Impact of Climate Variability on Internal Migration in the Philippines during 2005 – 2010

Final Report to the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Prepared by:

Prof. Alex Weinreb, University of Texas at Austin
Prof. Guy Stecklov, University of British Columbia
Dr. Aslihan Arslan, International Fund for Agricultural Development
Dr. Luis Molina, Alliance of Bioversity International and the International Center for Topical Agriculture
Dr. Godefroy Grosjean, Alliance of Bioversity International and the International Center for Topical Agriculture

October 14th 2020
Hanoi, Vietnam

Acknowledgements

This report was developed within the CGIAR Research Program on Climate Change, Agriculture and Food Security, with the support of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ).

.

Contents

1 Introduction

This report documents the extent to which changes in weather patterns—both short-term and sustained—influence internal migration in the Philippines. Our primary goal is empirical, as several detailed reviews of the scholarly literature on this topic have already been published in recent years (e.g., ADB 2012; Bohra-Mishra 2017; Rigaud et al 2018). In particular, using both municipality- and individual-level migration data in the 2010 census, we examine the effects of changes in weather and climate patterns on internal migration in the 2005-2010 period. We use a much larger, more detailed and higher-resolution array of indicators than any existing research. We believe that this combination of characteristics provides observers and policy makers in the Philippines with a robust starting point for anticipating future population movements in response to ongoing climate variability.

The report is divided into four main sections. In the first, we review some key themes that emerge in the literature and influence our analyses. In the second section, we introduce our data and describe key trends in our core variables. The third is the central empirical section, where in three subsections we address the following questions:

1. To what extent can climate-related measures, or changes in those measures, help us explain outmigration rates at the level of the municipality?
2. How much is the strength of a particular migration stream between a given municipality of origin (in 2005) and a given destination (in 2010) affected by their relative climatological characteristics (e.g., heat, precipitation, drought)?
3. How much do climate factors help us explain an *individual's* probability of migration, and if so, how does this vary by their individual characteristics, like gender, education, employment, indigeneity?

The fourth and final section briefly summarizes our results and points toward some policy relevant findings and recommendations.

2 Literature review

A combination of four factors makes the question of climate variability and migration highly salient to the Philippines. The Philippines:

1. Is a tropical archipelago on the Pacific Rim, the region of the world widely considered to be the most vulnerable to climate variability (Porter et al. 2014 ; ADB 2012);
2. Has a large and rapidly growing population—currently 108 million, double the number in 1985, and expected to exceed 140 million by 2050[1];
3. Has a relatively large agricultural sector, accounting for 9.3% of GDP and 24.3% of employment in 2018 (PSA & UPPI, 2019) which adds to its vulnerability;
4. Has a highly developed "culture of migration," both internal and international, which facilitates escape from the most affected areas, or from the country as a whole. The latest National Migration Survey by Philippines Statistics Authority (PSA) and University of the Philippines Population Institute (UPPI) reveals that 55% of Filipinos have migrated for 3 months or more at some point in their lives, and 88% of this migration was internal. Moreover, of the 15% of Filipinos who have migrated in the past 5 years, 84% migrated internally (PSA & UPPI, 2019).

---

[11] World Population Prospectes 2019, https://population.un.org/wpp/

A standard mechanism that contemporary social scientists employ to relate climate variability to migration—basically points 1 and 4 on this list—is a "livelihoods adaptation" framework. We expand on particular aspects of this paradigm a little more in our empirical section but for now, it is enough to say that the mechanism rests on a simple and commonsensical proposition. When the subsistence of an individual or household or extended family is under threat, one of the behavioral responses is migration.[2] That can involve all members of the household or wider family, which is likely more common in contexts of massive shifts in livelihood possibilities. More frequently, it involves selected members moving as a strategy to diversify income sources to manage risk. In either case, one or two less mouths to feed may lighten the consumption load at home, and also smooth income and consumption where out-migrants remit income back to their struggling families (Rosenzweig & Stark, 1989; Stark & Bloom, 1985). Yet depending on household composition and local labor market conditions, losing some members may also decrease labor available for agricultural production or other activities at home (De Brauw, 2010; Wouterse & Taylor, 2008). On the face of it, the livelihoods adaptation framework offers the easiest way to disentangle the complex relationships between climate variability and migration. The question is: How does it appear to apply to the Philippines? What do we know about climate variability and migration in the Philippines practice? In this section we briefly differentiate the two main ways climate variability manifests itself in the Philippines. We then discuss the current state of knowledge on internal migration (which is the focus of our study), and attend to the link between them.

2.1 Climate variability

The manifestations of climate variability in the Philippines can be categorized into two distinct types. The first are "sudden-onset" disasters involving catastrophic storms and flooding. Here, the Philippines scores high on international indices. Indeed, one group of local researchers has referred to the Philippines as "a locus of tropical cyclones, tsunamis, earthquakes and volcanic eruptions, . . ., a hotbed of disasters" (A. Lagmay et al., 2017). Typhoons, floods and droughts significantly affect agriculture, natural resources and food security, especially at the local level (Israel and Briones, 2012). Though not all of these disasters can be blamed on climate variability, those changes in weather patterns do appear to be raising the stakes: the frequency and strength of the tropical cyclones that cross parts of the Philippines every year appears to be increasing (Overland et al 2017). Their destructive capacity is also growing, partly because of Asia's growing coastal mega-cities that provide an increasingly unavoidable target (the "bullseye" effect). Indeed, this region as a whole, located in the "ring of fire", has experienced more of these disasters than any other global region (IDMC 2011).

The second type of climate variability manifestation that has affected the Philippines includes "slow-onset" factors. These include elements like soil degradation, higher and more frequent excess temperatures, unstable (and therefore unreliable) precipitation patterns, and sea-level rise. In general, these longer-term types of change receive more scholarly attention and, as we show below, are more influential drivers of long-term population mobility. In the Philippines, in particular, soil degradation has been documented since at least the 1980s, largely following agricultural extensification, deforestation, and heavier and more concentrated precipitation (Myers 1988; Lantican et al 2003; Cinco et al 2014). Historical changes in temperature have also be documented, with decreasing numbers of cold days and cool nights, and increasing numbers of hot days and warm nights (Manton et al 2001; Cinco et al 2014). Likewise, the slow rise of the sea, compounded by anthropogenic factors like the spread of urban areas into marginal flood lands, as well as land subsidence following excessive extraction of groundwater

---

[2] The same basic model can be used for higher order things, e.g. we can substitute consumer desires for subsistence and get to the same migration result.

(Rodolfo and Siringan 2007), can be seen in the more frequent flooding of the Philippines' coastal cities (Pati et al 2014). These patterns have also been documented elsewhere in South East Asia.

2.2 Internal migration

Our analysis focuses on internal migration. Bell and Charles-Edwards (2013) estimate about 3.5 times as many internal migrants as international migrants in Asia as a whole. The latest National Migration Survey indicates a ratio of 18 for migration experience of at least 3 months, and 6 for migration in the past 5 years (PSA & UPPI 2019). We cannot estimate a comparable comprehensive ratio with our 2010 census data, since it only references individual migrants who leave their households, missing the movement of complete households. With that constraint in mind, however, of the 6.1 million people aged at least 15 in the 2010 census data, 150,672 (2.46 percent) were reported by household members as "working overseas". That is only marginally less than the 180,426 reported as working in a different province, and 169,512 reported as working in a different municipality within the same province. Therefore, our data suggest that there are 2.3 internal labor migrants per single international labor migrant, although this figure may slightly over-estimate the relative strength of international migration experience as internal migration may capture more individuals but their migration intervals may be shorter. More generally, extrapolated to the whole census, our data imply that in 2010 there were about 1.5 million Philippines citizens of working age outside the country, who were still counted as *de jure* household members by their family members. This is largely consistent with the Philippines' status as the third major source of international migration in the world (after China and India) (ADB 2012:13).

There are two main types of internal migration in the Philippines: rural to urban, and rural to rural. Early patterns of internal migration in the Philippines were largely rural to rural. They were also unidirectional, "frontier-driven", male-dominated patterns, with a particularly strong stream from northern provinces to land-rich Mindanao. As Mindanao and other frontiers developed and become more urban, rural to urban and feminized migration patterns became more dominant (Herrin 1981). More recent data point to a partial change in these patterns: The NMS report shows that internal migration in the last five years has been dominated by rural-rural flows – not surprising given the near zero rate of urbanization now evident in the Philippines (UN 2019) - though the strong feminization of internal migration continues. In fact, it has come to characterize migration patterns in a number of other countries in South East Asia (e.g. Phongpaichit 1992, Thadani and Todaro 1984)—there are parallels in the international migration profiles (ADB 2012:49). In the Philippines in particular, Socorro and Xenos (2006), using 2000 census data, show that the sex ratio (males per female) of migrant populations in urban areas is 0.7 in the 15-29 age group, only exceeding 0.9 in the 30s.

Researchers have also shown that these migrant streams also vary by age. There are features of the standard age pattern of migration, widely documented across many different types of societies (Rogers and Castro 1983; Beauchemin 2010; Menashe-Oren and Stecklov 2017), part of which are also relevant here. However, we point to two ways in which age patterns in the Philippines are unusual. First, even though the Philippines has a relatively high number of young rural-to-urban migrants when we use broad age categories—Socorro and Xenos (2006) look at the 15-29 age group—close attention to *single* years of age shows that the mean age of internal migration in the Philippines is actually high by Asian standards. In fact, the Philippines is one of the only Asian countries (with age-specific migration data) where the mean age of migration is higher than the global mean (Charles-Edwards et al 2017).

A second age-effect focuses less on the person's own age than the number of people in the same age cohort in his/her area of origin. Simply, the greater the proportion of the population in the 20-29 age group in a migrant's place of origin, the more likely it is that the migrant will have made a long-distance interregional move (Socorro and Xenos 2006). In fact, this is part of a more general phenomenon which postulates that population growth increases migration, especially among adolescents and young adults.

The key factor at play in this regard in the Philippines is that overall rates of population growth in these younger age groups remain high, mainly because fertility has fallen so slowly: the total fertility rate (TFR) was 6.3 in 1970, 4.0 in 1995, and is now around 2.6. This "sluggish fertility decline and drawn-out demographic transition" (Socorro and Xenos 2006) suggests that the youth population of the Philippines (aged 15-24) will have increased by as much as 259% in the 66 years it will take the country to complete its fertility transition, that is, reduce fertility to replacement level of 2.1 (Xenos 2004). This is not only much slower than other Asian countries (whether we compare it to wealthy countries like Taiwan and South Korea, or to poorer ones like Thailand and Vietnam), but also places the Philippines in a very different category than other (migrant) sending countries like Mexico. A speedier decline in fertility from 6.6 children in 1970 to 3.0 in 1995 (and 2.1 today) in Mexico contributed to the sharp reductions in the number of Mexican migrants heading into the US (Passel et al., 2012). The relatively large cohort sizes create migration dynamics that maintain migration streams even with subsequent shrinking of cohort sizes following fertility declines due to cumulative causation, at least from smaller rural areas or towns (Fussell and Massey 2004). Demographic pressures will continue to stimulate migration in the Philippines, even in the absence of other factors, but these are going to vary across regions in parallel to population growth rates and, therefore, birth cohort sizes from 15-20 years earlier and this will be exacerbated by slower fertility decline in rural areas. In fact, 2017 Demographic and Health Surveys estimate TFR for ages 15-49 at 2.4 for urban women and 2.9 for women in rural areas.

The role of cohort sizes is clearly interwoven with established factors that determine both opportunities and constraints in origin and potential destination locations. This includes both labor market conditions and educational profiles. Internal (and international) migration is mainly driven by employment reasons in the Philippines: 46% of migrants mentioned it as a reason for their first internal move, though this falls to 23% for their last internal move (PSA & UPPI 2019). The educational profile of potential migrants also shapes movement. Analyses of the 2000 Philippines census data show that among migrants in the 15-29 age group, who moved from their area of origin, the more educated were more likely to move to *poblaciones* (i.e., primary administrative seats of rural districts in the Philippines) and other large urban areas, and less likely to return to their place of origin. The latest NMS report indicates that although people with migration experience are more likely to have completed high school compared to those that do not, this difference is smallest for internal migrants (35% vs. 32%) and probably not statistically significant, whereas this difference is biggest for international migration (44% vs. 32%).

Analysis of 2000 census data show once those migrants were in the cities, irrespective of their age or sex, they were much less likely to be enrolled in education than their non-migrant counterparts (Bohra-Mishra et al 2017; Socorro and Xenos 2006). In other words, education in rural areas predicted rural out-migration, but urban in-migrants were more likely to be working than studying. In other research, less educated were more likely to migrate to urban areas that are closer to them in distance, where they worked in manual labor (Deshingkar and Natali 2008).

At the same time, research elsewhere in Asia has shown that the distribution of human capital between rural and urban areas is a continuous process and depends on the sectoral composition of local economies and their surroundings (IFAD, 2016; Reardon, 2015). Rural transformation process increases the reach of non-agricultural as well as agri-food system value chains into rural areas, increasing connectivity between rural and urban areas by facilitating the growth of secondary cities and towns. These dynamics can both increase incentives to migrate as well as investment in education, and facilitate more short term and seasonal migration (Arslan et al. 2019). Kochar (2014), for example, finds that higher rural-urban migration opportunities increase educational attainment in rural India.

2.3 Climate variability and internal migration

References to environment-driven migration in Asia began to emerge in the 1990s (Subedi 1997). Since then, researchers have focused on both sudden- and slow-onset factors, with the complexity of models growing over time. Increasing availability of high resolution time series climate data from satellite sources along with large-scale geocoded household survey data has facilitated the growth of this literature.

Studies of displacement—typically triggered by sudden-onset factors—provide a starting point. A series of reports conducted by the Norwegian Refugee Council's (NRC) Internal Displacement Monitoring Centre suggest that natural disasters in the Philippines tend to displace people in the short term, usually locally, and often to urban areas. This is consistent with studies conducted in Indonesia (Rofi, Doocy and Robinson 2006) and Bangladesh (Martin et al 2014)[3]. In the Philippines context, the NRC also argues that conflict exacerbates the effects of natural disasters, both by disrupting recovery—conflict is often in areas that are less accessible to government or non-government actors—or by causing "secondary displacement" (NRC 2014, 2015).

To accurately identify effects of climate variability on migration in a more comprehensive manner, it is now standard to estimate the effects of changes in both precipitation *and* temperature in the same model. Covariation between these two—which in turn varies across climatological zones—means that leaving one of these out of a model is liable to generate biased estimates of the other (Auffhammer et al. 2013). To target the mechanisms implicated by the livelihoods adaptation framework, models also include other factors that might affect agricultural productivity and therefore household income and the motivation to migrate. In the Philippines, as asserted by Bohra-Mishra et al (2017), this is related in particular to rice production. Lansigan, de los Santos, and Coladilla (2000) document the high vulnerability of rice production in the Philippines to both short-term weather episodes and longer-term climate variability across three decades, with unusually warm temperatures associated with declines in rainfed rice yields. Peng et al. (2004) demonstrate that rice yield in the Philippines declined by 10 percent for each 1^{o}C increase in growing-season minimum temperature in the dry season, and by 15 percent for each 1^{o}C increase in growing-season *mean* temperature, though fluctuations in maximum temperature had no significant impact on yields. Israel and Briones (2012) estimate that, from 2007 to 2011, the monetary value of the damage to rice farming due to typhoons and floods amounted to around USD 1.2 billion (compared with USD 115 million due to droughts), with significant implications for food security.

Consistent with these effects of climate on rice yields, Bohra-Mishra et al (2017: 288) find that "rising temperature and to some extent typhoon activity promote internal migration, potentially through their negative effects on crop yields based on our findings on the effects of climate variability on rice yield. Precipitation, however, has no significant effect on migration." They also find stronger results in Provinces with a higher share of rural population, which is also consistent with the idea that they are more dependent on agriculture as a source of livelihoods and income. Finally, climatological factors affected the 1990s migration patterns of males and the more educated more than females and the less educated.

---

[3] The NRC report that in 2013, for example, around 327,000 people—almost all on Mindanao—fled their homes because of armed conflict. By the end of the year around 116,000 were still displaced, of whom roughly a third were in Zamboanga city, the commercial and cultural capital of Zamboanga Peninsula region (region IX), and the second largest city on Mindanao. Yet in November of the same year, Typhoon Haiyan, one of the most powerful typhoons ever recorded, displaced over 4 million people in western and central areas of Visayas Province (NRC 2014). Although the emergency response was relatively effective, the pace of rebuilding was much slower than planned (Arroyo and Åstrand 2019), leaving significant numbers in more temporary housing. We have not found literature with estimates of how much interregional movement was generated by Typhoon Haiyan.

This, too, is consistent with research elsewhere, even in quite different settings like Pakistan (Mueller et al. 2014) and Ethiopia (Gray and Mueller 2012).

Although this existing body of research on climate variability and migration in the Philippines we have cited is robust—we have intentionally referenced what we consider high-quality studies—it is important to point to some limitations, especially as we consider more recent patterns of movement, or project this effect into the future. We highlight four major limitations, which suggest that the effects of climate variability on migration in the future may be somewhat more complicated than implied by a basic reading of the livelihoods adaptation model, especially when looking at the relationship across time.

1. **Older data**: The most comprehensive and methodologically robust studies on the Philippines use relatively old data. Specifically, Bohra-Mishra et al. (2017) measures changes in both precipitation and temperature, incorporates sudden- and slow-onset changes, and employs measures of rice yield to tap into mechanisms linking climate variability and migration. The authors use 2000 census data, which covers migration in the 1990-2000 period. Amacher et al (1998), look at migration in the 1980s, focusing on the relative appeal of migration to forested upland versus other destinations. The use of old data raises three main issues.
    a. The Philippines has become much wealthier. Between 1990-2000, GDP per capita increased by 45 percent, from $716 to $1,039. Over the next decade, despite the impact of the Great Recession, the rate of increase more than doubled, pushing GDP *per capita* to $2,124, even with the increase in population from 78 to 94 million. As of 2018, GDP per capita had increased by 46 percent since 2010 (World Bank) with a faster rate of growth than during the 1990s.
    b. The Philippines' growing wealth is associated with—it reflects and reinforces—its increasing economic diversification away from the agricultural sector. Agriculture currently accounts for around 9 percent of the Philippines' GDP, which is more than in the most developed countries—it averaged 2.3% in OECD countries in 2017—but much less than it used to be. As little as 15 years ago, Habito and Briones (2005) reported that the wider agribusiness sector (agricultural production plus agro processing and trading and inputs and manufacturing) accounted for around 40% of GDP and two-thirds of jobs. It is particularly notable that this diversification, often associated with industrialized countries, is driven by structural and rural transformation processes that lead to diversification of income generating opportunities also in rural areas (Timmer 2004; RDR 2019). This significant reduction in the economic centrality of agriculture means that the Philippines as a whole may not be as *economically* vulnerable to the impacts of climate variability as it would have been in the absence of that diversification. Nor are as many families in the Philippines as dependent on agriculture at the individual level. Note, however, that the population remains heavily dependent on rice for energy and protein consumption; hence rice production shocks cause food insecurity at the local level (WFP 2017; Israel and Briones 2012).
    c. People at peak ages of migration in 1990-2000 were born in the 1970-1985 period, when TFR was slowly falling from 6.3 to 4.7, with fertility decline onset later in the rural sector. A simple back of the envelope examination of recent differences in DHS estimates of the rural and urban TFR's suggest the rural level are decline but have trailed urban levels by about two decades (own estimates from www.statcompiler.com). Migrants before 2000 were therefore part of much larger cohorts relative to their parents with greater pressure on agricultural livelihoods. Even with the Philippines' sluggish fertility transition, more recent migrants are

part of smaller cohorts relative to their parents' generation, which arguably has reduced financial pressure on families, especially given the diversification away from reliance on agriculture.

   d. The institutional capabilities of the Philippines state have improved significantly since the 1990s in ways that affect the state's ability to respond to climate variability. Since 2007, the debt to GDP ratio has been significantly lower than during the 1990s, which gives it more fiscal freedom. The state can draw on a much more educated population: World Bank estimates are that among the Philippines population aged 25 and over in 1990, 30% had completed Upper Secondary. By 2000 and 2010, that was true for 35.7 and 56% percent of the population aged 25 and over, respectively. Finally, it has instituted highly regarded laws that directly deal with climate related challenges: the Climate variability Act of 2009 and the Philippine National Disaster Risk Reduction and Management Act of 2010 (PDRRM-2010).

