is restricted to non-migrants with very low levels of economic, social, and political resources (Black et al. 2011; Foresight 2011). Provided that data are available, the focus might be further restricted to those who wish, or intend, to migrate (Adams 2016; Ayeb-Karlsson et al. 2018; Black and Collyer 2014). Second, among this subset of non-migrants, climate-related immobility must then be distinguished from immobility more generally.

Operational definition. In what follows, we unpack and subsequently illustrate these two steps using the tool of *migration propensity scores*, or predicted probabilities of migration, generated from statistical models of the climate-migration relationship in the research literature. Together, these two steps and the tool of migration propensity scores permit offering the first operational definition of trapped populations:

> *Populations trapped in place under climate variability are, at baseline in the absence of climate shocks, composed of differentiated and agentic non-migrants who (i) possess unique sets of characteristics that are similarly manifested in very low migration propensities, (ii) and, in the presence of climate shocks, experience very large increases in their propensities for migration.*

Identifying trapped populations

Guided by this operational definition, unpacking and implementing the two steps above depends, first and foremost, on the data available to the investigator. At a minimum, information is required on migration, relevant characteristics (e.g., economic, social, and political resources) per the literature on trapped populations, and climate shocks of interest. Research on the climate-migration relationship routinely uses census and survey data because these contain information on migration and relevant economic and social resources (Fussell et al. 2014). Information on political resources and migration intentions is generally less readily available. Using place identifiers in these data, this information is linked to local measures of climate variability constructed from temperature and precipitation data sourced from, for example, the University of East Anglia's Climate Research Unit or other organizations. All of this information is then used to fit a statistical model of migration, described in the next subsection. The resulting model parameter estimates can then combined with the information for each person in the data to generate a unique migration propensity score.

Ideally, the investigator fits a statistical model to the data available to them. However, with an eye toward accessibility and usability, it is worth considering situations where the investigator is not well-versed in statistics. In these situations, one option is to use already published model parameter estimates from the growing number of studies of the climate-migration relationship, which have increasingly covered more places and different temporal and spatial scales (DeWaard and Nawrotzki 2018; Fussell et al. 2014; Hunter et al. 2015; Piguet 2010). While more pragmatic than ideal, published model parameter estimates can be combined with the information for each person in the data available to the investigator to at least roughly identify those most likely to be trapped in place under climate variability using nothing more than basic arithmetic.

Step 1: Identifying non-migrants trapped in place. Guided by prior theoretical and empirical research on migration (Black et al. 2011; Bodvarsson and Van den Berg 2013; Castles et al. 2014; Hunter et al. 2015; Lee 1966; Massey et al. 1998), including research on climate and environmental migration, at baseline in the absence of a climate shock, it is common to model the log odds of migrating (m), versus staying (s), for person i residing in place j as a function of their relevant characteristics (X_{nz}) measured at the individual- and place-levels, denoted by the generic subscript, z (DeWaard and Nawrotzki 2018).

$$\ln\left(\frac{\pi_{ijm}}{\pi_{ijs}}\right) = \alpha + \sum_n \beta_n (X_{nz}) \qquad (1)$$

The model parameter estimates, β_n, can be combined with the information for each person in the data to generate a unique migration propensity score.[1] Hereafter, we refer to this quantity as their *baseline* migration propensity.

Subsequently restricting the focus to non-migrants, one then adopts a rule for identifying those with very low baseline migration propensities (i.e., those trapped in place). Later on, in our example focusing on identifying those most likely to be trapped in place in rural areas in Mexico, we select non-migrants with baseline migration propensities at or below the 5th and 1st percentiles.

Step 2. Distinguishing climate-related immobility. To pin immobility on climate variability, the next step is to add one or more climate measures to the statistical model in Equation 1, followed by generating a second migration propensity score for each person in the data. Hereafter, we refer to this quantity as their *climate* migration propensity.

$$\ln\left(\frac{\pi_{ijm}}{\pi_{ijs}}\right) = \alpha + \sum_n \beta_n (X_{nz}) + \lambda\left(ClimateShock_j\right) \qquad (2)$$

Restricting the focus to non-migrants trapped in place that were identified in Step 1, one then calculates the difference between each person's climate and baseline migration propensities. Under the assumption that baseline migration propensities reflect all relevant characteristics (e.g., economic, social, and political resources) that trap people in place, climate-related immobility occurs when a person's climate migration propensity exceeds their baseline migration propensity. Put differently, net of the relevant characteristics that trap people in place, summarized by a composite baseline migration propensity, climate-related trapping occurs when those who are trapped in place become more likely to, but do not and cannot, migrate in the presence of climate variability. The final step is to adopt a rule for selecting those with very large positive differences between their climate and baseline migration propensities. For example, in the next section, we use the 95th and 99th percentiles.