2. **Household adaptation**: There is a growing empirical literature on this phenomenon. Gaillard et al (2008) document families' increasing ability to adapt to more frequent flooding in terms of subsistence or family finances. The development and widespread promotion of new rice cultivars more tolerant of drought, salinity or longer submergence (Yorobe et al 2016) helps. So does increasing information about other crops that can be grown in areas with changing environmental conditions—the small-scale maps projecting crop-specific "suitability" across different areas of Isabella Province are an example of this (Balanza et al 2019).
3. **The magnitude and variability in climatic shocks**: There is some evidence that parts of the Philippines may be less affected by some of the most destructive slow-onset forces. Choi et al (2009) argue that there are smaller increases in heat indices in island nations in the Pacific than in their mainland counterparts, suggesting that "The moist atmosphere near the oceans may subdue the occurrences of extreme temperature events due to its high heat [absorbing] capacity compared with the drier inland atmosphere" (p.1922).[4] Likewise, even though there is some within-country consistency in the *direction* of decadal trends in both temperature and precipitation, there is considerable heterogeneity when we compare data from individual weather stations (Manton et al. 2001). In fact, it is becoming increasingly clear that slow-onset climate variability factors—as well as adaptation to those factors, already mentioned—are better observed at a more local scale (Bouroncle et al., 2017). We are aware of at least one such application in the Philippines (Balanza et al., 2019), a vulnerability assessment of agricultural smallholders "at landscape scale" in Isabella Province. Even at this local level, there is considerable heterogeneity in projected effects.
4. **Costs of migration:** Even if climate-induced poverty increases household members' or entire households' *motivation* or willingness to migrate as part of a livelihoods adaptation strategy, it may also reduce their actual *ability* to migrate, especially inter-regionally, since that is costlier. Or it may push them to migrate toward more accessible public lands—like forested uplands (Amacher et al., 1998), which can exacerbate downstream environmental effects if it leads to deforestation. This confound is a longstanding issue in this area of research, whether dealing with sudden-onset disasters or slow-onset climate variability (Bohra and Massey, 2009; Naik 2009; Juelich 2011; Gray et al. 2014). Furthermore, whereas more localized sudden onset crises may create migration flows to other rural areas, slower onset shifts may lead to increasing rural to urban migration flows.

---

[4] Note that the Philippines is not among the 10 Asian countries in Choi et al.'s (2009) comparative study.

We emphasize that in pointing to these four limitations in existing studies, our main goal is to show that the relationship between climate variability and migration is a dynamic and evolving process: because of changes in population characteristics, in the wealth of nations, in the capacities of their governments, in agricultural practices on the ground, and in the overall range of available economic opportunities. These changing characteristics independently affect both the risk that climate variability poses to life and livelihood, and therefore the livelihood strategies that individuals, households or families will likely adopt when confronted with either sudden- or slow-onset changes. In either case, the fact that this is a moving target underscores why it is crucial to replicate prior analyses on more recent data, particularly if our aim is to better understand ongoing and near term climate impacts on Philippine migration patterns. This is the main motivation of our approach, which we detail in the next section.

3 Data and baseline trends

3.1 Migration data

We analyze migration using the 10 percent sample of the 2010 Philippines census to which we have access through the Integrated Public Use Microdata Series (IPUMS)[5]. Our core measures of migration are constructed by comparing reported municipality of residence in 2010 to the reported municipality of residence in 2005. Because 2010 census data include municipality of residence five years earlier, whereas earlier censuses do not provide the same specificity, we focus our core analyses on this, most recent interval. In certain analyses we also distinguish those who moved within the same province from those who moved to a different province.

We conduct two types of analyses with these data: i) at the municipality-level, with a sample size of 1,273, and ii) at the individual-level, with a sample size of 8.142 million individuals aged at least 5 in 2010 (all of these were born and therefore "at risk" of being a migrant in 2005). We supplement these data with provincial-level data from the 2000 Census data[6]. We provide detailed information about our empirical approach below.

We begin with a descriptive analysis, identifying basic trends in patterns of in-migration over the five years preceding census enumeration. To generate more historical perspective, this section also includes some measures from prior waves of census data.

3.2 Migration trends

Table 3.1 provides the basic frequencies for 5-year in-migration patterns across the complete 10% samples in 1990, 2000 and 2010 censuses. In both the 2000 and 2010 data, these frequencies are calculated directly using the difference in municipality of residence at the time of the census and 5- years earlier. Since that question does not exist in the 1990 data, we used a comparable measure based on responses to the question about "years residing in the current locality." Anyone reporting having lived there for less than 5 years was classified as an in-migrant.

Table 3.1 provides clear signs of a secular decline in migration across the three periods. In 1990, 6.5% of the population (aged at least 5) had moved in the prior 5 years. By 2000 that had fallen to 4.5%, and by 2010, it had fallen further to 3.3%. Given that Philippines percentage urban has not been growing rapidly between 1990 and 2018 (UN Urbanization Report 2019 puts average urbanization rate at −0.01 per cent), these figures point to the importance of within urban (and rural) sector flows.

---

[5] https://international.ipums.org/international-action/sample_details/country/ph#tab_ph2010a

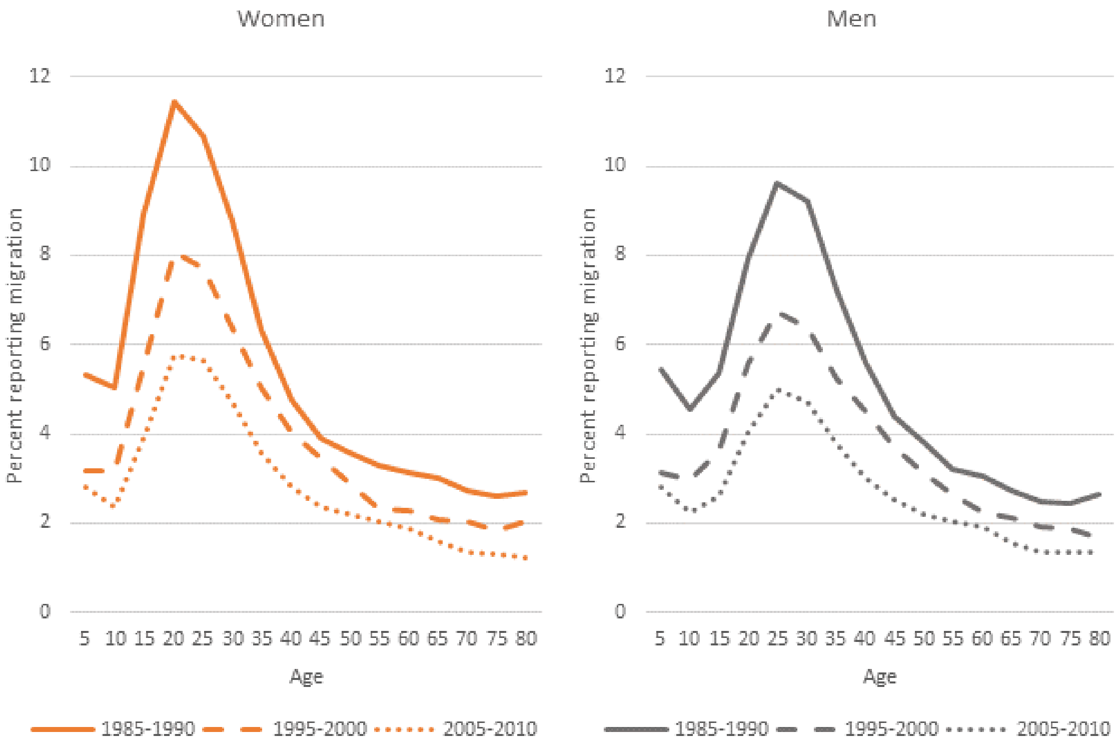
[6] We reviewed other data sources, in particular the Demographic and Health Surveys. A review of the advantages and disadvantages of each of these datasets is provided in Appendix A. Here, we merely note the major disadvantages of the DHS data: its focus on women of reproductive age and complex multistage sampling structure make it difficult to extrapolate to the general population.

Table 3.1. IPUMS population aged at least 5, by migration status

	Migrated in last 5 years			
Census	No	Yes	% Migrated	Total
1990	4,833,573	336,114	6.5	5,169,687
2000	6,192,465	289,768	4.5	6,482,233
2010	8,081,808	275,126	3.3	8,356,934
Total	19,107,846	901,008	4.5	20,008,854

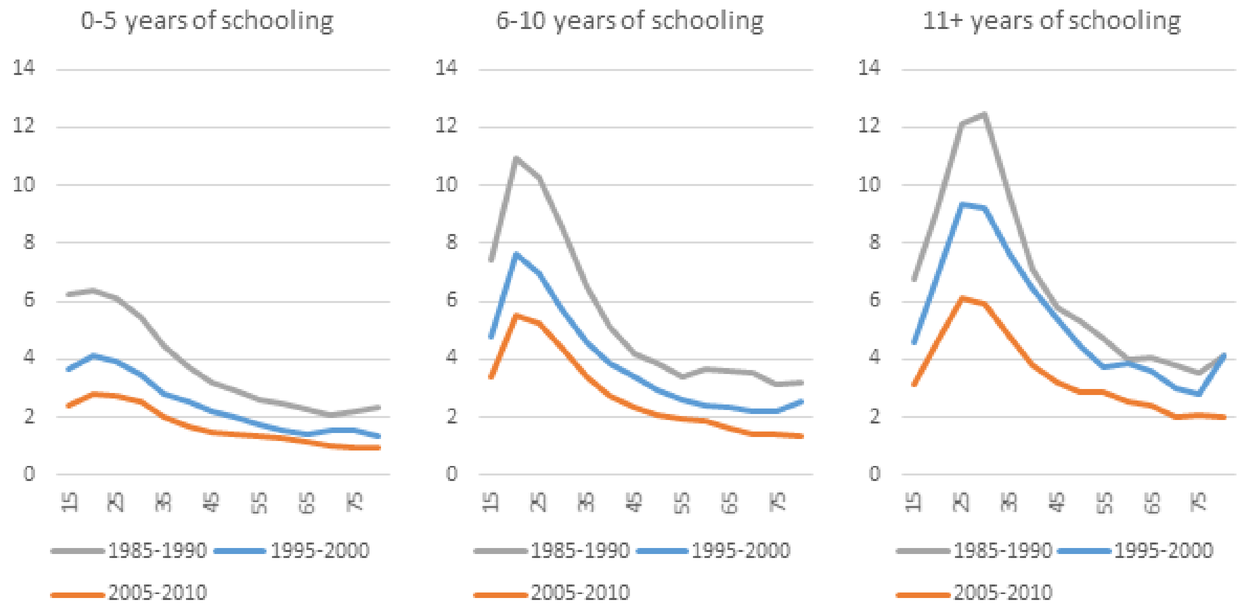
While these crude migration statistics ignore the impact of declining fertility on changing mean ages, the reduction in migration across time is evident across all ages, and among both women and men. This can be seen more directly in Figure 3.1. It confirms higher rates of migration among women, and shows that there have been very substantial reductions in migration, with the decline especially pronounced at peak ages—20s for women, late 20s and early 30s for men. In the late 1980s, around 11% of the female population in the Philippines had moved in the prior five years. By 2005-2010, that had fallen to less than 6%. The equivalent reduction for men was from around 9.5% to 5%.

Figure 3.1. Percent of population that are in-migrants, by gender, age, and period of migration.



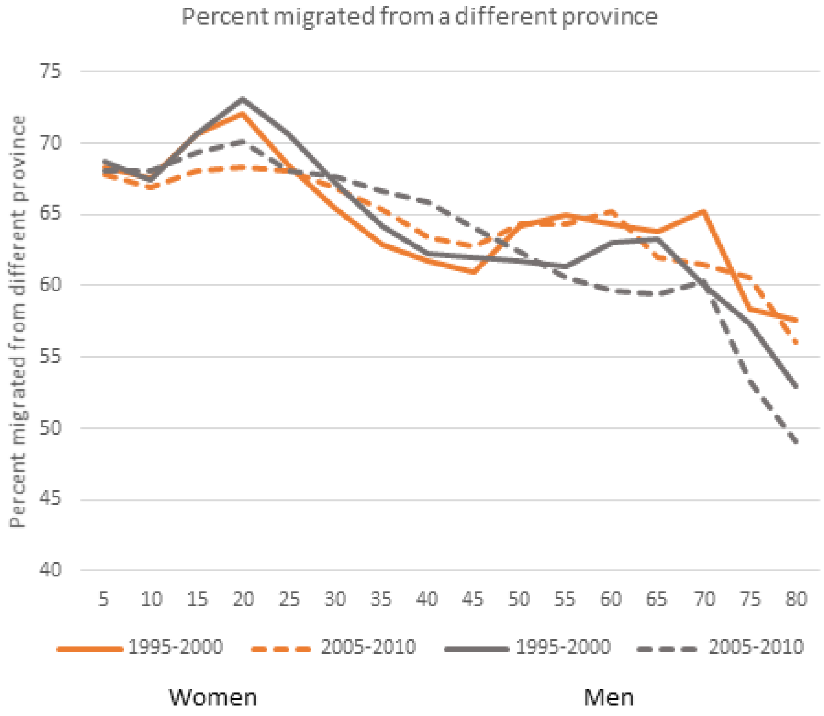
The reduction in migration has also occurred across all educational classes, as seen in Figure 3.2. Across all three periods, migration in the Philippines was selective on education, occurring at higher rates and peaking at older ages among the more than less educated. In both the 1995-2000 and 2005-2010 period, there was also a large difference in the frequency of migration among those with 6-10 years of schooling and those with at least 11 years of schooling. By the 2005-2010 period, however, the differences between these two more educated groups had shrunk very significantly, suggesting that even if members of these two groups remained about twice as likely to migrate as members of the least educated group, migration has become somewhat less selective over time.

Figure 3.2. Percent of the population that are in-migrants, by years of schooling, age, and period of migration.



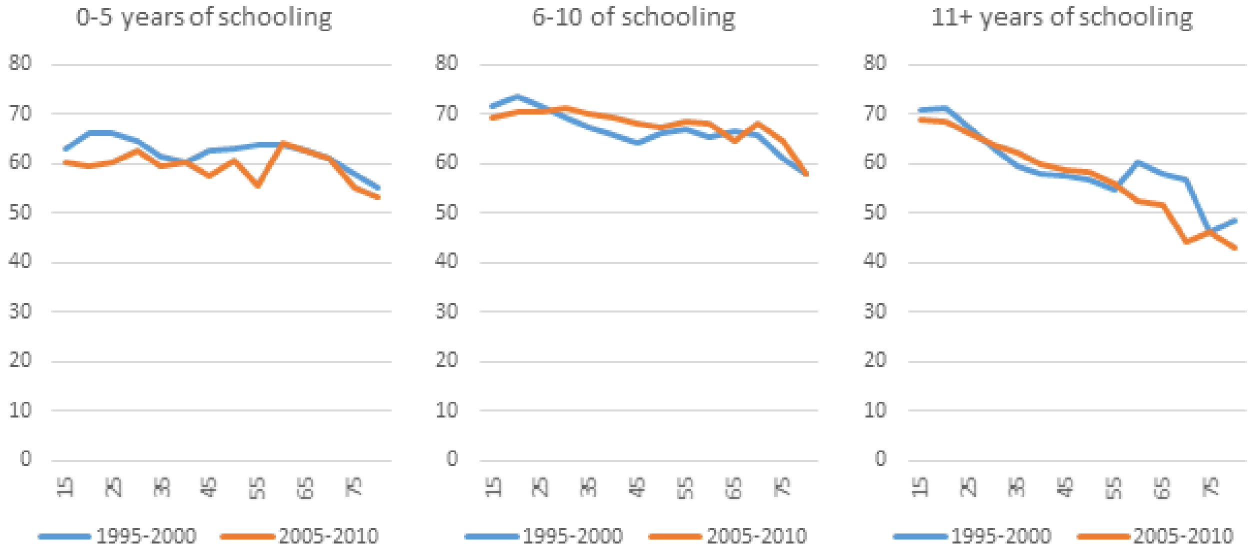
The 2000 and 2010 IPUMS data allow us to differentiate migrants arriving from elsewhere in the same province and a different province. We graph this in Figure 3.3. It shows that within each time period there is little difference between women and men. Also, only in the ages above 55 has there been some change across time—a slightly lower percentage of migrants heading to a new province than was the case in the 1995-2000 period. Over and above these differences, the most notable pattern is a slow reduction in the probability of *interprovincial* migration—among migrants—across age in both censuses. Under age 30, about 70% of recent female and male migrants moved from a different province. This percentage is lower at older ages, though still a majority.

Figure 3.3. Percent of all migrants that arrived from a different province, by gender and age.



Interestingly these patterns of migration within or across-province vary significantly by education, as shown in Figure 3.4. Among recent migrants with little schooling, roughly 60% of them have come from a different province, irrespective of age. In the intermediate education group—with 6-10 years of schooling—we find the same basic gradient seen in Figure 3.3, beginning at 70% among the young, and ending around 60% among the elderly. In contrast, in the most educated group—those with at least 11 years of schooling—there is a much steeper slope. Around 70% of those aged 15-24 migrated from a different province, but the percentage falls in a relatively linear way across all age groups, especially for migrants in the 2005-2010 period. There is a notable surge in migration in the early retirement years in the 1995-2000 period, which appears to disappear by 2005-2010. By age 70, across both periods of measurement, a majority of these migrants are remaining in the same province.

Figure 3.4. Percent of recent migrants from a different region, by years of schooling, age, and period of migration.



To complete this general description of internal migration in the Philippines, we also look at differences across regions in Table 3.2. It confirms that people moving in the 2005-2010 period represented 2.8 percent of the population (weighted average) across all regions, ranging from a high of 4.7 percent of the population in Calabarzon to a low of 0.76 percent of the population in the Autonomous region in Muslim Mindanao.

Table 3.2. Migrants who moved 2005-2010 as a percentage of the population in 2010, by region and point of origin.

Regions	Number (aged ≥5)	% moved from other province	% migrated within municipality	Total % move
Autonomous Region in Muslim Mindanao	378,854	0.10	0.66	0.76
Bicol	471,394	1.45	0.74	2.20
Cagayan Valley	291,434	0.96	0.69	1.65
Calabarzon	1,114,120	3.57	1.15	4.72
Caraga	212,501	2.20	0.79	2.99
Central Luzon	910,820	2.18	0.91	3.09
Central Visayas	610,685	1.47	1.61	3.08
Cordillera Administrative Region	145,249	2.17	1.09	3.27
Davao	396,976	2.20	0.74	2.94
Eastern Visayas	358,630	1.73	0.72	2.45

Ilocos	426,005	1.10	0.62	1.73
Mimaropa	242,875	1.16	0.91	2.07
National Capital Region	1,107,112	3.02	0.57	3.60
Northern Mindanao	379,806	1.83	1.00	2.83
Soccsksargen	358,623	1.49	0.65	2.15
Western Visayas	654,209	0.95	0.78	1.73
Zamboanga Peninsula	297,641	1.11	0.71	1.82

Overall, these trends strengthen the points made during the earlier part of this report. Alongside the rapid growth in the Philippines' population, and other changes documented above, the incidence of internal migration in the Philippines fell steadily and significantly across the 1985 to 2010 period. We reemphasize that migration is a dynamic process that changes as countries develop. As a result, any model that seeks to understand the effects of climate variability on migration needs to be replicated in different time periods and control for other factors that drive migration, which is the only way to identify robust linkages.

3.3 Climate and biophysical data and trends

3.3.1 Climate variability

One of the important contributions of this study is the calculation of an extensive collection of 21 separate indices (Table 3.3) to capture a wide range of rapid onset events in temperature and rainfall that may be hypothesized to affect internal migration in the Philippines. The selection of these indices was coordinated by the Climate Variability and Predictability (CLIVAR) Expert Team (ET) on Climate Change Detection Monitoring and Indices (ETCCDMI). For temperature, we use data from the land surface component of the fifth reanalysis of the European Centre for Mid-Range Weather Forecasts (ERA5-LAND). This dataset has a large temporal and spatial coverage, which allows us to cover all the municipalities in the country over a long time to capture trends and variations from long-term trends. The data consists of modeled estimates of daily minimum and maximum temperatures over grid cells of approximately 9km x 9km. For precipitation, we use estimates of daily precipitation rates from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) that are available at a horizontal resolution of approximately 5 km (Funk et al., 2015). We calculate rainfall indices over the period 1981 – 2010.

Table 3.3 lists the 21 indices we use along with their definitions and units of measurement. Most of these are annual, but some are calculated at a monthly scale. These indices are used as predictors for migration rates individually or as cumulative (or mean) values across one, three and five years prior to the migration window in our data, and in terms of change in each of these relative to the preceding 12 years (see Section 4).

Table 3.3. Rainfall and temperature indices: definitions and measurement units.

	ID	Indicator name	Definition	Unit
1	TXx	max Tmax	annual maximum value of daily maximum temperature	°C
2	TNx	max Tmin	annual maximum value of daily minimum temperature	°C
3	TXn	min Tmax	annual minimum value of daily maximum temperature	°C
4	TNn	min Tmin	annual minimum value of daily minimum temperature	°C
5	TN10p	cool nights	percentage of days when TN < 10th percentile	% days
6	TX10p	cool days	percentage of days when TX < 10th percentile	% days
7	TN90p	warm nights	percentage of days when TN > 90th percentile	% days
8	TX90p	warm days	percentage of days when TX > 90th percentile	% days
9	WSDI	warm spell duration indicator	annual count of days with at least 6 consecutive days when TX > 90th percentile	% days
10	CSDI	cold spell duration indicator	annual count of days with at least 6 consecutive days when TN < 10th percentile	% days
11	DTR	diurnal temperature range	annual mean difference between TX and TN	°C
12	RX1day	max 1-day precipitation amount	annual maximum 1-day precipitation	mm
13	RX5day	max 5-day precipitation amount	annual maximum consecutive 5-day precipitation	mm
14	SDII	simple daily intensity index	annual total precipitation divided by the number of wet days (defined as precipitation >= 1.0mm) in the year	mm/day
15	R10mm	number of heavy precipitation days	annual count of days when precipitation >= 10mm	days
16	R20mm	number of very heavy precipitation days	annual count of days when precipitation >= 20mm	days
17	CDD	consecutive dry days	maximum number of consecutive days with daily rainfall < 1mm	days
18	CWD	consecutive wet days	maximum number of consecutive days with daily rainfall >= 1mm	days
19	R95p	very wet days	annual total PRCP when RR > 95th percentile	mm
20	R99p	extremely wet	days annual total PRCP when RR > 99th percentile	mm
21	PRCPTOT	annual total wet-day precipitation	annual total PRCP in wet days (RR >= 1mm)	mm

The analysis of the time series of extreme weather indices for temperature indicated that, for the Philippines as a whole, there was no clear sign of warming or cooling, given that there were no statistically significant trends across the region (Table 3.4). Spatially, this is consistent with the trends detected at municipality level for TXx, TXn and TNx, which did not show statistically significant trends across the whole country (Figure 3.5). On the other hand, municipality level trends indicating a warming tendency, expressed as decreasing trends in the number of cool days (TX10p) and nights (TN10p), and increasing trends in the number of warm days (TX90p) and nights (TN90p) were statistically significant over extensive areas in the country (Figure 3.6) -- though these were not significant at the national level. Over 1981 – 2010 the number of cool nights decreased over central Mindanao and most of Palawan (Figure 3.6a), as did the number of cool days over most of the island groups of Mindanao, Visayas, and the southern Luzon and Palawan (Figure 3.6b). Significant warming trends were observed in the number of warm nights (Figure 3.6c), especially over most of mainland Luzon and partly in central Mindanao, and the number of warm days also over Mindanao and Luzon (Figure 3.6d).

Table 3.4. Analysis of regional trends (i.e. over the whole Philippines) for the period 1981 – 2010. Values in bold are statistically significant at 95% confidence.

ID	**Units**	**Trend (units/decade)**
Temperature		
TX90p	% of days	0
TN90p	% of days	0
TX10p	% of days	-0.03
TN10p	% of days	-0.30
TXx	°C	0.08
TXn	°C	0.13
TNx	°C	-0.15
TNn	°C	0.15
Precipitation		
PRCPTOT	millimeters	160.2
SDII	Millimeters	**0.5**
R95p	Millimeters	**108.7**
R99p	Millimeters	9.9
RX1day	Millimeters	2.4
RX5day	millimeters	3.7
R10mm	Number of days	**13.0**
R20mm	Number of days	**5.0**
CDD	Number of days	1.1
CWD	Number of days	-13.1

In terms of rainfall, the country as a whole showed a positive, although (statistically) non-significant, trend in the annual total wet-day precipitation (Figure 3.7a and Table 3.4). However, significant trends indicated an increase of 0.5 mm/decade in the mean daily rainfall intensity, in the intensity of very wet days (~109 mm/decade) and in the frequency of heavy precipitation days (~13 days/decade) and very heavy precipitation days (~5 days/decade) (Figure 3.7b,c and Table 3.4). Figure 3.8 shows that most municipalities did not exhibit significant trends, except large clusters in south and southeastern Luzon, Mindoro and Mindanao (Figure 3.8). Very wet days (daily precipitation ≥ 95th percentile) and the number of very heavy precipitation days have increased across most of Mindoro. Eastern Mindanao has seen an increase in both very wet days and in average daily rainfall intensity, while the number of heavy precipitation days has increased in the southwest.

Figure 3.5. Trends for the (a) annual maximum of daily maximum temperature, (b) annual minimum of daily maximum temperature and (c) annual maximum of daily minimum temperature over 1981 – 2010. Blue and red shades represent decreasing and increasing trends, respectively. Dark and light shades statistically significant and non-significant trends, respectively.

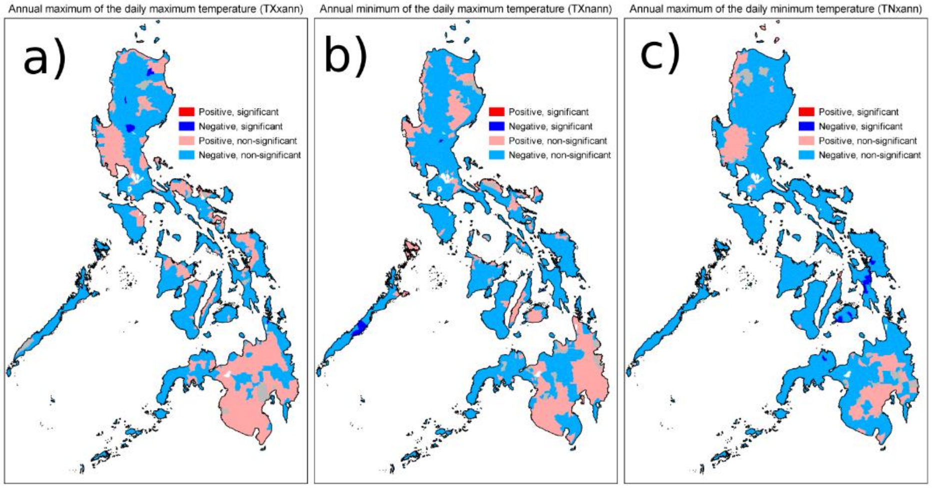


Figure 3.6. Trends at municipality level for the number of (a) cool nights, (b) cool days, (c) warm nights and (d) warm days over 1981 – 2010. Blue and red shades represent decreasing and increasing trends, respectively. Dark and light shades statistically significant and non-significant trends, respectively.

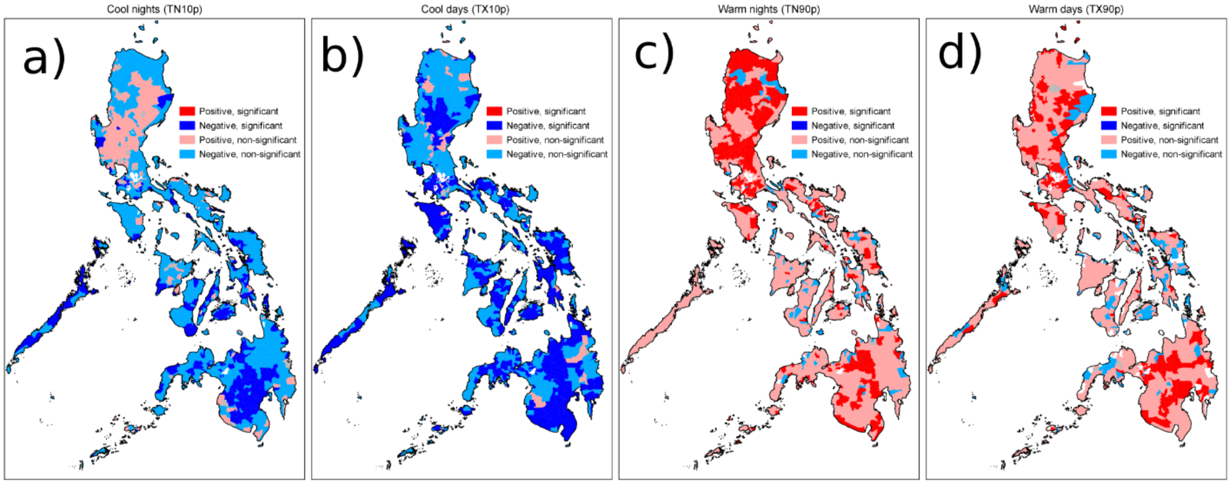


Figure 3.7. Regional trends in (a) annual total precipitation during wet days, (b) precipitation during very wet days and (c) number of heavy and very heavy precipitation days.

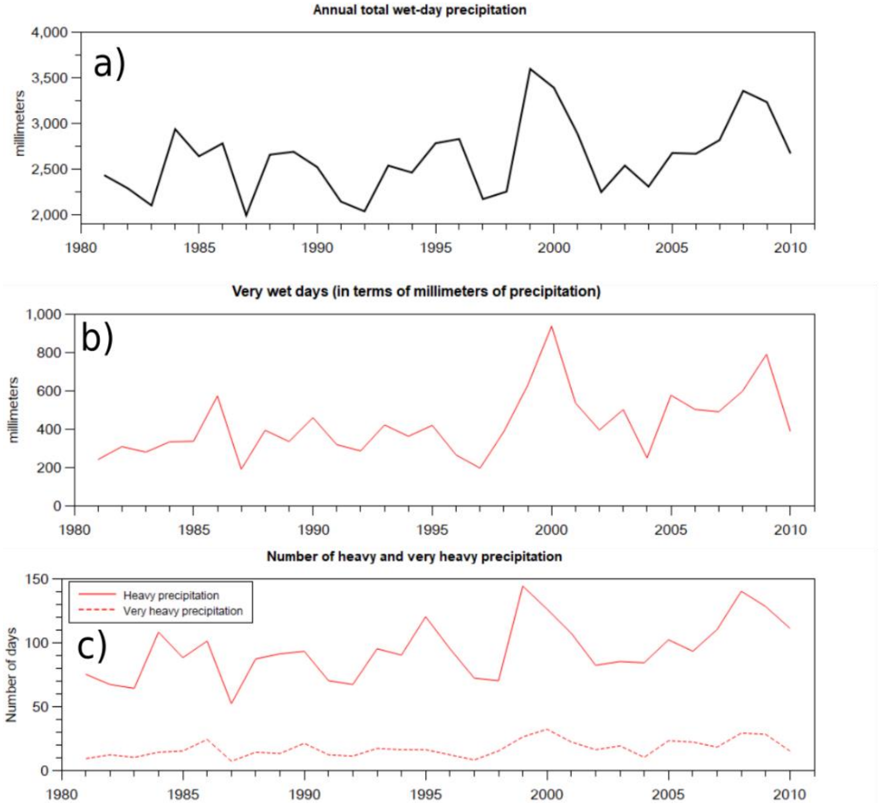
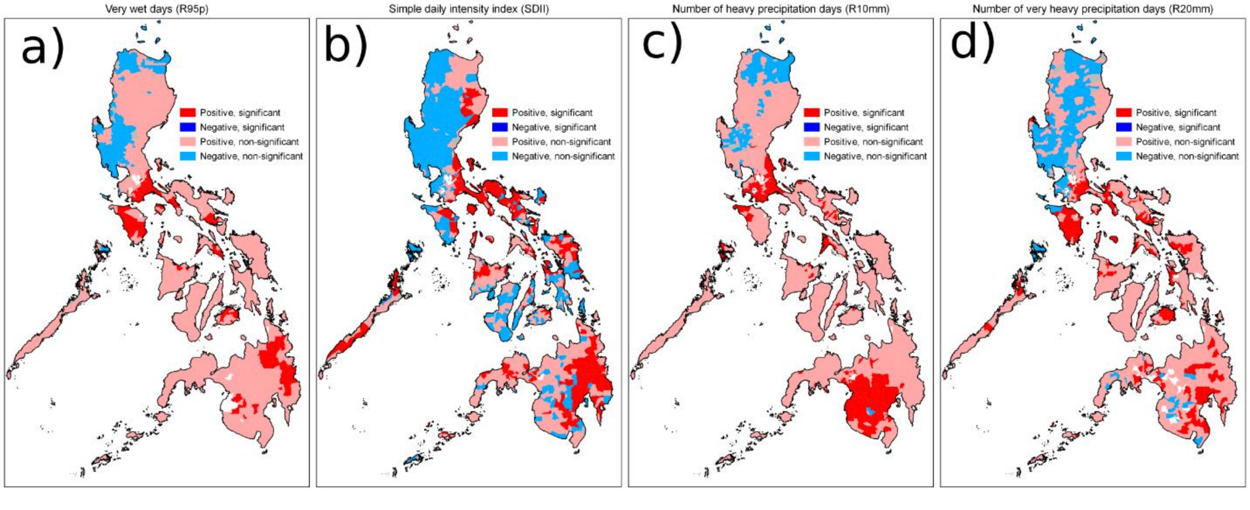


Figure 3.8. Trends at municipality level for (a) very wet days, (b) simple daily intensity index, (c) number of heavy precipitation, (d) and number of very heavy precipitation days over 1981 – 2010. Blue and red shades represent decreasing and increasing trends, respectively. Dark and light shades statistically significant and non-significant trends, respectively.



3.3.2 Slow onset events

The main slow onset event considered in our study is drought. We use the Standardized Precipitation and Evapotranspiration Index (SPEI) (Vicente-Serrano et al., 2010), which allows for comparison of drought conditions across different geographic areas and across multiple time scales. SPEI estimates drought conditions based on the balance between water input as rainfall and the evaporative capacity of the atmosphere. It is commonly accepted that drought develops across and has impacts at different time scales (McKee et al., 1993), and the time between the arrival of rainfall (i.e. water input), and the availability of the water resources for different uses (e.g. agriculture, irrigation) has important implications. The accumulation of water deficit across different time scales becomes extremely important. SPEI accounts for this by considering the water balance several months (time window) prior to a given month. We included SPEI for each municipality over the period 1981 – 2010 for time windows of 3 – 24 months.

Figure 3.9 illustrates moisture stress based on SPEI across the Philippines during the April 2005 (roughly the end of the dry season) over different time scales. Water deficit across different time scales (i.e. months prior to the current month) can be seen across northern and southern Luzon, especially between 6 and 24 months before the current period. Conversely, SPEI did not indicate moisture stress conditions over western Luzon across the different time windows, and it is remarkable that over the 3-month time window most of the island of Luzon experienced no drought conditions. A similar spatial pattern can be seen over Mindanao, which did not experience drought to the west of the island for time scales > 9 months. Like in the case of Luzon, most of the Visayas islands group experienced drought conditions across all time scales, except beyond 9 months across Negros and part of Cebu.

Trends in dryness across the country using SPEI showed (statistically) significant positive trends across most of the country at 1-month time scale, which indicated that country has seen less water deficit at monthly scale during the study period (Figure 3.10a - c). At longer time scales, and especially for 9 months and beyond, the trends across the country are also positive but non-significant (Figure 3.10d – g).

Figure 3.9. Spatial distribution of drought conditions over Philippines for April 2005 over 1 – 24-month time windows, based on the standardized precipitation and evapotranspiration index (SPEI). More negative values (brown shades) indicate stronger water deficit derived from decreased rainfall and/or increased temperature (i.e. evaporative capacity of the atmosphere). More positive values reflect water excess.

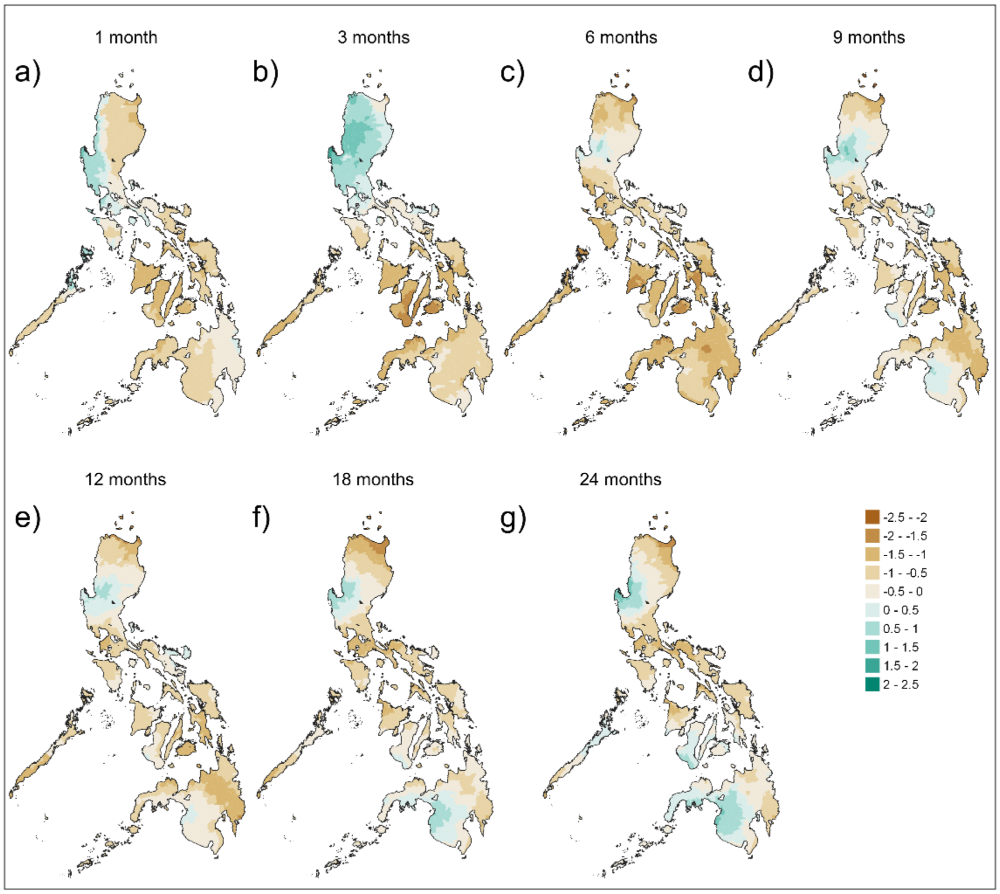
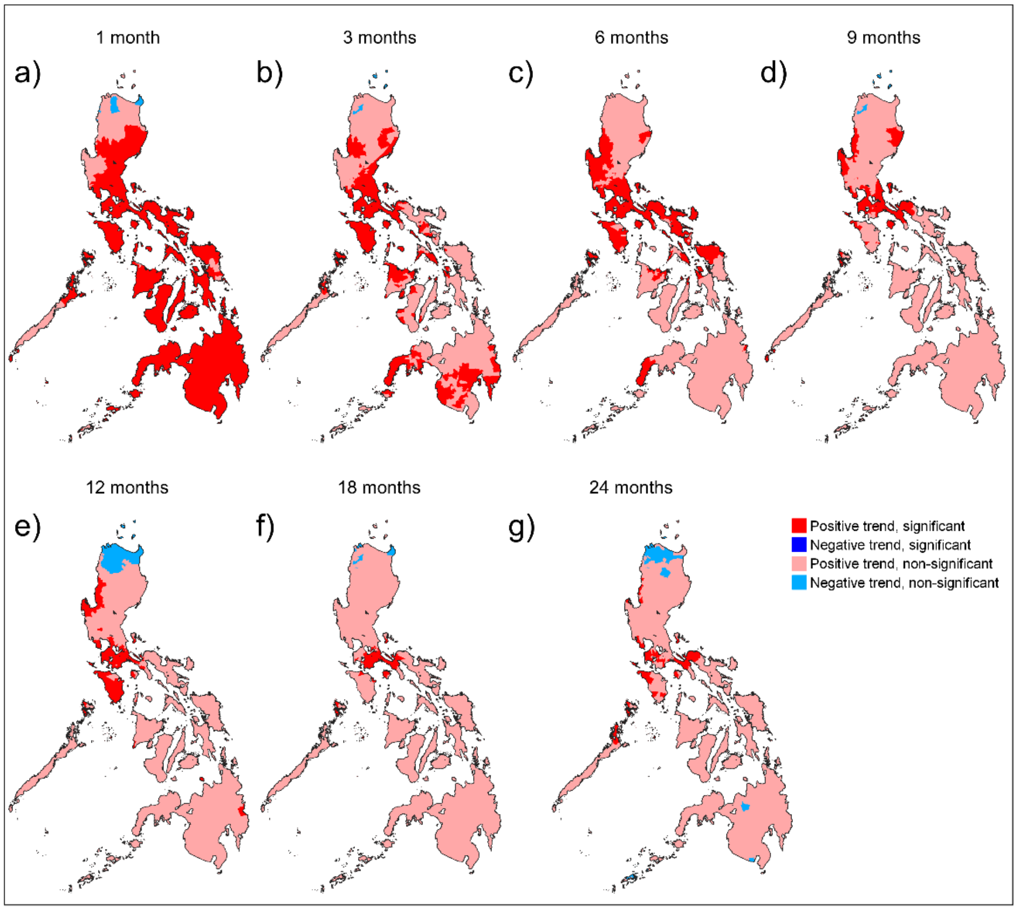


Figure 3.10. Spatial distribution of drought trends as reflected in the standardized precipitation and evapotranspiration index SPEI for the period 1981 – 2010, over time scales of 1 – 24 months. Red shades indicate increasing trend in SPEI (wetter conditions) and blue shades indicate decreasing trend (drier conditions). Dark and light shades represent significant and non-significant trends, respectively, at 5% significance level.