Identifying trapped populations in Mexico

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[1] A propensity score, or predicted probability, is calculated from the log odds as follows: $\frac{\exp(\ln(odds))}{1+\exp(\ln(odds))}$.

In this section, we provide a concrete example to illustrate the two steps just described. We focus on identifying those most likely to be trapped in place in rural areas in Mexico. Mexico is a illustrative case for several reasons. First, Mexico has a rich history of both international migration, primarily to the United States, and internal migration (Aguayo-Téllez and Martínez-Navarro 2013; Arenas et al. 2008; Massey 1987; Massey and Espinosa 1997). Second, Mexico is a well-documented climate hotspot (Karmalkar et al. 2011; McSweeney et al. 2008; Wehner et al. 2011). Third, rural areas in Mexico are highly vulnerable to climate variability given widespread reliance on rain fed agriculture (Conde et al. 2006; Wiggins et al. 2002).

Restricting our focus to rural municipalities in Mexico, the data for this example are taken from Nawrotzki et al. (2017), who sourced and prepared these from IPUMS Terra, which combines census microdata from IPUMS International with temperature and precipitation data from the University of East Anglia's Climate Research Unit (Harris et al. 2014; Minnesota Population Center 2015; Minnesota Population Center 2016). The data include 390,408 individuals living in 1,495 rural municipalities in the 2000 and 2010 Mexican General Census. Given that most climate-related migration is and is projected to be within, versus between, countries (Rigaud et al. 2018), we focus on internal migration, defined as having migrated within Mexico between the census and five years prior to the census (see Supplemental Table S1). The data contain basic information on economic and social resources, but not on political resources or migration intentions, from the Mexican General Census and from other sources like Mexico's National Council of Population (Consejo Nacional de Población, or CONAPO). With respect to measures of climate variability, the data contain two measures of excessive heat and drought months at the municipal level, constructed as counts of the number of months during the six years prior to the census that the maximum temperature was more than one standard deviation above, or precipitation was more than one standard deviation below, a preceding 30-year long-term climate reference period.

Step 1: Identifying non-migrants trapped in place. Using these data, we estimate the statistical model shown earlier in Equation 1. Specifically, at baseline in the absence of heat and drought shocks, we model the log odds of individual migration from rural municipalities as a function of individual-, household-m municipal-, and state-level characteristics.

Using the resulting model parameter estimates (see Supplemental Table S2), we calculate baseline migration propensities for each person in the data (see Figure 2). The mean baseline migration propensity for the 7,764 migrants in the data is 0.035. The corresponding estimate for non-migrants is 0.020. We then adopt two rules to identify non-migrants with very low baseline migration propensities. Vertical orange and red bars separate non-migrants at or below the 5th percentile (hereafter, Rule 1a) and the 1st percentile (Rule 1b), respectively, from other non-migrants. Rule 1a results in a trapped population with a mean baseline migration propensity of 0.003. Rule 1b is more conservative and results in a trapped population with a mean baseline migration propensity of 0.002. Clearly, the choice to adopt these or other rules is up to the investigator.

Step 2. Distinguishing climate-related immobility. To distinguish climate-related immobility from immobility more generally, we add measures of excessive heat and drought months to the statistical model estimated in Step 1. Using the resulting model parameter estimates (see

Supplemental Table S3), we calculate climate migration propensities for each person in the data. Among non-migrants with baseline migration propensities at or below the 5th percentile, differences between the climate and baseline migration propensities range from -0.001 to 0.002, with a mean slightly less than zero (see Supplemental Figure S1). The corresponding range for non-migrants with baseline migration propensities at or below the 1st percentile is smaller, with a mean also slightly below zero. We then adopt two rules to identify non-migrants in each the two groups from Step 1 with very large positive differences between their climate and baseline migration propensities (see Figure 3). Orange and red points identify non-migrants with differences between their climate and baseline migration propensities at or above the 95th percentile (Rule 2a) and 99th percentile (Rule 2b), respectively. These individuals are non-migrants who are most likely to be trapped in place in the presence of climate variability. Put differently, these individuals are particularly susceptible to climate-related trapping.

Recalling the starting point for our work in this paper—namely, the idea that those trapped in place are the most vulnerable to climate variability and environmental change given very low levels of resources (Black et al. 2011; Foresight 2011)—we conclude by examining means for selected variables among members of the identified trapped population (T) relative to other non-migrants (O) and migrants (M). We focus specifically on the trapped population identified by adopting Rules 1b and 2b, the most conservative of the four possible options in this example (see Supplemental Figure S2 for comparable results showing all possible combinations of adopting Rules 1a, 1b, 2a, and 2b). Relative to other non-migrants and migrants, members of the identified trapped population are, on average, less educated and reside in municipalities that are more economically marginalized and have fewer adults with internal migration experience (see Figure 4). They are also exposed to about twice the number of heat months and a comparable number of drought months.

Conclusions and steps forward

Identifying people and populations most at risk of being trapped in place under climate variability and environmental change is critically important for preventing large-scale humanitarian emergencies (Black et al. 2011; Foresight 2011; Martin et al. 2014; Nawrotzki and DeWaard 2018). It is also of *increasing* importance given the growing number climate and environmental disasters worldwide (UNISDR 2019). Toward helping to ensure that prior research on trapped populations offers something more tangible than “a very broad conceptual application” (Black and Collyer 2014:54), we provided the first operational definition of trapped populations and a corresponding set of empirical steps that can be used and adapted by researchers, policymakers, and practitioners to identify those most likely to be trapped in place under climate variability and environmental change.

We hope that our efforts will spur the development of innovative, accessible, and useable identification strategies in this area, as well as raise greater awareness about those who are unable to adapt to climate variability and environmental change by migrating. Climate variability and environmental change are, after all, a “wicked *social* problem” (Grundmann 2016:562; emphasis ours) due to the differential vulnerability of the people, populations, and places involved, which, in turn, is rooted in deep and persistent inequality and poverty. At a time when inequality is growing within and across societies (Cingano 2014; Ho 2018; Piketty 2013), climate vulnerability and environmental change will have increasingly major and disproportionate impacts on those who are unable to adapt by migrating and on the places in which they are trapped.

We broke new ground to help move research on trapped populations from the more abstract to the more concrete; however, as a starting point, our efforts are limited and raise several important questions. One question concerns the goal(s) and objective(s) of interest. The two steps described and illustrated in this paper are useful for identifying exactly *who* is most at risk of being trapped in place under climate variability and environmental change, as well as *where* these individuals live. Another important question that we did not and, given our use of percentiles (Rules 1a, 1b, 2a, and 2b), could not address in this paper concerns exactly *how many* people are potentially trapped in place. Estimates and projections of the number of people trapped in place would provide a much needed contrast to corresponding figures of climate and environmental migrants (Rigaud et al. 2018).

A second question concerns the data available to the investigator and the statistical model(s) used to generate migration propensity scores. Unfortunately, data are always limited by issues of availability, quality, and comparability; and these issues can have serious implications (e.g., omitted variable bias) for both statistical and substantive significance. What is more, research on the climate-migration relationship is hardly settled on which statistical model(s) and specifications to use, and there is growing consensus that the choice depends on and should be tailored to the idiosyncrasies of specific cases (DeWaard and Nawrotzki 2018; Fussell et al. 2014; Hunter et al. 2015; Piguet 2010).

Third, and finally, while we have proposed and demonstrated a data-driven and statistical approach to identify people and populations most at risk of being trapped in place under climate variability and environmental change, such an approach runs the risk of being too mechanical and deterministic. We therefore offer some critical food for thought in the way of three suggestions for future research going forward.

Starting with the steps that we described in this paper, our first suggestion is to leverage more and better data on relevant economic, social and political resources and pathways, migration intentions, and climate variability. Future research should also experiment with other statistical modeling strategies, including, for example, multilevel models and generalized additive models (DeWaard and Nawrotzki 2018; Grace 2017). Future research should also test different and more flexible rules and thresholds for identifying non-migrants who are particularly susceptible to climate-related trapping (Bardsley and Hugo 2010; McLeman 2017). Finally, it is important to remain cognizant of the fact that climate-related immobility (and migration) can unfold simultaneously at different temporal and spatial scales (Massey et al. 1998; Nawrotzki and DeWaard 2016).

Next, we suggest looking for opportunities to "ground truth" our approach. This might take the form of Rapid Response Research. This might also take the form of mixed methods approaches that make use of historical and archival data, interviews and focus groups, and ethnographic methods. Migration scholars have increasingly called for more holistic and inter-disciplinary approaches (Willekens et al. 2016), and there are growing institutional supports for this sort of work (the Global Knowledge Partnership on Migration and Development (KNOMAD), the Population Environment Research Network (PERN), the National Socio-Environmental Synthesis Center (SESYNC), etc.).

Lastly, whether incorporated into the steps that we laid out in this paper or into a different approach altogether, the agency of those trapped in place under climate variability and environmental change deserves greater attention (Adams 2016; Ayeb-Karlsson et al. 2018). While economic, social, and political resources are clearly important for understanding climate-related immobility and migration (Black et al. 2011; Foresight 2011), so, too, are people's perceptions of their situations, their attachments to others and to place, their desires and intentions, their lived experiences, and their resolve. To borrow the phrase from Simon (1981), the "*ultimate* resource" is the creative and adaptive potential of the people involved (emphasis ours). A more agentic and empathic understanding would therefore go a long way.