3.3.3 Climatological conditions

To account for the importance of the intensity and frequency of extreme weather events, and/or of their cumulative effects, on migration, relative to the long-term climate context of a given location, we included estimates of the current climate conditions (average over 1970 – 2000) of rainfall and temperature for each municipality. We used the version 2 of the WorldClim database (Fick & Hijmans, 2017), which consists of monthly means of precipitation and temperature calculated over the period 1970 – 2000, calculated from observations and interpolated at a horizontal resolution of 1 km. Derived from these average conditions of precipitation and temperature, we incorporated in our models a suite of ecologically relevant variables (bioclimatic variables; Table 3.5) that express annual trends, seasonality and extreme or limiting environmental conditions at a given location.

Table 3.5. Bioclimatic variables are derived from the monthly mean temperature and rainfall values.

Annual Mean Temperature	Mean Temperature of Coldest Quarter
Mean Diurnal Range (Mean of monthly (max temp - min temp))	Annual Precipitation
Isothermality	Precipitation of Wettest Month
Temperature Seasonality (standard deviation ×100)	Precipitation of Driest Month
Max Temperature of Warmest Month	Precipitation Seasonality (Coefficient of Variation)
Min Temperature of Coldest Month	Precipitation of Wettest Quarter
Temperature Annual Range	Precipitation of Driest Quarter
Mean Temperature of Wettest Quarter	Precipitation of Warmest Quarter
Mean Temperature of Driest Quarter	Precipitation of Coldest Quarter
Mean Temperature of Warmest Quarter	

3.3.4 Ancillary data

Extreme weather events, in particular heavy precipitation events, are commonly associated with natural disasters such as landslides and floods when combined with certain topographic conditions. To account for potential interactions between extreme weather and terrain conditions we included information on average elevation and slope in the models at municipality level in our migration models. Our estimates were based on a digital elevation model (1 km horizontal resolution) obtained also from WorldClim version 2. Figure 3.11 shows that the highest slopes and elevation in the country are located along the Cordillera Central in northern Luzon. Coastal municipalities along eastern Luzon show moderate-to-high slopes, due to these provinces extending across the Sierra Madre mountain range. These areas did not coincide with the areas that exhibited significantly increasing rainfall extremes that were identified particularly in Mindanao (Figure 3.6), in particular in the number of heavy precipitation rates. Some municipalities in Mindoro, however, exhibited moderate-to-high slopes and were collocated with areas showing increasing trends in rainfall intensity during very wet days, and in the number of very heavy precipitation days.

Weather extremes can have negative impacts on agricultural production, food prices and consequently threaten rural livelihoods. Crop failures or yield losses associated with extreme weather, thus, can be a driver migration processes. However, there may be differential responses from the farmers depending on the crops they grow, which can be more or less resilient to extreme weather conditions. To account for this we used land cover data[7] to calculate the share of perennial or annual crops at municipality level. Figure 3.12 illustrates that municipalities with ≥ 80% of annual crops cover most of northern Luzon, Mindoro, Panay and Negros and central Mindanao. Conversely, municipalities with higher share of perennials (≥ 80%) extend across southeast Luzon, most of the Visayas islands group, and eastern and western Mindanao. Municipalities mostly devoted to annual crops in Mindanao coincide with areas with significant warming trends (lower number of cool days and nights) (Figure 3.6a, b). Similarly, a large number of municipalities where annual crops dominate in Luzon and Mindanao also have experienced an increasing number of warmer days and nights (Figure 3.6c, d).

---

[7] Land cover map from the National Mapping and Resource Information Authority (2015).

Figure 3.11. Average terrain slope (a) and (b) elevation across the municipality.

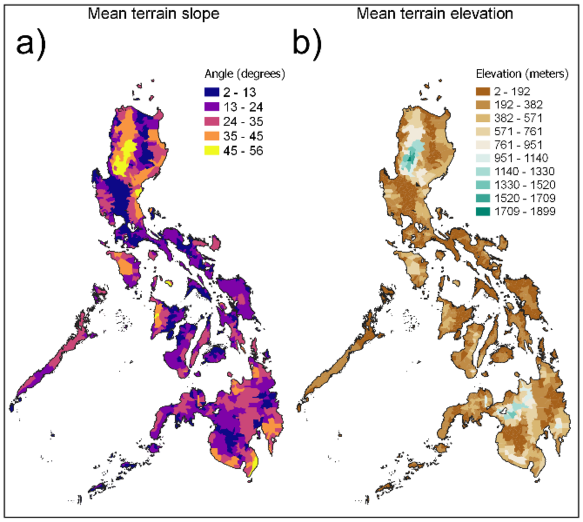
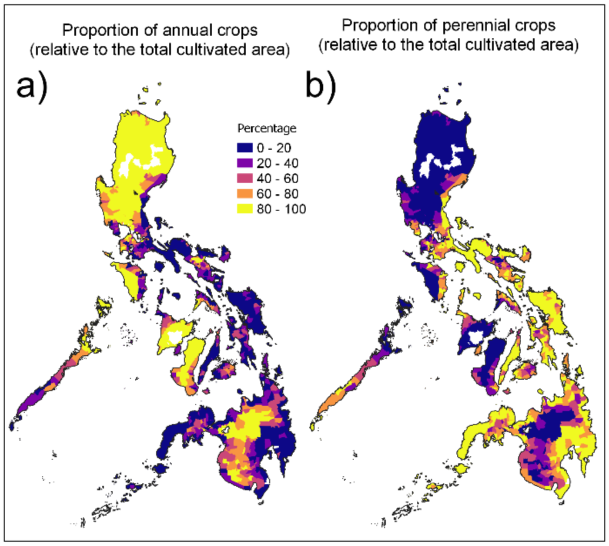


Figure 3.12. Distribution of areas cultivated with (a) annual and (b) perennial crops.



4 Empirical Analyses

Our empirical analyses are framed around three main questions.

Question 1. The first is a simple analysis of out-migration rates at the municipality level. **Do changes in climate factors in the pre-migration period help us explain out-migration rates**? To do this, we shift all migrants back to their old municipality—taking advantage of this unique attribute in the Philippines 2010 census[8]—adding them to the sample of people who remained. This allows us to look at how changes in weather patterns *within* that municipality affected outmigration rates, irrespective of destination. Across our sample of 1,273 municipalities, these rates varied from zero to 11 percent, with a mean of around 2.5 percent. Different versions of these models were run to identify effects of climate variability on the total out-migration rate, and on out-migration rates of people aged 20-34, 35-49 and 50+.

One of the limitations of the first approach is that it only looks at out-migration rates, ignoring how movement is also contingent on having a place to go. In other words, even if climate variability appears to be a threat, potential migrants need to be relatively sure that they are going to a better place. This implies knowing something about the relative characteristics of a given place of origin and the larger set of *potential* destinations.

Question 2. The second key question taps into this line of thinking. **How much is the strength of a particular migration stream between a given municipality of origin (in 2005) and a given destination (in 2010) affected by their relative climatological characteristics (e.g., heat, precipitation, drought) in the pre-2005 period?** The 1,273 municipalities yield approximately 1.6 million possible combinations of origin and destination (1273^2-1273). Unsurprisingly, given that migration streams tend to follow existing migration patterns and concentrate on particular origin-destination pairs, most of these have zero out-migration in the 10% sample. Nonetheless, there is considerable variation and this information can be used to better understand if and how specific climate factors are driving population movements.

Question 3. The third question moves the analysis down to the individual- and household-level: **How much do climate factors affect help us explain an individual's probability of migration, and if so, how does this vary by age, gender, education, employment and marital status?** There are clear advantages to conducting an analysis at this level: it most accurately conforms to the level at which migration occurs. There is, however, one important disadvantage: we cannot prospectively identify the effects of personal characteristics on the likelihood of migration in our data. Instead, the census describes individual and household characteristics in 2010, which is *after* the migration has occurred. Although this timing issue does not affect things like age and gender, it requires certain assumptions about the relative stability of characteristics such as education and employment over time. Likewise, we can only look at the effects of marital status for those who have been married for more than 5 years.

In answering all three sets of questions, we systematically compared the full array of indicators of climate variability, both in terms of cumulative effects over the preceding year, 3 years and five years, and those cumulative measures relative to a prior 12-year period. As described earlier, these allow us to comprehensively characterize the effects of climate factors on internal migration in the Philippines in the 2005-2010 period.

---

[8] The 2000 census asked about province of origin so we cannot replicate this analysis at the same level of detail on those older data.

4.1 General modeling approach

To answer the first two set of questions, we specified a series of negative binomial regressions. These are much better suited to the measures of out-migration at the municipality-level since the distribution of the latter is characterized by a long right tail. Tests for overdispersion confirm that the negative binomial regression is better suited to these data than a more standard Poisson model.[9]

Models in the first series—analyses of out-migration rates—run through the array of climate variables, measured cumulatively across one and three years prior to the migration window, as well as in terms of change in each of these relative to the preceding 12 years. All models also include controls for the share of cultivated land devoted to annual crops, the share devoted to perennials, the share of individuals who are involved in agriculture as skilled workers, the share who work as professionals or managers, and our index of change in the number and severity of earthquakes (the latter measured at the provincial level). Together, these controls are intended to capture the level of dependence on different types of agriculture, the diversification of the municipalities' economy into more white-collar employment opportunities, and the impacts of sudden-onset disasters that drive outmigration.

All models in the second series—analyses of specific migration streams—focus on the effects of relative climate characteristics in origin and destination municipalities in the period prior to 2005. All models also include controls for the Euclidean distance between the municipalities, and differences in the following indicators: the average precipitation and temperature in the 1970-2000 period; the number of earthquakes of given severity over the 2000-2004 period; the percentage of residents that are skilled agricultural workers; the percentage of residents working as managers or other white-collar professionals; and household wealth (as measured by assets). These controls are intended to capture other factors that may either attract or deter potential migrants over and above any effect of climate factors. This is particularly important for urban areas—which we capture with the agricultural variables—since cities are often built in areas susceptible to specific impacts of climate change such as sea level rise.[10]

To answer the third set of questions we use a logit regression model to examine out-migration at the individual level. Here, in addition to the array of climate controls we specify a series of interactions with age, and estimate discrete regressions for men and women. Extensions of these models also look for variation by educational and employment status though, as mentioned above, these make assumptions about the relative stability of those characteristics.

---

[9] We replicated our basic models in the second set of regressions using a 2SLS framework, in which the first equation looked at selection into having an outmigration rate >0, explained by within-municipality changes in climate factors, and the second looked at the actual outmigration rate (logged) from one municipality to another, explained by relative climatological characteristics in those two places. Since there were no substantive differences between these 2SLS models and the more straightforward nbreg models, we present the results of the latter. The robustness of our results to model specification augment our confidence in our analytical approach.

[10] Cities are not randomly placed. Port cities are, by definition, by the coast, or a little upriver from the coast. Older inland cities were always built close to water sources. Colonial-era cities in tropical climates were built in higher-altitude zones to escape malaria and low-altitude discomfort in general. Once established, there is a path dependence to cities' growth. The result is that cities, especially in rapidly growing developing countries, have often expanded rapidly in spite of being in climatological settings that are less-than-ideal. The few attempts around the world to change this—e.g., moving Nigeria's capital from Lagos to Abuja, or Tanzania's from Dar es Salaam to Dodoma—have been relatively unsuccessful in terms of generating large scale movement of people or capital to those new places.

4.2 Outmigration rates: Municipality-level analyses

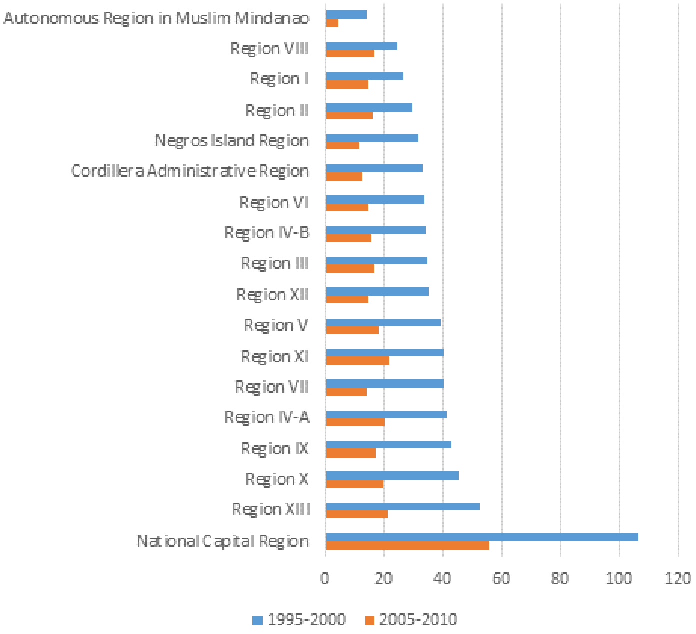
The first set of analyses is conducted at the municipality level and addresses the extent to which climate factors in the pre-migration period help us explain outmigration rates? We begin by pointing to core trends and establishing baseline models. We then systematically add different types of indices reviewed in Section 3.3.

4.2.1 Baseline trends

Figure 4.1 presents the number of interprovincial migrants in the 1995-2000 and 2005-2010 period, per 1,000 residents at the start of those 5-year periods. These are crude out-migration rates. They do not control for rates of in-migration or differences in age structure; however, because they are per 1000 they control for population sizes of the municipality. Two observations stand out. First, and not surprisingly, there is significant variation across regions in the rates of out-migration. In both periods, National Capital Region is the clear outlier in terms of magnitude of out-migration. More than 10 percent of its residents in 1995 had moved out of the province by 2000.[11]

Second, consistent with the national trends described in the previous section, these rates of interprovincial out-migration fell significantly from 1995-2000 to 2005-2010. Across the whole sample, the average reduction—weighted by the municipal populations—was 53.4 percent. This ranged from a 70 percent reduction in the Autonomous Region in Muslim Mindanao, which already had the lowest outmigration rates in the late 1990s, and by the 2010 census had fallen to around 4 out-migrants per 1000, to a mere 31.9 percent reduction in Region VIII (Eastern Visayas).

Figure 4.1. Number of interprovincial out-migrants per 1,000 residents in 5-years following 1995 and 2005.



---

[11] Note that NCR also stands out as one of the top net migrant-losing regions (together with Calabarzon) in the NMS (PSO 2019).

Understanding this variability across regions and across time is important, both conceptually and in terms of building an appropriate model. Out-migration patterns across these two periods are highly correlated—0.96 at the regional level—which in itself suggests that short-term shifts in climate variability have only a marginal effect on migration. As discussed in the literature review, other factors, including the strength of the "culture of migration" in a given place, and potentially longer-term changes in climate variability, have much stronger effects. We tease out some of these below.

4.2.2 Baseline models: Effects of prior geographic characteristics

We begin by addressing the question of how much out-migration is affected by prior geographic characteristics of a given municipality. Some of these characteristics are fixed "endowments": its susceptibility to earthquakes; whether it is coastal; its elevation; the mean slope of its terrain. Others are the product of prior investments. These include how much the cultivated land is devoted to annual or perennial crops.

Table 4.1 shows that there are some high correlations between some of these, which underscores the difficulty of identifying their individual effects on migration. For example, terrain elevation is highly correlated (0.71) with the slope of the terrain; the slope is also somewhat correlated (0.15) with a municipality being coastal; coastal is positively correlated (0.32) with the cultivation of perennial crops, with having experienced more earthquakes in the 2000-2004 period than during the 1990s (0.21), and negatively (-0.41) with the cultivation of annual crops; and coming full circle, the latter are much less a focus of agricultural activity in steeper municipalities (-0.53), but much more likely to be grown in areas that experienced an increase in earthquakes.

Table 4.1. Pearson correlation coefficients between selected municipality characteristics (N=1270).

	Difference in earth-quakes 2000/04 – 1990/99	Coastal municip.	Mean slope of terrain	Mean terrain elevation	Annual crops as % cultivated land
Difference in earthquakes--2000/04:1990/99					
Coastal municipality	0.211				
Mean slope of terrain	0.027	0.151			
Mean terrain elevation	-0.082	-0.213	0.709		
Perennial crops as % cultivated land	-0.278	-0.406	-0.529	-0.208	
Annual crops as % cultivated land	0.371	0.320	-0.001	-0.133	-0.467

Table 4.2 presents results from a series of three models which, respectively, look at the effects of all four fixed endowments on out-migration rates (per 1,000), then add the measures of annual and perennial cultivation, then retain the combination of variables necessary to maximize model fit. As described above, we estimate these models using negative binomial regression, correcting the standard errors to control for clustering within provinces.

Table 4.2. Baseline covariates (standard errors) of municipality out-migration rates, 2005-2010.

	Fixed characteristics (1)	Add land use (2)	Combined (3)
Difference in earthquakes--2000/04:1990/99	0.0096	0.0041	
	(1.78)	(0.74)	
Coastal municipality	-0.0992	-0.164*	-0.155*
	(-1.36)	(-2.55)	(-2.33)
Mean slope of terrain	-0.0047	-0.0118	-0.0130**
	(-0.59)	(-1.29)	(-2.91)
Mean terrain elevation	-0.00014	-0.00005	
	(-0.32)	(-0.12)	
Annual crops as % of cultivated land		-0.0052**	-0.0054**
		(-2.87)	(-3.06)
Perennial crops as % of cultivated land		0.0004	0.0006
		(0.26)	(0.47)
_cons	3.456***	3.720***	3.720***
	(35.92)	(20.68)	(21.96)
Lnalpha	-0.890***	-0.918***	-0.919***
	(-4.59)	(-4.52)	(-4.50)
N	1270	1270	1274
Wald test (d.f.)	8.05 (4)	21.66 (6)	19.8 (4)

Notes: Estimated in negative binomial regression

Levels of statistical significance: *** 0.001; ** 0.01; * 0.05

Results show outmigration rates are lower in municipalities on the coast (57% of cases), lower in hillier municipalities, and in those with a higher percentage of cultivated land devoted to annual crops. Other variables, including the percentage of cultivated land devoted to perennial crops, the change in the number of earthquakes over time (shown in models 1 and 2), or the absolute number and strength of earthquakes (not shown), have no independent effects on rates of out-migration.