Acknowledgements

This work is supported by center grant #P2CHD041023 awarded to the Minnesota Population Center at the University of Minnesota and center grant #2P2CHD066613-06 awarded to the CU Population Center (CUPU) in the Institute of Behavioral Science at the University of Colorado Boulder by the Eunice Kennedy Shriver National Institute of Child Health and Human Development. This work is also supported by Grant No. 1416860 from the National Science Foundation, and benefited from the CUPC Conference on Climate Change, Migration and Health (NICHD project 5R13HD078101), specifically, the installment held at the University of Colorado Boulder on May 17-18, 2018, with support from the International Union for the Scientific Study of Population.

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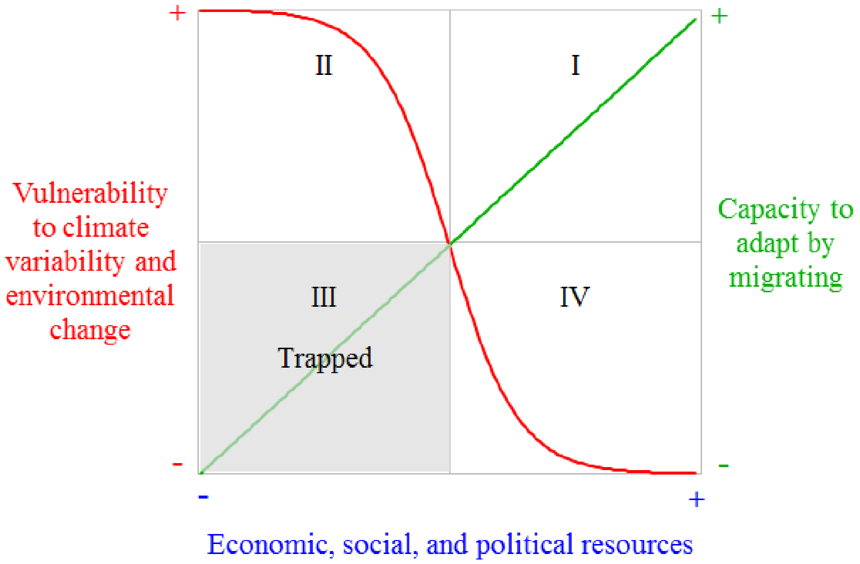
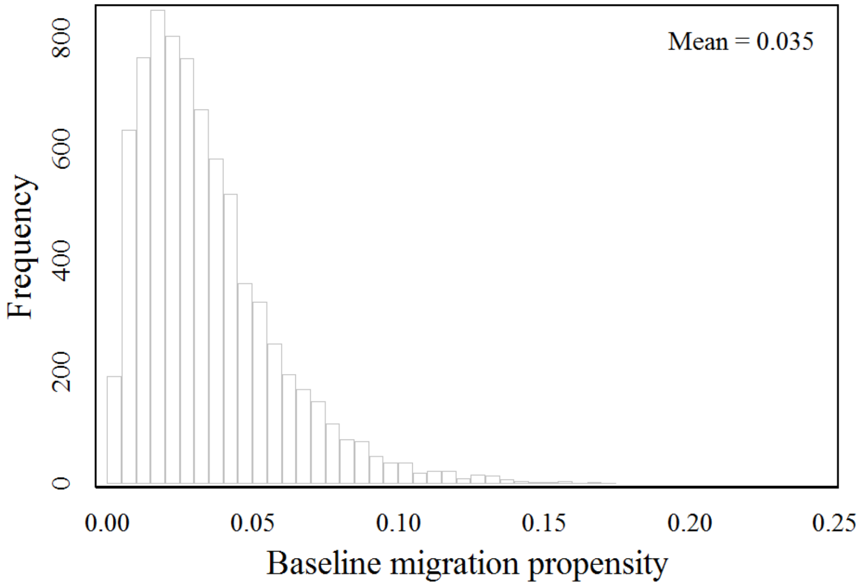
Figure 1. Conceptualizing trapped populations



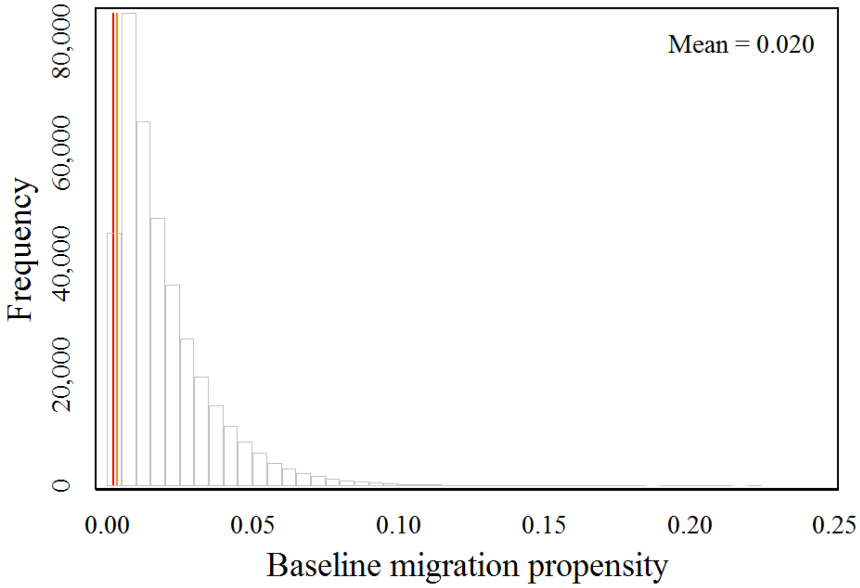
Notes: Adapted from Black et al. (2011:14) and Foresight (2011:449).

Figure 2. Baseline migration propensity scores

Panel A. Migrants



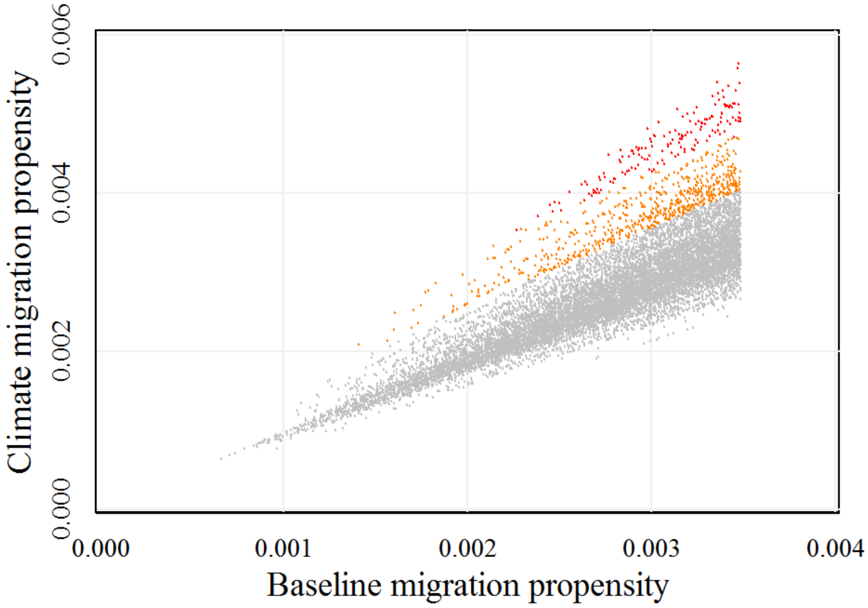
Panel B. Non-migrants



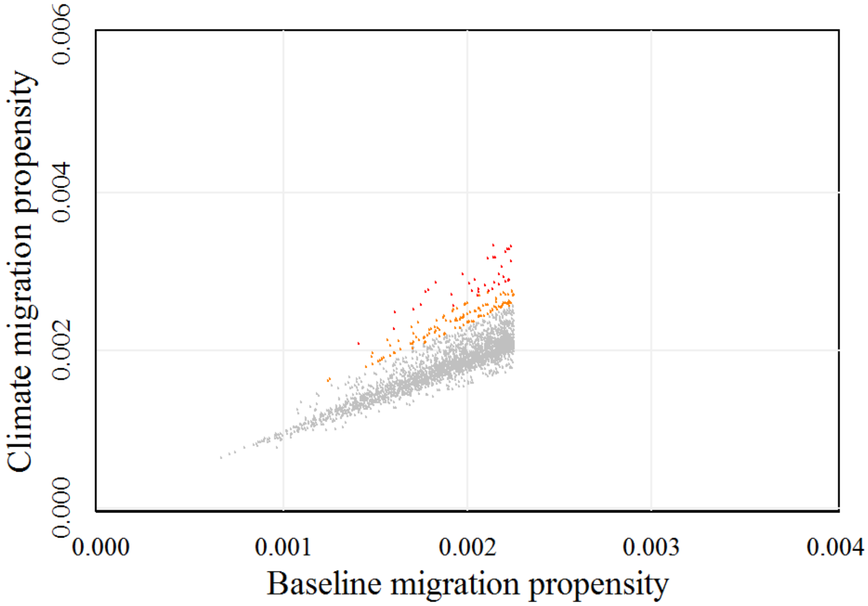
Notes: Scales of y-axes differ across Panels A and B. Vertical orange and red lines in Panel B denote 5th and 1st percentiles, respectively.