Municipalities also vary in a number of other ways that are relevant to out-migration. One is overall size. Whether rural-urban migration is directed toward mega-cities or smaller second- and third-tier cities, circular patterns of migration imply that there should be some movement out of cities, especially at older ages. In addition, the higher rate of growth of smaller cities over the last 20 years implies that there could also be some level of out-migration from the largest municipalities, since these are closely associated with the largest urban areas.

Another factor is the percentage of the population considered indigenous. The population of the Philippines is highly heterogeneous in terms of ethnicity—more than 170 discrete ethnic groups are coded in the census, and a number of these have official status as indigenous.[12] This has implications for these groups' own migration patterns—whether because of language skills, other types of human capital, or cultural preferences. It also has implications for migration into and out of areas associated with indigenous groups.

Table 4.3 presents results from models that estimated the effects of municipality size and proportion indigenous on outmigration rates, adding indicators of these two characteristics to model 3 in the preceding table. It also specifies discrete models by age-group: 15-29, 30-49, 50+, and across all ages.

Table 4.3. Covariates of municipality outmigration rates, 2005-2010, by age.

	15-29 (1)	30-49 (2)	50+ (3)	all ages (4)
Coastal municipality	-0.028	-0.143	-0.204*	-0.114
	(0.075)	(0.076)	(0.087)	(0.064)
Mean slope of terrain	-0.012**	-0.018***	-0.022***	-0.013***
	(0.004)	(0.005)	(0.006)	(0.004)
Annual crops as % of	-0.002	-0.006**	-0.009***	-0.005**
cultivated land	(0.002)	(0.002)	(0.002)	(0.002)
Perennial crops as % of	0.003*	0.0002	-0.003*	0.002
cultivated land	(0.001)	(0.001)	(0.001)	(0.001)
Populous municipality[1]	0.045	0.105	0.257***	0.135*
	(0.060)	(0.061)	(0.069)	(0.058)
Proportion indigenous				
(Reference category: the lowest quartile)				

---

[12] The National Commission on Indigenous Peoples (NCIP) lists 109 indigenous ethno-linguistic groups and sub-groups. We use the list in IFAD 2012 to control for the effects of indigenous status on out-migration.

- Second quartile indig.	0.163*	0.212**	0.174	0.161*
	(0.075)	(0.082)	(0.103)	(0.071)
- Third quartile indig.	0.282**	0.343***	0.330**	0.277***
	(0.088)	(0.093)	(0.109)	(0.083)
- Highest quartile indig.	0.253**	0.281**	0.380***	0.274**
	(0.095)	(0.093)	(0.094)	(0.092)
Constant	3.390***	3.053***	2.719***	3.434***
	(0.184)	(0.197)	(0.226)	(0.169)
lnalpha	-0.731***	-0.846***	-0.316*	-0.963***
	(0.159)	(0.154)	(0.131)	(0.196)
R-squared	0.0056	0.0133	0.0157	0.0098
N	1274	1274	1274	1274
Wald (8 d.f.)	23.81	26.14	61.44	40.44

Notes: Estimated in negative binomial regression

Levels of statistical significance: *** 0.001; ** 0.01; * 0.05

[1] Top 20% of municipalities in terms of population

Results highlight three main findings. First, out-migration rates are higher from the largest municipalities, but this effect is almost completely driven by people aged above 50, which is consistent with circular migration patterns described above.

Second, out-migration rates rise with the percentage of the municipality's population categorized as indigenous. Note that across these data, only 8.4 percent of individuals are categorized as indigenous, so this effect is likely to be driven by out-migration of non-indigenous residents of these municipalities. This hypothesis is tested and confirmed below in our analyses of individual-level data.

Third, and more generally, there are some significant differences in the effects of the original baseline variables—fixed endowments and types of cultivation—across different age groups' out-migration patterns. The rate of out-migration from a coastal municipality falls with age. The relationship to different types of cultivation is also highly dependent on age. As the percent of cultivated land devoted to annual crops rises, out-migration rates fall more sharply at older ages (50+) than prime-age (30-49), and not at all among the young. Most interesting: the percent of cultivated land devoted to perennial crops is *positively* associated with out-migration rates of 15-29 year olds, but *negatively* associated with out-migration rates of people older than 50 (each of these effects statistically significant at the 5% level). These completely different age patterns account for the lack of statistically significant effect in the combined model for all-ages.

4.2.3 Effects of 1970-2000 patterns of temperature and precipitation on outmigration rates

Our first series of climate-specific models adds historical indicators of precipitation and temperature to the baseline "all ages" model (model 4) in Table 4.3, then replicates these on each of the age-specific out-migration rates: 15-29, 30-49, and 50+.

The variables used in these models was described in section Table 3.3 of this report and cover a range of mean and extreme values, all averaged across the 1970-2000 period. The central goal of these models is to see whether, net of the baseline characteristics identified in Table 4.3, out-migration rates in the 2005-2010 period can be linked to long-term climate characteristics that are relatively fixed, their extreme values or unusual years having been smoothed over by the process of averaging trends across the 30-year period. For example, across the 1,274 municipalities in the Philippines, how are out-migration rates associated with higher precipitation, higher variation in precipitation, or higher maximum values of rain in a given month or quarter? And, how are they associated with equivalent temperature measures? Specifying a series of models across all available indicators allows us to comprehensively answer a subset of questions at the heart of this study. In turn, this lends itself to a secondary goal. Identifying which of these 1970-2000 measures has an effect on migration in the 2005-2010 period allows us to specify models looking at more recent shifts in climate characteristics with more confidence.

Full model results are presented across Appendices A and B. The first two tables in each appendix, 1 and *2*, focus on the all-age models. A1 and A2 contain 11 models, each with a control for mean annual precipitation while switching between the 11 available indicators of temperature. Tables B1 and B2 contain 8 models, each with a control for mean annual temperature while switching between the 8 available indicators of precipitation. This set of models is then repeated on each of the three discrete age-specific outmigration rates: 15-29, 30-49, and 50+.

Table 4.4. Statistically significant relationships between 1970-2000 climate variables and out-migration rates, 2005-2010, by direction of effect and climate domain. Full results in Appendix Tables A1-B8.

		Age-specific model: out-migration rates at		
Direction of effect	Domain	ages 15-29	ages 30-49	ages 50+
Positive	temperature	seasonality, maximum temperature of warmest month, mean temperature of warmest month	seasonality, maximum temperature of warmest month, and temperature annual range	
	precipitation	*no statistically significant effect*	precipitation of wettest month, wettest quarter and precipitation seasonality	precipitation of wettest month, wettest quarter and precipitation seasonality
Negative	temperature	isothermality[a]	isothermality[a]	isothermality[a]
	precipitation	*no statistically significant effect*	*no statistically significant effect*	Precipitation of coldest quarter

[a] Isothermality quantifies how the range of day-to-night temperatures oscillations relative to seasonal oscillations. See footnote 12.

Overall, our results highlight relatively weak direct effects of climate factors on out-migration. In the all-ages model, not one variable out of the 11 temperature and 8 rainfall variables from the 1970-2000 period has a statistically significant association with out-migration rates in 2005-2010. However, there are some effects in the age-specific models, summarized in Table 4.4 by climate variable domain—temperature or precipitation—and direction of the statistical relationship.

In general, we see stronger effects of temperature variables. Across all three age groups, out-migration rates in the 2005-2010 period were higher in municipalities that experienced higher seasonality in terms of temperature, and higher maximum temperatures in the warmest months. In all three age groups they were also lower in municipalities with higher levels of isothermality.[13] Out-migration rates above age 30 were also positively associated with a greater annual range of temperature—correlated with higher seasonality and maximum temperature.

None of the 1970-2000 measures of precipitation had a statistically significant association with the 2005-2010 outmigration rates of 15-29 year olds. Rates among those older than 30 were positively associated with the magnitude of rainfall in the wettest month and quarter, and with the level of seasonality in precipitation.

A final set of models was specified to check whether the association between climate variables in the 1970-2000 period and 2005-2010 out-migration rates are different in coastal as opposed to inland municipalities. This hypothesis addresses the concern that sea-level rise may potentially and disproportionately affect out-migration in low-lying coastal areas. We focus on the all-ages out-migration rate. Across the 19 models, there was only one statistically significant interaction term between climate variables and coastal municipality indicator. The annual temperature range is positively associated with out-migration rates in coastal municipalities, but not in inland municipalities.

Overall, our large set of models shows that historical patterns of temperature and precipitation are only weakly associated with out-migration rates in the 2005-2010 period. Where there are associations, they are not between out-migration rates and annual means or totals of climate variables —e.g., mean total rainfall or mean annual temperature. Rather, the out-migration rates are associated with measures that tap into more extreme values like higher maximum temperatures and the magnitude of rainfall in the wettest months. Each of these also increases within-year variation and seasonality. In terms of temperature, it also reduces isothermality (since an increase in the maximum monthly temperature without an equivalent increase in the minimum temperature raises seasonal oscillations relative to day-to-night oscillations).

Finally, even in those models where individual measures of climate characteristics in the 1970-2000 period have a statistically significant association with 2005-2010 out-migration rates, they hardly add to the explanatory power of the model. The pseudo-R^2 is hardly affected, remaining on a paltry 1.35 percent level in the ages 15-29 models, 1.34 percent in the 30-49 models, and a marginally higher 1.58-1.64 percent range in the ages 50+ models.

---

[13] Isothermality quantifies how the range of day-to-night temperatures oscillations relative to seasonal oscillations. Formally, it is equivalent to the (mean annual diurnal range/annual temperature range) x 100, where the diurnal range is the mean of monthly maximum temperature minus minimum temperature, and the annual temperature range is maximum temperature of warmest month minus minimum temperature of coldest month. In these data, this index ranged from 54.7 to 88.5, characteristically below 100 as is the norm for tropical areas.

4.2.4 Effects of 1992-2003 cumulative patterns of temperature, precipitation and drought on out-migration rates

Are the relatively weak effects of 1970-2000 climate variables on out-migration the result of an inappropriate time scale? As noted in the first sections of this report, there have been notable oscillations in a number of climate factors over the last few decades. Arguably, even if measures smoothed over the entire 1970-2000 period are good enough to identify *very* slow onset impacts of climate variability on migration, they may dull our ability to identify any effects of slightly faster impacts, like those that accumulate over the final 10 to 15 years of that time period.

In order to test whether this is the case, we specified a second series of models linking out-migration to measures of climate variability, but now focused on variables that:

a. are more oriented to unusual or extreme values (Table 3.3). They include lengthy periods of rainfall (or lack thereof), its magnitude, the number of cool days or cool nights, warm days or warm nights, and a number of maximum and minimum values. They also include the standardized precipitation evapotranspiration index (SPEI), with calibrations across 1, 3, 6, 9, 12, 18 and 24 month periods.
b. cover a more recent time period—Each of these measures is estimated across the 12-year period beginning January 1992 and ending December 2003. In other words, they cover the period immediately prior to the migration window in the IPUMS data, therefore are expected to affect migration decisions more significantly compared to distant past.

As before, the models are fit using negative binomial regression and include measures of both precipitation and temperature in each model. In the precipitation and drought models, the control is the diurnal temperature range; in the temperature models, the precipitation control is the simple daily intensity index (SDII). Given differences across age-groups documented in Table 4.4, we focus on discrete age-specific models.

Full results are available in Appendices C (precipitation models), D (temperature models) and E (drought models). We summarize the key substantive results in Table 4.5, and discuss two main findings.

Table 4.5. Statistically significant relationships between 1992-2003 climate variables and out-migration rates, 2005-2010, by climate variable domain and direction of effect. Full results in Appendix Tables C1-E8.

		Age-specific model: outmigration rates at		
Direction of effect	Domain	ages 15-29	ages 30-49	ages 50+
Positive	temperature	Monthly max. value of daily max. temperature	Number of cool days	Monthly max. value of daily max. temperature
	precipitation	Simple daily intensity index (mm/day)	Simple daily intensity index (mm/day)	*no statistically significant effect*
	drought	5/7 SPEI variables[a] (calibrations 6-24 months), cumulative num. dry days	5/7 SPEI variables[a] (calibrations 6-24 months), cumulative num. dry days	4/7 SPEI variables[a] (calibrations 9-24 months), cumulative num. dry days
Negative	temperature	*no statistically significant effect*	*no statistically significant effect*	*no statistically significant effect*
	precipitation	*no statistically significant effect*	*no statistically significant effect*	*no statistically significant effect*
	drought	1/7 SPEI variable (calibration 1 month)		1/7 SPEI variable (calibration 1 month)

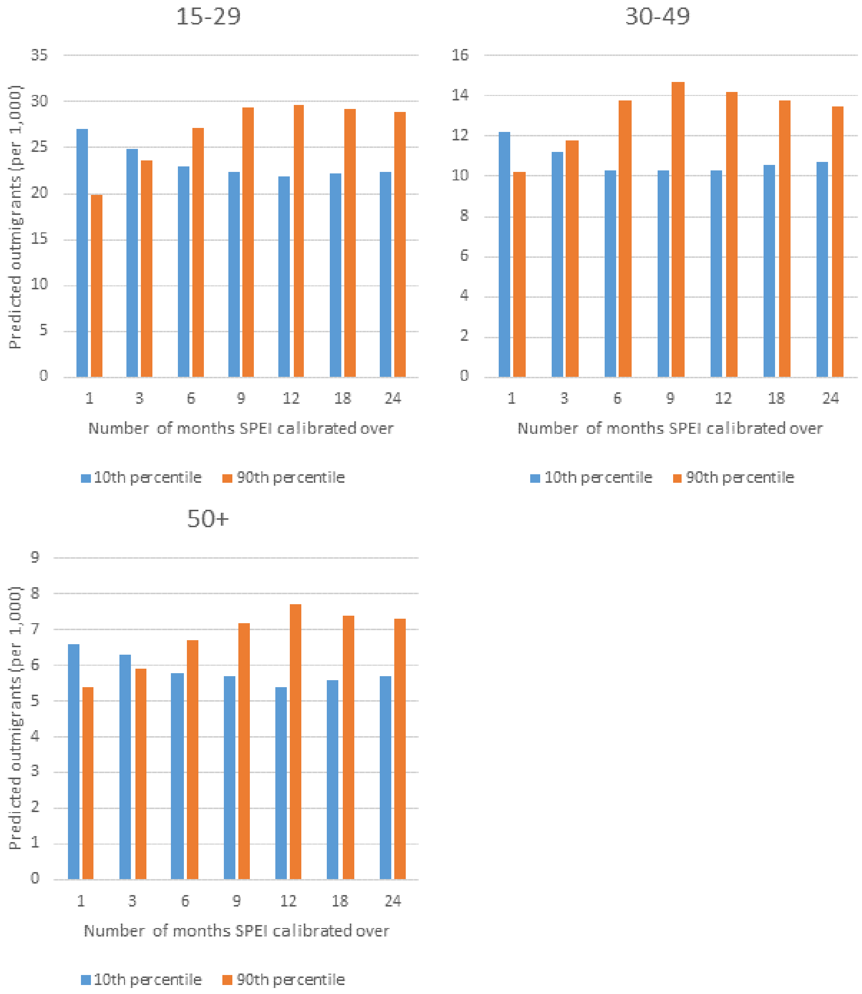
[a] SPEI is the Standardized Precipitation and Evapotranspiration Index. In the version employed here, a positive value points to a higher likelihood of drought. See section 3 in the text.

First, in terms of measures of temperature and precipitation, effects are relatively thin. Of the seven discrete indicators in the temperature domain, only one had a statistically significant positive relationship with each of the age-specific out-migration rates: in the 15-29 and 50+ age groups, this was the monthly maximum value of the daily maximum temperature, an indicator of changing upper extreme value in temperature. The same 1/7 success rate can be seen in the precipitation models. In this case, it was the simple daily intensity index. Likewise, none of these 14 temperature and precipitation variables of interest were negatively associated with any of the three age-specific outmigration rates.

Second, in contrast to the thinness of these precipitation and temperature variables' empirical performance, cumulative drought measures across this 12-year period are much more strongly associated with out-migration rates, and they have relatively uniform effects across age-groups. All calibrations of SPEI between 9 and 24 months are positively associated with out-migration rates at all ages. However, the 1-month calibration is *negatively* associated with out-migration rates in the 15-29 and 50+ age groups.

These are statistically powerful and substantively important effects. To get a sense of their magnitude, we generate a series of predicted outmigration rates from these models for municipalities that fall in the 10th and 90th percentile in terms of their 1992-2003 SPEI indices. The calculation of these "marginal effects", replicated over each model, allow us to compare how different SPEI calibrations—essentially a time horizon over which the index is calculated—are associated with subsequent out-migration rates.[14] Results are graphed in Figure 4.2.

Figure 4.2. Influence of the drought conditions on migration rates. Cumulative effects of drought over 12 months prior to the migration event and over 1 – 24-month time windows.



The overall pattern of predicted SPEI effects on subsequent out-migration across different time windows is similar in all three age-groups. The shortest-term calibration is associated with lower out-migration rates in municipalities experiencing more drought. Specifically, moving from the youngest to the oldest of these three age groups (net of all other variables in the model), out-migration is, respectively, 27, 16, and 18 % lower in municipalities that, between 1992 and 2003, suffered the most intense droughts (i.e. in the 90th percentile for SPEI) than in those that suffered the least intense droughts (i.e. in the 10th percentile). This difference is, therefore, particularly pronounced among 15-29 year olds—the peak migration age.

---

[14] In each case, the calculations assume a coastal municipality that is not among the 20% most populous, and is in the lowest quartile in terms of indigenous residents. The value of other variables in the model—the diurnal range, and the percent of cultivated land devoted to annual or perennial crops—is set to the national mean.

However, with every additional month of calibration, municipalities that experienced more drought conditions had higher subsequent out-migration rates, with the difference peaking at a 9-month window for out-migration at ages 30-49 and a 12-month window for out-migration at ages 15-29 and 50+. At those peaks, out-migration rates in 2005-2010 were, respectively, 43, 35, and 43 percent higher in municipalities that, between 1992 and 2003, were in the 90th percentile for SPEI than in those that were in the 10th percentile.

4.2.5 Effects of the most recent changes in temperature, precipitation, and drought indices on outmigration rates

Table 4.6. Summary of effects of recent changes in selected precipitation, temperature, and drought variables on age-specific out-migration rates, by window of change. Direction of variables is marked if and only if they were statistically significant.

	1-year window of change (2004 relative to mean 1992-2003)			3-year window of change (mean 2002-2004 relative to mean 1990-2001)		
	ages 15-29	ages 30-49	ages 50+	ages 15-29	ages 30-49	ages 50+
Precipitation						
Consecutive wet days	positive***	positive***		positive*	positive**	
Annual total wet-day precipitation				negative**	negative***	negative**
Number of heavy precipitation days			positive***	negative**	negative***	
Number of very heavy precip. days				negative**	negative***	negative***
Very wet days				negative**	negative**	negative**
Extremely wet days				negative**	negative**	
Simple daily intensity index				negative*	negative***	negative***
Temperature						
Diurnal temperature range						
Monthly min. value of daily min. temp.		negative***				
Monthly max. value of daily max. temp.				positive**	positive*	
Number of cool days						
Number of cool nights						
Number of warm days	positive**	positive***		positive**	positive**	
Drought						

Consecutive dry days						
SPEI indices calibrated over:						
- 1 month			positive*		positive*	positive**
- 3 months				positive*		
- 6 months						
- 9 months		positive*	positive*			
- 12 months	positive*	positive***	positive***		positive**	positive**
- 18 months		positive*	positive**			
- 24 months						

Models thus far have addressed the associations between historical weather patterns—the first smoothed over the 1970-2000 period, the second over the 1992-2003 period—on migration in the 2005-2010 period. Both of these implicitly target "slow onset" effects: patterns that cumulatively affect out-migration. We now turn our attention to more recent shifts in weather patterns. Using the same temperature, precipitation, and drought indices employed in the preceding analyses (results summarized in Table 4.5), we estimate the effects of changes in each of those variables on out-migration. Since it remains an open question how big a window of time—in terms of factors driving migration decisions—potential migrants look at when deciding whether to migrate, we estimate recent change in both 1 and 3 year segments relative to the prior 12-year mean. That is, all indicators are measured in 2004 and compared to their mean for the 1992-2003 period—this is the 1-year window of change. A second measure of each indicator is then calculated for the 2002-2004 period and compared to the mean for 1990-2001—this is the 3-year window of change.

As before, the models are fit using negative binomial regression and include the same precipitation and temperature controls: diurnal temperature range in the precipitation and drought models; and simple daily intensity index (SDII) in the temperature models. We also retain the cumulative value of the variable of interest in each municipality—covering 1992-2003 and 1990-2001 across the two specifications—since that helps anchor the interpretation of change in that attribute.

The final modification to model structure is to add the provincial outmigration rate in the 1995-2000 period. Including this variable controls for unobserved factors that led to prior rates of out-migration, and that should be correlated with current levels. This includes factors typically associated with the "culture of migration", whether those affect the financial and psychological cost of moving (it is easier to move to a place where locals have already moved, as those existing networks offset cost or risk), or simply normative expectations).

A summary of analytical results—focused only on the change variables—is presented in Table 4.6. Each cell in the table represents a discrete model.

Results overall point to three main findings. First, our ability to identify the effects of recent changes in precipitation and drought indices on out-migration rates depends on the window of time within which we measure that change: 1 year or 3 years relative to the preceding 12. Here, for example, we see that the changes in precipitation have much stronger effects on out-migration rates where the window of change is measured across 3 years. In contrast, changes in drought indices have much stronger effects on out-migration rates where the window of change is measured across a single year (though only where that change is calibrated over at least 9 months).

Second, and more specifically, there are very pronounced effects of recent changes in excess rainfall on out-migration. Even though an increase in the number of consecutive wet days is positively associated with out-migration (both the 1 and 3-year window), all six variables measuring changes in the intensity of rainfall in 2002-2004 period, relative to the preceding 12 years, show that an increase in intense or heavy rainfall is associated with significantly lower out-migration rates. In four of these variables, this effect can be seen in all three age groups. In the other two measures, it can be seen in the 15-29 and 30-49 age groups.

Third, out-migration rates are mildly affected by changes in drought indices, with effects concentrated at ages above 30. In the 1-year window, we see a positive effect for longer calibrations. In the 3-year window, increases in both the 1 and 12 month calibrations—respectively, short- and longer-term measures—are associated with significantly higher out-migration rates.

4.2.6 Summary

In this section we have identified a number of different types of predictors of municipality-level out-migration rates in the 2005-2010 period: baseline; ancillary factors; average climate characteristics in the 1970-2000 period; more detailed measures of climate variability in the 1992-2003 period; and changes in those measures in the 1 and 3 years immediately preceding the migration window. To further sharpen our understanding, we have also distinguished the out-migration rates by age groups.

A number of important results emerge from these analyses. First, there are some important baseline factors affecting out-migration that need to be taken into account. Out-migration rates in general are lower in municipalities on the coast (57% of cases), in hillier municipalities, and in those with a higher percentage of cultivated land devoted to annual crops. They are higher in the most populous municipalities, but this effect is almost completely driven by people aged above 50, a pattern that is consistent with circular migration patterns. Out-migration rates also rise with the percentage of the municipality's population categorized as indigenous, though we show in the final series of analyses (section 4.4) that this driven by out-migration of non-indigenous residents of these municipalities. To the extent that climate variability differentially affects municipalities that vary on these ancillary characteristics, researchers must be careful not to misappropriate the cause of any change in migration.

Second, a long series of models shows that average patterns of temperature and precipitation in the 1970-2000 period are only weakly associated with out-migration rates in the Philippines over the 2005-2010 period. Where there are associations, they are not between out-migration rates and annual means or totals—e.g., mean total rainfall or mean annual temperature. Rather, the out-migration rates are associated with measures that tap into more extreme values like higher maximum temperatures and the magnitude of rainfall in the wettest months. There was no significant variation in these factors across coastal and non-coastal municipalities.

Third, among the measures of climate variability in the 1992-2003 period, temperature and precipitation indices had virtually no impact on out-migration rates. In contrast, higher drought indices measured across 9-24 month periods were positively associated with out-migration rates at all ages, implying a 30-40% difference in out-migration rates between municipalities that experienced less and more intense droughts.

Fourth, there are very pronounced effects of recent changes in weather patterns on out-migration rates. A substantial 3-year increase in rainfall intensity relative to the preceding 12 years is associated with significantly lower out-migration rates. And an increase in drought relative to the preceding 12 years is associated with significantly higher out-migration rates. This represents a shift from the prior set of models in which average measures of temperature and precipitation in the 1992-2003 period had virtually no association with out-migration rates.

Overall, these results highlight the importance of conducting these types of research in ways that diversify the range of indices, time scale over which they are measured, and number of observations over which any potential effects are measured. In total, the results of more than 150 models are reported in this section. In most of those models, the core variables of interest—the various climate indices—were not significantly associated with out-migration rates. That is particularly true in models that combined migration rates across all ages. Yet by differentiating age and layering different arrays of climate indices, we have identified some significant patterns associated with out-migration at the municipality level. In the next section we will document the extent to which differences in these factors appear to affect the strength of a particular stream of migration from a given point of origin to a selected destination.

4.3 Place to place analysis

Most of our analysis is focused on the impact of climate variables on out-migration streams from municipalities. Both descriptive analyses and the earlier models highlight variability in out-migration and are able to connect this variability to climate-related factors. While these insights enable us to explore climate variables as push factors, our causal insights can be deepened by complementing the out-migration analysis with models that utilize information on climate effects in both municipalities of origin and destination. The combination of information on origin and destination enables us to consider not only the decision to move but also to look more carefully on how climate factors influence destination choices.

We consider two distinct dimensions of climate factors to see how their relative values between origin and destinations may be impacting migration patterns. We include two indicators of heavy rainfall and two indicators to capture drought or drought-prone conditions. The rainfall measures include days with 10 or more mm of rain and days with 20 or more mm of rain in the preceding year (indicators 15 and 16, respectively, in Section 3, Table 1). The drought measures include the number of consecutive dry days (item 17, Table 3.3) and two variables from the Standardized Precipitation and Evapotranspiration Index (SPEI), one calibrated over 6 months, the other over 9.

Our analysis builds on the earlier municipality level models discussed in Section 4.2. We focus attention here primarily on the key climate variables. We continue using negative binomial model in our empirical analysis given the evidence of over-dispersion in all our dependent variables. An additional challenge arising in this analysis is that many migration streams have no occurrences. In total, there are around 1.5 million potential streams to be measured ($1{,}274^2$-1,274). Not surprisingly given that we are using 10% samples, most possible migration streams are not visible. In our analysis, the dependent variable is positive migration streams measured as the number of migrants from origin *i*, to destination *j*. These models follow on work done on gravity models, enabling us to explore the role of distance but in our case more relevant, the relative effects of climate variables on migration between origins and destinations.

We begin with a set of models where the climate factors are included as simple linear predictors. The measure of distance between the center of each municipality shows the well-recognized role of distance as a key predictor of migration flows (Ravenstein xx). We include past historical temperature (Ratio Hist Annual Temp) and rainfall (Ratio Historical Annual Rainfall), and find that temperature shows consistent negative correlations indicating that a 10% higher temperature in the destination municipality over the temperature in the municipality of origin is associated with a decline of about 0.05 migrants per 1,000 inhabitants. Similarly, the difference in rainfall between destination and origin is also negatively correlated with migration, suggesting that relatively higher historical rainfall levels in the destination are also associated with lower migration to these municipalities. Earthquakes are also deterrents to migration.

Several economic variables provide additional insights with unsurprising results. Migrants are drawn to destinations with relatively few unskilled laborers in comparison to where they are located. Interestingly, the effects of a differential in the share of skilled labor are not significant. A series of wealth indicators all point to the fact that migrants are selecting destinations with higher living standards. Higher shares of washing machines and internet availability both are positively related to destinations of choice. On the other hand, a higher share of cultivated land devoted to annual crops is associated with a less popular destination.

Turning to our main climate variables, a first set of models considers the role of intensity of precipitation using number of days with 10 or 20 more mm of rainfall. The results in Table 4.7 provide a useful first look at whether or not higher precipitation in the destination relative to the origin – a value greater than 1.0 – is associated with more or less migration to that destination from the origin. The results in columns (1) and (2) show that relatively high rainfall in destinations is associated with less migration to these destinations. This is true for both rainfall measures. More specifically, the coefficient on 10mm indicates that rainfall days that are 10% more in the destination relative to the origin are associated with a decline of 0.06 in the number of migrants per 1,000 from the origin to the destination. The same sized difference between destination and the origin in terms of 20mm days signals a decline of just under 0.02. Thus, destinations with excess rain do not appear to draw in migrants, rather the excess rainfall appears to reduce inflows.

Table 4.7. Results of the place-to-place models during the period 2005 – 2010 across all ages.

	(1)	(2)	(-3)	(-4)	(-5)
Distance	-0.00753***	-0.00752***	-0.00753***	-0.00755***	-0.00760***
	(0.000105)	(0.000105)	(0.000105)	(0.000106)	(0.000105)
Ratio Hist Annual Temp	-0.606***	-0.456***	-0.516***	-0.485***	-0.302***
	(0.0904)	(0.0886)	(0.0938)	(0.0882)	(0.0895)
Ratio Hist Annual Rainfall	-0.0763**	-0.218***	-0.412***	-0.428***	-0.420***
	(0.0328)	(0.0419)	(0.0259)	(0.0257)	(0.0259)
Ratio Earthquakes	-0.0341***	-0.0330***	-0.0333***	-0.0335***	-0.0330***
	(0.00167)	(0.00164)	(0.00166)	(0.00166)	(0.00164)
Ratio Unskilled	-0.0114***	-0.0115***	-0.0117***	-0.0115***	-0.0111***
	(0.000742)	(0.000759)	(0.000768)	(0.000755)	(0.000748)
Ratio Skilled	-0.00148	-0.00185	-0.00187	-0.00174	-0.00173
	(0.00146)	(0.00152)	(0.00154)	(0.00151)	(0.00151)
Ratio Share Wash Machine	0.00580***	0.00582***	0.00584***	0.00589***	0.00595***
	(0.000383)	(0.000383)	(0.000383)	(0.000382)	(0.000383)
Ratio Share Internet	0.0185***	0.0188***	0.0188***	0.0187***	0.0184***
	(0.000677)	(0.000677)	(0.000681)	(0.000675)	(0.000673)
Ratio Annual Crops	-0.000766**	-0.000833**	-0.000842**	-0.000789**	-0.000770**
	(0.000332)	(0.000345)	(0.000348)	(0.000332)	(0.000328)

Ratio Diurnal Temp Range	0.130***	0.0828***	0.0616***	0.0772***	0.0674***
	(0.0151)	(0.0153)	(0.0146)	(0.0146)	(0.0145)
Ratio 10mm Days	-0.635***				
	(0.0474)				
Ratio 20mm Days		-0.180***			
		(0.0333)			
Ratio Consecutive Dry Days			0.0250***		
			(0.00932)		
Ratio SPEI 0101/6				0.113***	
				(0.0123)	
Ratio SPEI 0103/9					0.291***
					(0.0171)
Constant	-0.857***	-1.270***	-1.202***	-1.328***	-1.693***
	(0.107)	(0.103)	(0.105)	(0.102)	(0.109)
Observations	1,528,932	1,528,932	1,528,932	1,528,932	1,528,932
Pseudo R-squared	0.189	0.189	0.189	0.189	0.189

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *p<0.1

The effects of drought or drought-prone conditions are captured using three separate variables in columns (3) to (5) of Table 4.7. The model in column (3) includes the ratio of average annual consecutive days without rainfall in destination to that in the origin. The models in columns (4) and (5) include the ratio of SPEI in destination to origin calibrated, respectively, at 12 months over a single year, and the average of 9 months over the preceding 3 years. The drought measures all point towards higher levels of drought conditions in destinations relative to origins associated with higher levels of migration for that stream.

Consistent with our earlier out-migration results, the differences in the impact of climate factors in migration show some variability across age, but these are not particularly large and, for the most part, do not stand out. As seen earlier, migration patterns vary by age, but the short-term climate effects, at least with these data, do not point to dramatically different effects across the life course.

A more interesting question is the extent to which these climate effects have linear or nonlinear effects. There are strong reasons to expect that the linear coefficients conceal more interesting relationships. We repeat our main analyses with a categorical parameterization of each of the climate variables to capture potential nonlinearities (Table 4.8). The reference category reflects broadly similar values across origin and destination, a low level dummy captures levels of the destinations that are well below 1.0 indicating a ratio that is less than or equal to 0.8, and a high level dummy captures levels that are greater than or equal to 1.2. Thus, the low levels capture situations where the destination is at least 20% lower than the origin, whereas the high dummy reflects comparisons where the destination is 20% higher than the origin.

Our tests for non-linear effects largely support our simpler results shown in Table 4.7. However, they also point to some possible quadratic effects. In comparison to contexts where destination rainfall levels are both higher and lower than the origin, migration is reduced. Thus, the effect of rainfall in the destination relative to the origin appears to have an inverse-U shape. That is both excess and a possible shortage of rainfall appear to reduce migration flows. Turning to the drought indicators, the destination municipalities with higher drought proneness indicators appear to draw in migrants, as seen earlier in Table 4.7. However, this effect seems to taper off slightly and very drought prone destination areas are weaker draws for migrants. Overall, this effect tends to support the simpler models that indicated that both heavy and low rainfall make destinations somewhat less appealing.

Table 4.8. Results of the categorical place-to-place models during the period 2005 – 2010 across all ages.

	(1)	(2)	(3)	(4)	(5)
Distance	-0.00731***	-0.00731***	-0.00736***	-0.00724***	-0.00727***
	(0.000104)	(0.000102)	(0.000102)	(0.000101)	(0.000100)
Ratio Hist Annual Temp	-0.531***	-0.448***	-0.617***	-0.510***	-0.356***
	(0.0907)	(0.0897)	(0.0949)	(0.0902)	(0.0890)
Ratio Hist Annual Rainfall	-0.201***	-0.290***	-0.396***	-0.443***	-0.425***
	(0.0307)	(0.0368)	(0.0256)	(0.0261)	(0.0255)
Ratio Earthquakes	-0.0336***	-0.0327***	-0.0338***	-0.0337***	-0.0328***
	(0.00165)	(0.00165)	(0.00167)	(0.00165)	(0.00163)
Ratio Unskilled	-0.0112***	-0.0111***	-0.0111***	-0.0102***	-0.0108***
	(0.000744)	(0.000752)	(0.000748)	(0.000725)	(0.000742)
Ratio Skilled	-0.00186	-0.00213	-0.00133	-0.00199	-0.00165
	(0.00151)	(0.00155)	(0.00136)	(0.00152)	(0.00150)
Ratio Share Wash Machine	0.00565***	0.00565***	0.00609***	0.00545***	0.00553***
	(0.000381)	(0.000376)	(0.000378)	(0.000382)	(0.000385)
Ratio Share Internet	0.0187***	0.0188***	0.0187***	0.0184***	0.0183***
	(0.000678)	(0.000684)	(0.000674)	(0.000670)	(0.000678)
Ratio Annual Crops	-0.000804**	-0.000871**	-0.000781**	-0.000743**	-0.000775**
	(0.000336)	(0.000348)	(0.000352)	(0.000319)	(0.000326)
Ratio Diurnal Temp Range	0.107***	0.0744***	0.0641***	0.0896***	0.0744***
	(0.0152)	(0.0150)	(0.0145)	(0.0148)	(0.0147)
Low Ratio 10mm Days	-0.127***				
	(0.0267)				
High Ratio 10mm Days	-0.513***				
	(0.0313)				
Low Ratio 20mm Days		-0.319***			
		(0.0240)			
High Ratio 20mm Days		-0.437***			
		(0.0266)			
Low Ratio Consecutive Dry Days			-0.478***		
			(0.0236)		

High Ratio Consecutive Dry Days			-0.251***		
			(0.0206)		
Low Ratio SPEI 0101/6				-0.620***	
				(0.0258)	
High Ratio SPEI 0101/6				-0.223***	
				(0.0206)	
Low Ratio SPEI 0103/9					-0.667***
					(0.0257)
High Ratio SPEI 0103/9					-0.173***
					(0.0189)
Constant	-1.364***	-1.235***	-0.947***	-1.025***	-1.212***
	(0.107)	(0.108)	(0.108)	(0.104)	(0.104)
Observations	1,528,932	1,528,932	1,528,932	1,528,932	1,528,932
Pseudo R-squared	0.193	0.193	0.193	0.193	0.193

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

As a final step, and building on the municipality-level analyses described in the preceding section, we also explore whether there are clear differences in the ways these climate variables affect migration streams across age groups. The results of these models, estimated in separate models for ages 15-29, 30-49, and 50 and over, are included in the appendices. The results show mostly consistent effects with mostly small and qualitatively similar differences across the age groups.

4.4 Individual-level analyses

A final series of analyses deals with the characteristics of internal migrants at the individual- and household-level: How much do climate factors affect help us explain an individual's probability of migration, and if so, how does this vary by age, gender, education, employment and marital status? We noted above that there are clear advantages to conducting an analysis at this level: it most accurately conforms to the level at which migration occurs. However, the available data yields one important disadvantage: we cannot prospectively identify the effects of personal characteristics on the likelihood of migration. Instead, the census describes individual and household characteristics in 2010, which is after the migration has occurred. This timing issue does not affect things like age and gender. But it means that to look at the relationship to education and employment, we need to make certain assumptions about relative stability of those parameters.

4.4.1 Baseline models

Table 4.9 presents results from two logit regression models. In both models, we see expected variation by age and education and gender: the probability of having migrated in the 2005-2010 period rises across individuals' teens and twenties, then falls steadily into people's old age; it rises across each consecutive category of educational attainment; and it is higher for women than for men. There is also expected variation by marital status: people who are separated/divorced or in consensual unions are more likely to have migrated than those who are married.

Table 4.9. Logit estimates of selected characteristics on having migrated 2005-2010: Baseline models.

VARIABLES	Model 1	Model 2
Age in 2005		
0-10	*reference group*	
10-19	0.210***	0.228***
	(0.0326)	(0.0309)
20-29	0.270***	0.300***
	(0.0201)	(0.0170)
30-39	-0.109***	-0.0701***
	(0.0194)	(0.0157)
40-49	-0.473***	-0.426***
	(0.0224)	(0.0196)
50-59	-0.651***	-0.595***
	(0.0357)	(0.0342)
60-69	-0.980***	-0.919***
	(0.0492)	(0.0463)
70+	-1.120***	-1.075***
	(0.0564)	(0.0541)
Male	-0.0857***	-0.0578***
	(0.00877)	(0.00855)
Religion		
- Muslim	*reference group*	
- Catholic	0.281	0.260
	(0.386)	(0.383)
- Protestant	0.498	0.485
	(0.382)	(0.379)
- Other	0.446	0.435
	(0.393)	(0.390)

Educational status		
Less than secondary school	*reference group*	
Completed secondary school	0.146***	0.120***
	(0.0301)	(0.0262)
Some post-secondary education	0.182***	0.154***
	(0.0570)	(0.0533)
Completed university	0.292***	0.273***
	(0.0872)	(0.0824)
Current marital status		
Never married, currently married, widow	*reference group*	
Consensual union	0.757***	0.754***
	(0.0472)	(0.0478)
Separated/divorced	0.169***	0.159***
	(0.0340)	(0.0337)
Number of persons in HH	-0.104***	-0.105***
	(0.00748)	(0.00757)
Provincial outmigration rate, 1995-2000	12.34	12.05
	(8.493)	(8.519)
Member of indigenous ethnic group	-0.123	-0.107
	(0.133)	(0.131)
Lived in coastal municipality (2005)	0.130	0.136
	(0.178)	(0.179)
Employment (2010)		
- Skilled agriculture or fisheries		-0.427***
		(0.0851)
- Elementary or unskilled occupations		0.137***
		(0.0420)
- Professional or senior official/management		-0.0446**
		(0.0198)
Constant	-4.147***	-4.120***
	(0.460)	(0.461)
Observations	8,019,031	8,019,031
Pseudo R-squared	0.0436	0.0436

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Model 2 adds some employment characteristics—as measured in 2010—to the model. It shows some important variation in outmigration, at least to the extent that people's employment in 2010 was largely consistent with that in 2005. Most notably, relative to a range of non-professional positions, people employed in unskilled positions were more likely to have migrated in this period. But skilled agricultural workers were much less likely to have migrated, and professionals marginally less likely to have migrated.