Figure 3. Baseline and climate migration propensity scores

Panel A. Non-migrants with baseline migration propensities ≤ 5th percentile

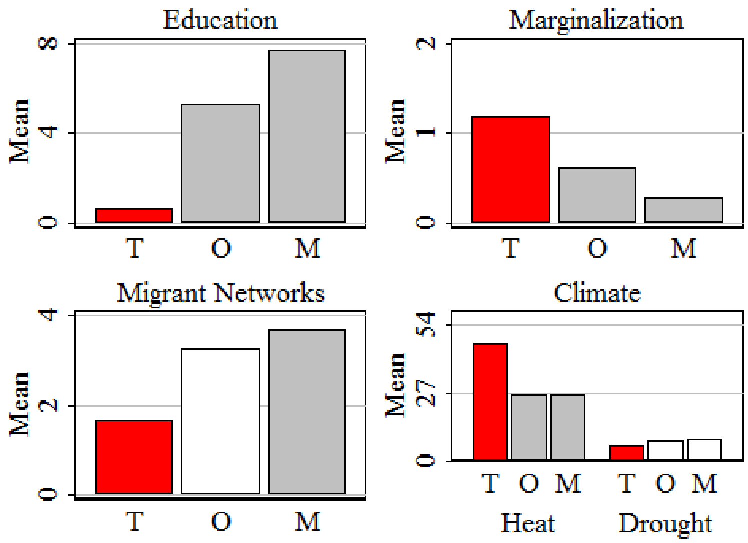


Panel B. Non-migrants with baseline migration propensities ≤ 1st percentile



Notes: Orange and red markers denote difference between climate and baseline migration propensities ≥ 95th and 99th percentiles, respectively.

Figure 4. Group means and significance tests for selected variables: Non-migrants with baseline migration propensities ≤ 1st percentile and difference between climate and baseline migration propensities ≥ 99th percentile



Notes: Scales of y-axes differ across variables. Education = Years of schooling during census round; Marginalization = CONAPO marginalization index in units of z-scores; Migrant networks = Percent of adults with domestic migration experience in prior census round; Heat = Number of months during six years prior to census where monthly maximum temperature was one standard deviation above 30-year mean; Drought = Number of months during six years prior to census where monthly precipitation was one standard deviation below 30-year mean. T = Trapped population; O = Other non-migrants; M = Migrants. Red shading denotes trapped population; Greyscale shading denotes statistically significant difference from mean of trapped population at $p<0.05$ (white shading otherwise) using Scheffe multiple comparisons tests.

Table S1. Variables and descriptions

Variable	Description
Dependent variable (individual-level)	
Internal migrant	Migrated within Mexico between census and five years prior to census (1=yes, 0=no)
Independent variables	
Climate variables (municipality-level)	
Heat months	Number of months during six years prior to census where monthly maximum temperature was one standard deviation above 30-year mean
Drought months	Number of months during six years prior to census where monthly precipitation was one standard deviation below 30-year mean
Individual-level	
Male	Sex (1=male, 0=female)
Age	Age five years prior to census
Education	Years of schooling during census round
Household-level	
International migrant networks	International migrant in household (1=yes, 0=no)
Municipality-level	
Domestic migration prevalence	Percent of adults with domestic migration experience in prior census round
International migration prevalence	CONAPO international migration intensity in units of z-scores
Marginalization	CONAPO marginalization index in units of z-scores
Agriculture	Percent employed in agriculture
Maize	Area (square meter / 10 hectare) of maize harvest
Wheat	Area (square meter / 10 hectare) of wheat harvest
Irrigation	Percent of agricultural land irrigated
Baseline maximum temperature	Average monthly maximum temperature during 30-year baseline period
Baseline precipitation	Average monthly precipitation during 30-year baseline period
State-level	
GDP change	Average percent change in inflation-adjusted GDP during six years prior to census

Table S2. Model parameter estimates used to generate baseline migration propensities

Variable	Coefficient and standard error
Male	-0.142*** (0.020)
Age	-0.033*** (0.002)
Education	0.083*** (0.005)
International migrant networks	-0.536*** (0.084)
Domestic migration prevalence	0.005 (0.006)
International migration prevalence	-0.048 (0.034)
Marginalization	-0.279*** (0.055)
Agriculture	-0.012*** (0.004)
Maize	0.001 (0.031)
Wheat	-0.250 (0.161)
Irrigation	-0.005** (0.002)
Baseline max temperature	0.012 (0.018)
Baseline precipitation	0.001** (0.001)
GDP change	-0.044** (0.018)
Census year = 2010	-0.643*** (0.053)
Constant	-2.884*** (0.540)
N = 390,408 individuals in 1,495 rural municipalities in 27 states BIC = 71,580	