In both models there are also some unexpected *non*-effects. Net of the other variables in these models, the likelihood of having migrated in the 2005-2010 period was no different for a member of an indigenous ethnic group than for their non-indigenous counterpart, implying that the higher outmigration rates of from municipalities with higher percentage of indigenous—detailed in an earlier section—disproportionately consists of non-indigenous individuals.[15] Nor was the likelihood of migration significantly associated with living in a coastal as opposed to inland municipality. Nor, most surprisingly, was it associated with prior outmigration rates from the province (in 1995-2000).

4.4.2 Simple effects of climate variability

To test whether climate indices affect the likelihood of migration, we fit a second series of models in which we add a single measure of climate variability—all of which were statistically significant predictors of outmigration at the municipality level—to the first of the baseline models in Table 4.10. We also added a single control that would complement the main climate effect: Temperature seasonality, 1970-2000, in the precipitation and drought models (1-3 and 6-8); and Precipitation seasonality, 1970-2000, in the temperature models.

Since the coefficients on all baseline variables are almost identical to those presented in Table 4.10, we do not present them. Instead, we merely show the parameter values for each of the eight indicators that we used in these analyses. The results are quite clear. Across the board, none of these variables have a statistically significant effect on an individual's likelihood of migration, even with the threshold of significance set to a generous 0.1 level.

Table 4.10. Logit estimates of selected climate characteristics on having migrated 2005-2010 (net of all controls in Table 1, model 1).

Model		logit estimate (SE)	constant
1	Simple daily intensity index (SDII) (1992-2003)	-0.0179	-3.820***
		(0.0213)	(0.517)
2	Change in SDII	-0.0182	-3.971***
	(2002-2004 relative to 1992-2003)	(0.0424)	(0.474)
3	Change in number of very heavy precipitation days	-0.0029	-3.980***
	(2002-2004 relative to 1992-2003)	(0.0115)	(0.471)
4	Monthly max. value of daily max. temp	0.0054	-4.204***

---

[15] Note that in more parsimonious models, "indigenous" is negatively associated with the likelihood of migration, but only at the 0.1 level of significance.

		(0.0279)	(1.014)
5	Change in monthly max. value of daily max. temp	0.0798	-4.070***
	(2002-2004 relative to 1992-2003)	(0.142)	(0.470)
6	SPEI index, 1992-2003: 1 month calibration	-0.698	-3.465***
		(0.826)	(0.798)
7	SPEI index, 1992-2003: 12 month calibration	0.0039	-3.976***
		(0.521)	(0.473)
8	Change in 12-month SPEI index	-0.356	-4.282***
	(2002-2004:1992-2003)	(0.475)	(0.608)

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

As noted in the municipality-level analyses, the effects of various climate indices appear vary across age groups. The existing literature also provides grounds for expecting effects to co-vary with other characteristics, like gender and education. Our final set of models addresses these directly.

4.4.3 Interactions with other individual-level characteristics

To examine the extent to which climate effects on migration vary across these individual characteristics we selected five climate variables. Three of these are focused on precipitation: the SDII 1990-2001, a measure of the intensity of rainfall; a change in the SDII in the period 2002-2004 relative to the preceding 12 years; and a measure of change in very heavy rainfall. Two other measures are focused on drought: the 12-month calibration of SPEI averaged over the 1990-2001 period; and the change in the same index in 2002-2004 relative to the preceding 12 years.

We fit a series of seven logit models for each of these five variables. In each model we estimated interaction terms between the climate variable of interest and an individual's age, while limiting the analytic sample in terms of a gender, person's educational attainment, and type of employment. This allows us to generate an age-specific probability of migrating for people in the following subgroups:

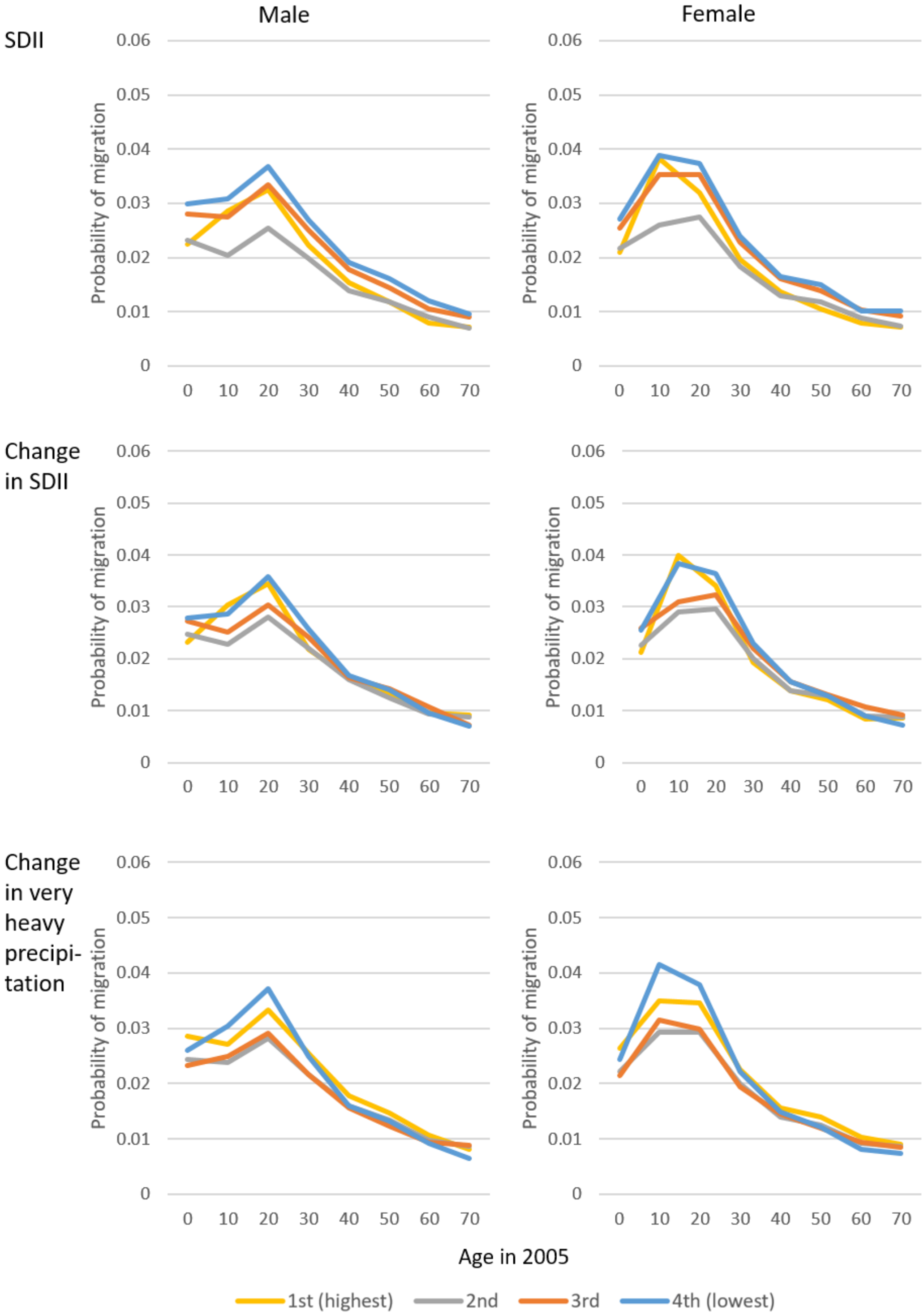
- men versus women
- someone with a primary or secondary school education versus someone who had at least some tertiary education;
- someone employed in an unskilled labor category versus someone employed in skilled agriculture or fisheries position versus a person in a professional or senior official/management position.

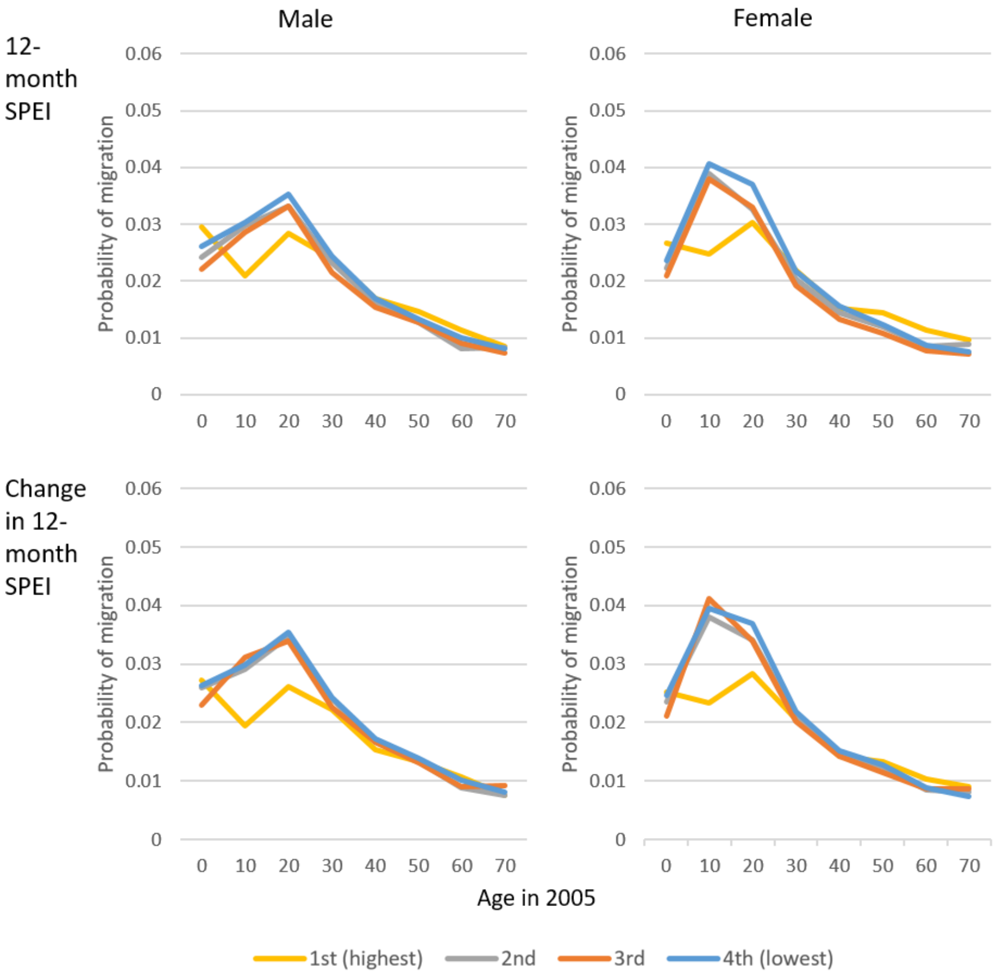
More specifically, to ease interpretation of these effects we divided each of the climate variables into quartiles, where the first quartile represents the 25 percent of municipalities with the highest value on the variable of interest—the highest amount of rain, highest temperature, highest score on SPEI drought index, or largest increase in any of these—and the fourth quartile represents the 25 percent of municipalities with the lowest value on these variables.

The core results of these models are presented in Figures Figure 4.3 to Figure 4.5. Each panel represents a different subsample: men in the left column of panels in Figure 1, women on the right; those with primary or secondary school education in the left column of panels in Figure 4.4, and those with at least some tertiary education on the right; and finally, those employed in an unskilled position, skilled agricultural/fisheries position, or professional/managerial position, respectively, across the three columns of Figure 4.5.

Within each panel, each line represents the predicted age-specific probability of outmigration out of a municipality with a given value on the climate variable, net of all other characteristics in the model.

Figure 4.3. Predicted outmigration rates by differences in selected precipitation variables and by age and gender, net of covariates.





Across these models we see the standard gender-specific age pattern of migration, rising and falling in a similar way for both men and women, though peaking earlier and higher for the latter. Within some of the panels, however, there are also some significant the different 25% groupings of municipalities, with each grouping having experienced different types of climate variability in the period leading up to 2005.

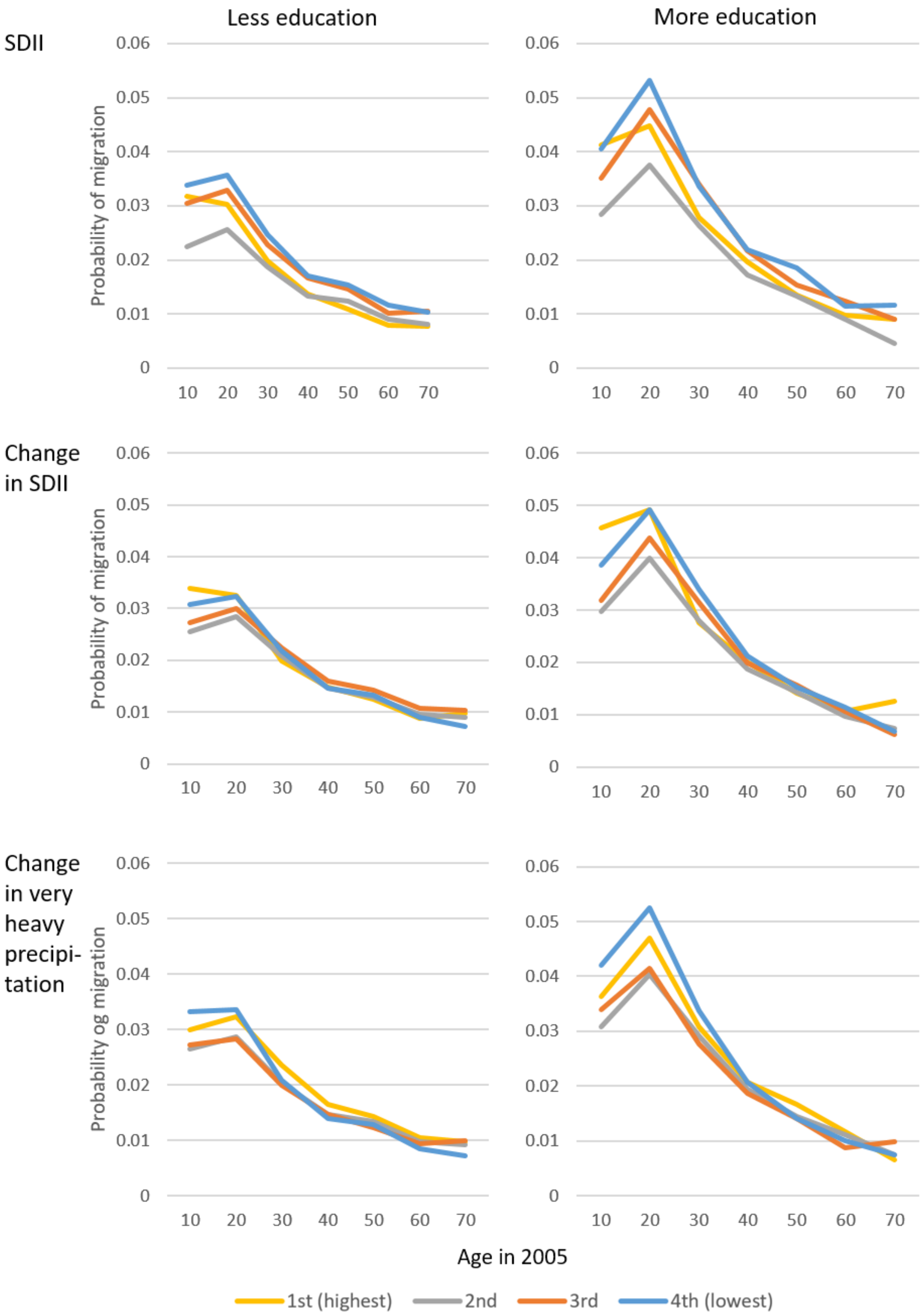
These differences are easy to see in the final four panels that look at the SPEI variables in the bottom two rows of Figure 4.3. Having controlled for all other variables in the model, the predicted age-specific probability of migration is identical for men in the bottom three quartiles of municipalities that experienced no drought whatsoever or only moderate signs of one. However, the age-pattern of migration in the top quartile—municipalities that had highest scores on the drought index—is lower for both men and women, especially in the change in SPEI variables. The outmigration probability for women in their teens and 20s from these municipalities was in the 2.4 – 2.8 percent range, instead of 3.5-4.1 percent for their counterparts elsewhere. But from age 30 and up, the age-specific lines are almost identical.

The age-specific patterns of the precipitation variables (top 3 rows of Figure 4.3) point to a similar effect—to the extent that rainfall and drought are negatively correlated.[16] Among both men and women, we see a higher probability of outmigration from municipalities that experienced the lowest levels of rain intensity, or the lowest level of increase in rain intensity. However, migration probabilities were also relatively high from areas in the top quartile of these measures. In other words, outmigration was lowest from the middle (especially second) quartiles, the areas that were not at the extremes of the distribution. As was the case with the SPEI drought indices, the magnitude of differences is greatest in the peak migration ages.

---

[16] They are, but not perfectly. In fact, some of the municipalities in these data score highly on the SPEI index and relatively high on the "consecutive number of days of rain." Where that it the case, they score low on rain *intensity* measures.

Figure 4.4. Predicted outmigration rates by differences in selected precipitation variables and by age and educational level, net of covariates.