Notes: Standard errors in parentheses clustered at municipality level; *** p<0.01, ** p<0.05, * p<0.10

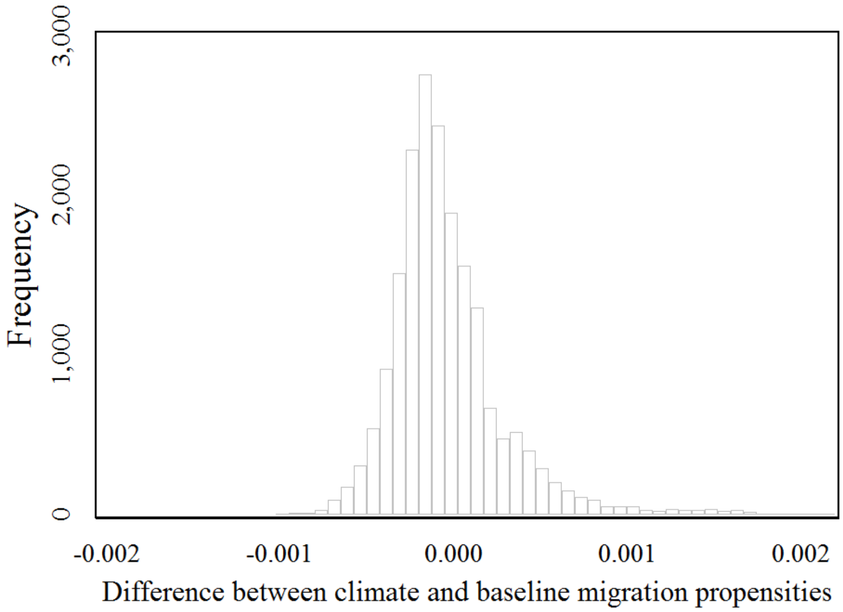
Table S3. Model parameter estimates used to generate climate migration propensities

Variable	Coefficient and standard error
Heat months	0.016*** (0.004)
Drought months	0.003 (0.007)
Male	-0.143*** (0.020)
Age	-0.033*** (0.002)
Education	0.083*** (0.005)
International migrant networks	-0.540*** (0.084)
Domestic migration prevalence	0.004 (0.006)
International migration prevalence	-0.040 (0.033)
Marginalization	-0.283*** (0.055)
Agriculture	-0.012*** (0.004)
Maize	-0.019 (0.030)
Wheat	-0.302* (0.170)
Irrigation	-0.006** (0.002)
Baseline max temperature	0.018 (0.018)
Baseline precipitation	0.001 (0.001)
GDP change	-0.064*** (0.017)
Census year = 2010	-0.668*** (0.061)
Constant	-3.315*** (0.542)
N = 390,408 individuals in 1,495 rural municipalities in 27 states	
BIC = 71,292	

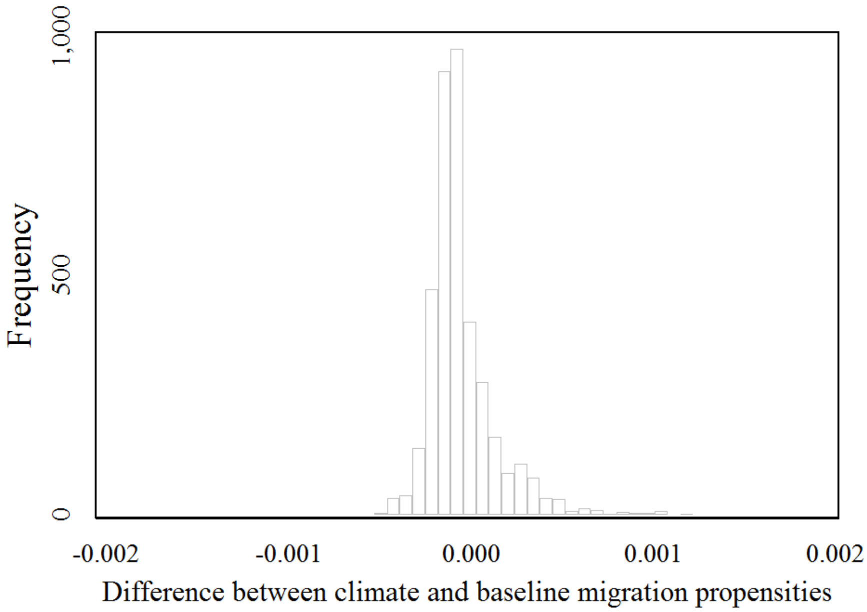
Notes: Standard errors in parentheses clustered at municipality level; *** p<0.01, ** p<0.05, * p<0.10

Figure S1. Difference between climate and migration propensities

Panel A. Non-migrants with baseline migration propensities ≤ 5th percentile



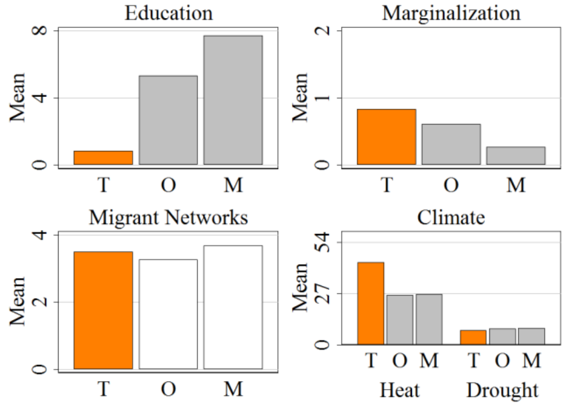
Panel B. Non-migrants with baseline migration propensities ≤ 1st percentile



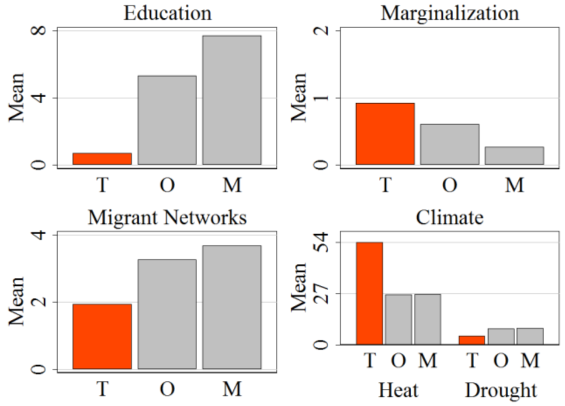
Notes: Scales of y-axes differ across Panels A and B.

Figure S2. Group means and significance tests for selected variables: Four selection criteria

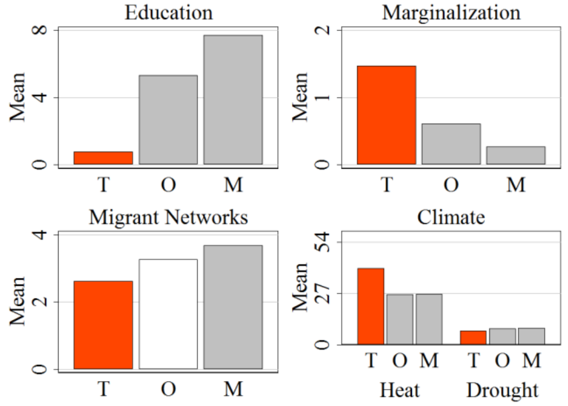
Panel A1. Non-migrants with baseline propensities ≤ 5th percentile and difference between climate and baseline propensities ≥ 95th percentile



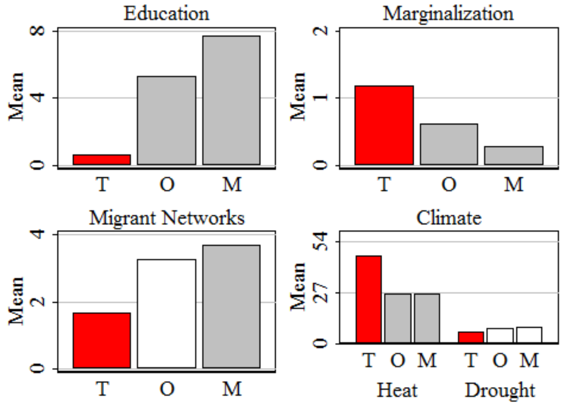
Panel A2. Non-migrants with baseline propensities ≤ 5th percentile and difference between climate and baseline propensities ≥ 99th percentile



Panel B1. Non-migrants with baseline propensities ≤ 1st percentile and difference between climate and baseline propensities ≥ 95th percentile



Panel B2. Non-migrants with baseline propensities ≤ 1st percentile and difference between climate and baseline propensities ≥ 99th percentile



Notes: Scales of y-axes differ across variables. Education = Years of schooling during census round; Marginalization = CONAPO marginalization index in units of z-scores; Migrant networks = Percent of adults with domestic migration experience in prior census round; Heat = Number of months during six years prior to census where monthly maximum temperature was one standard deviation above 30-year mean; Drought = Number of months during six years prior to census where monthly precipitation was one standard deviation below 30-year mean. T = Trapped population; O = Other non-migrants; M = Migrants. Orange-red shading denotes trapped population; Greyscale shading denotes statistically significant difference from mean of trapped population at p<0.05 (white shading otherwise) using Scheffe multiple comparisons tests.