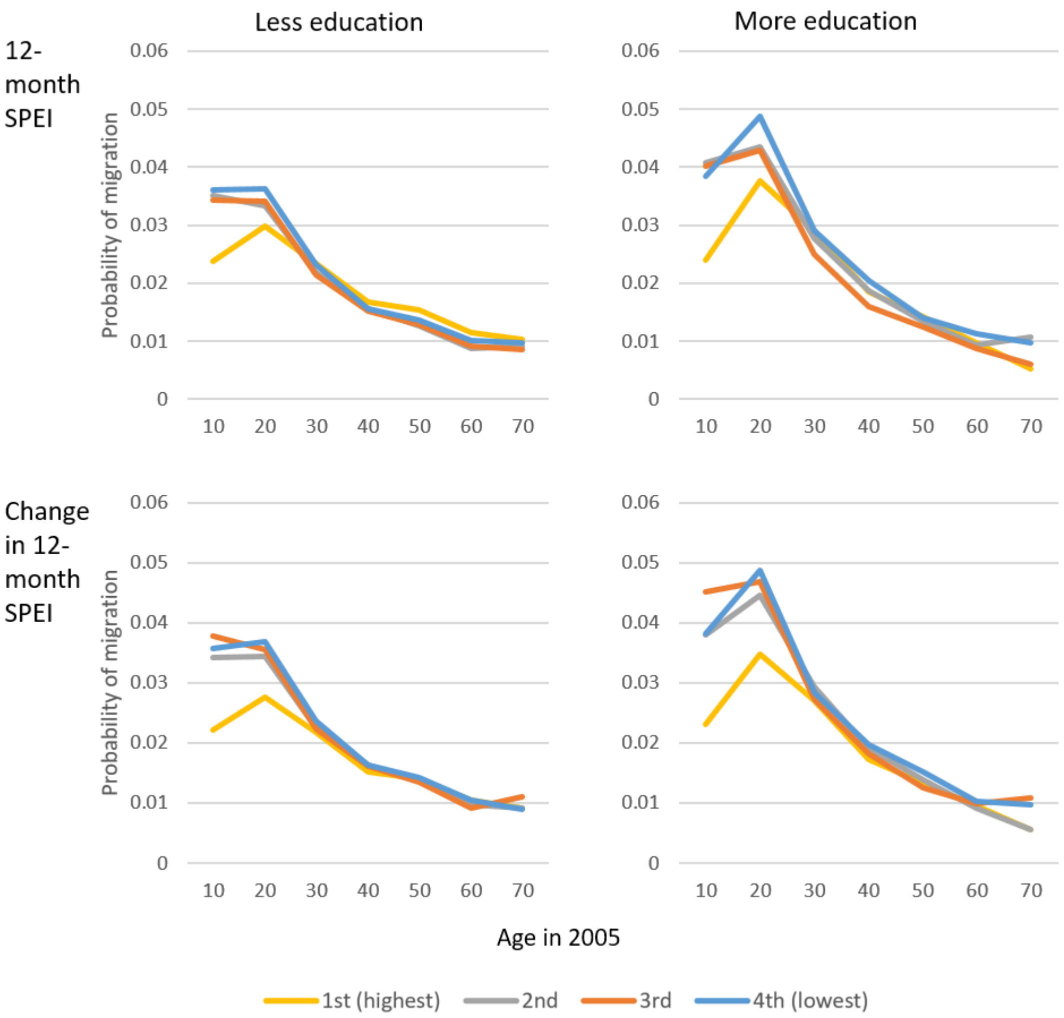
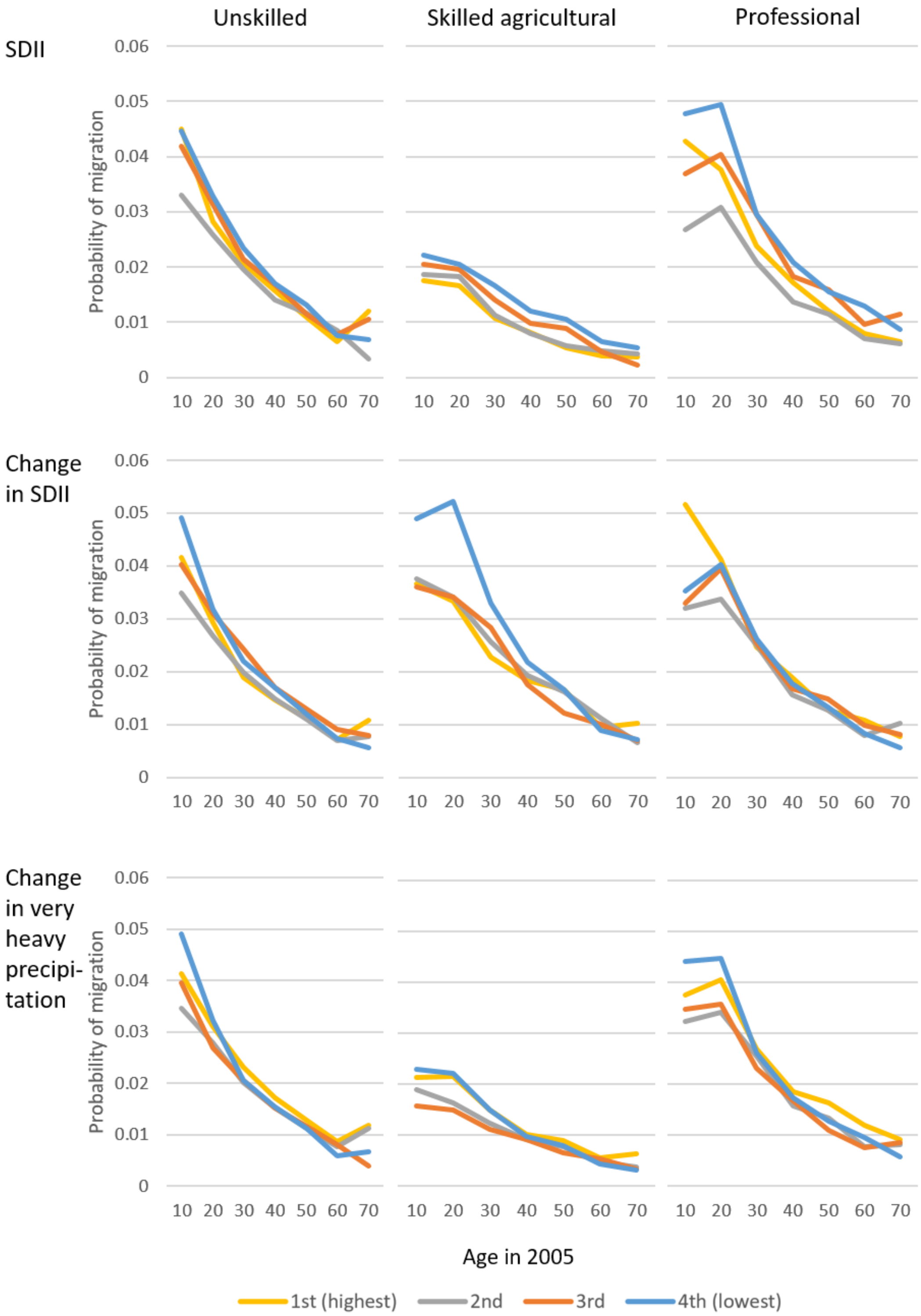


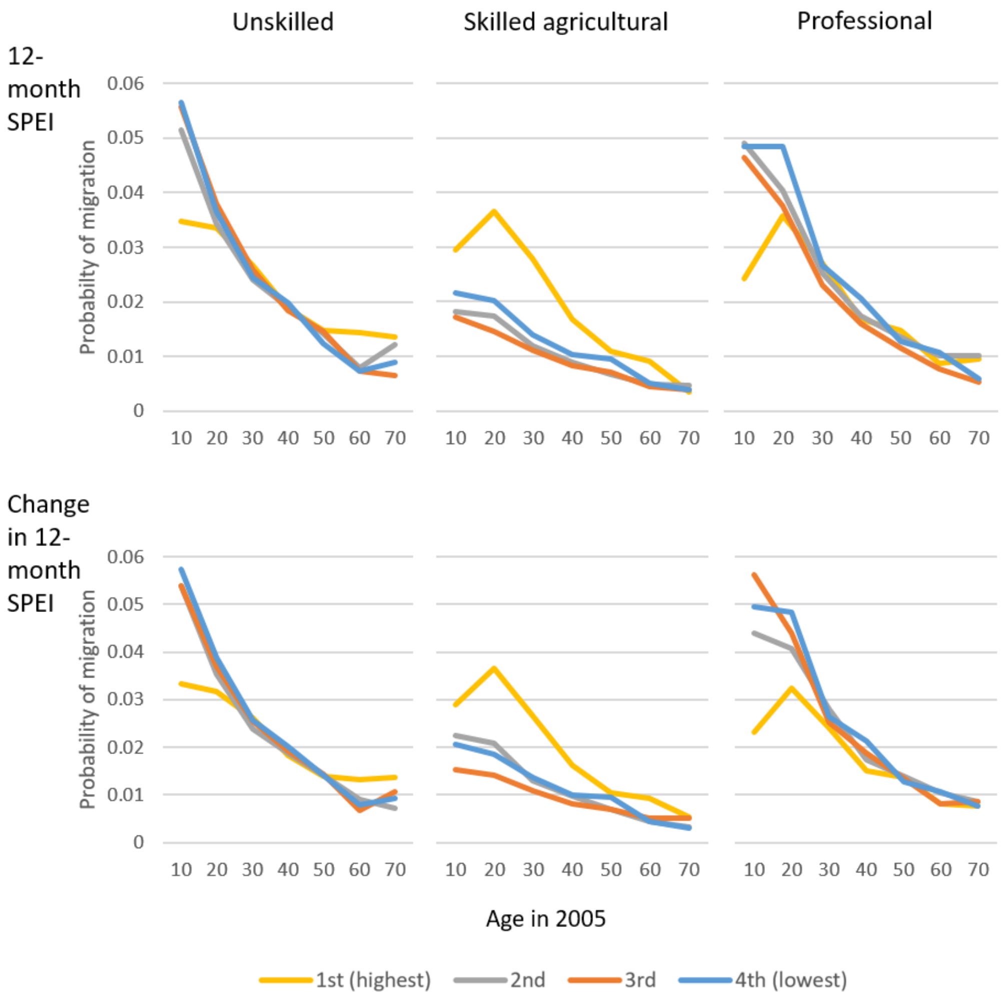
Figure 4.4 shows that there is also some age-specific variation in climate effects by an individual's education level. Overall, as noted in the regression models in Table 4.1, the probability of migration rises with education, so the overall height of the lines in the right-hand panels is higher than those on the left. However, by comparing the height of particular colored lines across each set of graphs, we can see that these differences vary with climate variability. In both the precipitation and drought panels, for example, the difference between the highest and lowest points on the curve tend to be larger among the more educated than among their less educated counterparts, suggesting that the overall effect of climate factors is larger among the more educated. This makes sense: the more educated have more options and are typically wealthier.

There are also signs of a more specific climate effect. Individuals living in municipalities in the top quartile in terms of scores on the drought index had a lower probability of migration than those in less droughty municipalities. This effect can be seen among both the more and the less educated, but it is particularly strong among more educated teens and 20s. Are they less likely to migrate because of lack of resources? Or because the relatively moderate drought conditions of even the most drought-prone municipalities in the Philippines ironically provide more opportunities for the more educated?

Likewise, in the precipitation panels, we see the highest probability of migration out of municipalities that had the lowest levels of intensive rain, with the lowest probability once again in the middle quartiles, the municipalities in the middle of the rain distribution. These effects can be seen in both educational groups, though as remarked above, the differences are greater among the more educated.

Figure 4.5. Predicted outmigration rates by differences in selected precipitation variables and by age and employment category, net of covariates.





The final set of models looks at the variation in climate effects on migration by current sector of employment. Here we see some of the biggest variation in effects. We begin with the SPEI indices. Among people living in municipalities in the highest quartile of drought, or change in drought, there was no difference in migration rates between unskilled, skilled agricultural workers, or people in professional/managerial positions: it was around 3.5% in all three sectors. In contrast, there were very substantial differences in municipalities scoring in the bottom three quartiles on the drought index. People who had been teens or in their 20s working in 2005 and were working in either unskilled or professional positions in 2010 were much less likely to be migrants if they had lived in a high-drought municipality in 2005. If they lived in low-drought municipality, their probability of migration was in the 5% range for teens.

The skilled agricultural and fisheries sector is particularly instructive. People currently engaged in skilled agricultural work were twice as likely to have migrated as a teen if they lived, in 2005, in a municipality with relatively high scores on the SPEI drought index: If they had lived in municipalities with lower scores on the drought index, their probability of migration was a mere 1.5-2%. The difference in probability of migration between the types of municipalities based on their recent climate characteristics is the only one—of all the variables that we checked—that extends into people's 30s and 40s.

The precipitation indices tell a similar story, albeit for younger ages. Skilled agricultural workers have lower migration probabilities in general. But the middle panel on the second row shows that where they lived in a municipality that experienced a reduction in rainfall (the lowest quartile on the change in SDII), their migration probabilities climbed significantly above those of their counterparts in municipalities with different weather characteristics.

Among those employed in unskilled and professional sector, there are parallel precipitation effects, though these tend to be concentrated in the teens among unskilled, extending into the 20s only among professionals.

4.4.4 Summary

Here, as in prior sections of this report, we have found that climate factors explain part of an individual's probability of migration, but only a small part. General models yield little. In order to empirically observe any statistically significant climate-induced migration, we have to be quite specific about how we specify our models. In this regard, disaggregating effects by age is crucial. It allows us to see how, with few exceptions, the effects of climate indices on migration are concentrated in people's teens and 20s, even when we look at variation by education and employment. There also appear to be few differences in terms of gender.

To some, these will be disappointing conclusions. But it is important to remember the following limitations of this study. We return to these in more detail below but it is useful to at least introduce them here.

First, in contrast to our rich array of climate indices, we are limited to only one type of migration. If we could look at others, focus on a much smaller window of time, or recreate household structures at a time and place of origin in order to examine how migration decisions are made within the household—selecting one type of person but not another—we would almost certainly be able to identify a much broader set of climate-related effects on migration. By extension, we would then be able to see how those effects operate through age, gender, education, employment, marital status and other factors.

Second, this analysis used 2010 census data. Internal migration fell significantly during the preceding 10 years, making it in some ways an even more dynamic and challenging analytic target, since it suggests that there were more things keeping people in place in 2005 than there had been in 1995. It is difficult to know how things have changed since then, but it is certainly the case that the Philippines is better prepared for climate-induced changes now than it was then—we reviewed some of the legislative changes, shifts in production and rise of a richer and more diverse array of human capital, in the first section of this report. This points to an augmented process of collective and policy-led adaptation, which is certainly a good thing for the Philippines' population, but equally poses more challenges to analysts wanting to identify the effects of some slow- and fast-onset macro-level changes on individual behavior.

5 Summary and Implications for Policy & Research

Climate-migration nexus has been attracting increasing scholarly attention in the last decades. The various manifestations of climate change including extreme events that are expected to get more frequent and more intense, and slow-onset changes that increasingly affect livelihoods in a context of international climate coordination failure add fuel to the fire. Countries in South-East Asia are among the most vulnerable to climate change (Porter et al. 2014), and future climate scenarios predict increases in multiple indicators, including temperatures (average, minimum and maximum), annual precipitation, number of consecutive too wet and dry days, among others (Collins et al., 2013). Understanding how these changes may shape human mobility is key to effective policy design to protect livelihoods and establish migration as a choice rather than necessity.

This report contributes to the discourse on climate change and internal migration linkages in the Philippines in three important ways. First, we use data from the latest census available (10% sample from 2010 census) to assess more recent relationships between climate change and migration than found in the robust literature to date. Given the highly dynamic nature of climate-migration nexus, as well as the structural and rural transformation in the country shaping migration, more up to date understanding of these linkages is crucial. Second, we use a large set of climate change indicators selected by a climate variability expert team and capture both extreme and slow-onset events at high spatial and temporal resolution. Third, by conducting analyses at different levels (municipality, migration streams and individual) and applying a livelihoods adaptation framework (controlling for a large set of migration drivers in addition to the climate variables) we identify linkages that can be used as policy entry points at different levels.

Our descriptive analysis documents a secular decline in internal migration rates for both men and women, with much steeper declines for women between 1985 and 2010. It also shows that internal migration became somewhat less selective on education over the same time period. The rich set of climate indicators show that although no significant warming or cooling trends can be detected at the national level, most warming trends are significant at the municipality level. We also document important heterogeneities in rainfall and drought indicators across municipalities, underlining the importance of using data with high spatial resolution.

A number of findings stand out in our empirical analyses. First, important general factors affecting out-migration need to be taken into account. Out-migration rates are lower in municipalities on the coast; that are hillier; and have higher percentage of cultivated land devoted to annual (as opposed to perennial) crops. They are higher in municipalities with highest populations (almost completely driven by people aged above 50), and with higher percentage of indigenous populations (driven by out-migration of non-indigenous residents). To the extent that climate variability differentially affects municipalities that vary on these ancillary characteristics, researchers and policy makers must be careful not to confound the various causes of migration.

Second, we show that average patterns of temperature and precipitation in the 1970-2000 period are only weakly associated with out-migration rates in the Philippines over the 2005-2010 period. While annual means or totals are not relevant, climate indicators capturing extreme values like higher maximum temperatures and the magnitude of rainfall in the wettest months are more associated with out-migration.

Third, looking at more recent (1992-2003 period) measures of historical weather patterns, we still find that the majority of temperature and precipitation indices had virtually no impact on out-migration rates at all age ranges. Only higher cumulative drought indices were positively associated with out-migration rates at all ages. Fourth, our analysis on the effects of most recent changes (1-3 years preceding migration relative to the preceding 12 years) in weather patterns on out-migration rates show much stronger associations. A substantial 3-year increase in rainfall intensity is associated with significantly lower out-migration rates - especially for ages 15-49, while an increase in drought is associated with significantly higher out-migration rates. This underlines the importance of deviations from longer-term indicators (as opposed to long-run averages) in affecting migration decisions, which is consistent with portfolio diversification and decision making under uncertainty.

Migration streams from an origin to a destination are naturally affected by how certain characteristics of these locations compare with each other. We uncover these relationships in our migration stream analysis. We find that, controlling for the origin characteristics; migrants prefer destinations with similar climate indicators to their origins. Both excess rainfall and too low rainfall in destinations (compared to the origin) decrease migration streams. Finally, at the individual level, we find that climate characteristics, especially rainfall and drought conditions, affect individuals differently by age, gender, educational levels and employment sectors. Most notably, effects are concentrated at peak migration ages under 30. Beyond that, more educated people in their teens and 20s are much less likely to migrate out of municipalities experiencing more drought than their peers in less drought-affected municipalities. At the same time, they are also more likely to migrate away from municipalities experiencing the largest increases in rain intensity. Finally, people working in skilled agricultural work, irrespective of their educational levels, are much more likely to leave those same drought prone municipalities, to head, as observed in the place-to-place analysis, to the destinations with a somewhat better drought profile.

Overall, this report highlights the importance of conducting detailed analyses that cover a range of indices, time scales, and spatial resolutions at which climate variation and migration are measured. They also highlight the importance of age-differentiated analyses, as most of the generally used core variables of interest—averages of climate indices—were not significantly associated with out-migration, especially in models that combined migration rates across all ages. Yet, by differentiating age categories, we identified significant patterns between some climate indicators and out-migration rates.

The climate change and migration challenges in the Philippines play out against a backdrop of a slow demographic transition, the related large youth population (especially in rural areas), and dynamic structural and rural transformation processes that continuously reshape employment and livelihood opportunities. The long-standing culture of migration makes the country the third largest international migration source in the world (ADB 2012). Internal migration (dominated by rural-rural flows), however, has been much more common, though out-migration rates have been declining since the 1980s — across all ages and especially among women.

In spite of the worries about high youth migration in the national discourse, the average age of internal migrants in the Philippines is actually higher than the global average. Notwithstanding, the standard age patterns of migration are also relevant here, with migration peaking at ages between 20 to 30, towards the lower end of this range for women, and somewhat higher for men. Whether or not climate change affects migration of youth differently from adults (hence deserves special attention for policy), is an empirical question that requires age differentiated analyses as in this report. We have shown that the probabilities of migration from late teens to late 20s are magnified by certain types of climate characteristics, but an extension of this work could break this down into single years. Migration in the Philippines is also usually framed in a gendered way as females tend to dominate migrant populations. Climate change impacts on migration patterns, however, do not differ by gender as shown in our analyses.

It is important to keep in mind that some basic characteristics of migrant origins and destinations loom more important than most climate indicators (when used jointly in multivariate analyses), and these relate to the larger rural opportunities that frame livelihoods. Examples include lower out-migration rates from coastal municipalities and those that highly depend on annual cropping, as well as higher out-migration from populous areas and those with larger shares of indigenous populations. Migration streams towards municipalities with higher living standards (compared to the origin) are stronger, as are those where the pool of unskilled laborers is smaller.

Combined with the fact that an overwhelming majority of migrants mentioned employment as the main reason to move in the NMS 2018, these underline the importance of broader rural development and climate adaptation policies that can shape the climate-migration linkages through impacts on employment opportunities, food security and disaster preparedness. The Philippines is among the countries with development momentum, whose main policy challenge around migration and rural development issues is focusing on creating employment opportunities by strengthening agricultural value chains and promoting the development of regional [peri-urban and] urban centres (FAO 2018). Such policies would reshape the sectoral distribution of jobs from unskilled to skilled, and need to be coupled with active labour market policies to strengthen the needed skills of the young population (RDR 2019, Ch. 10). Youth in all societies are more mobile than the other segments of the population, and Filipino youth are not more so than others (in fact, there is some evidence that they may be less so). What they need is not policies to stop their mobility, but create opportunities (for them and the larger society) to make mobility a choice.

Equally important is to note that generic long run averages of climate-change indicators fail to capture relevant migration linkages, as migration is mostly influenced by deviations in selected extreme weather indicators in 1-3 years preceding migration from longer-term averages. These interactions also have distinct age structures, which need to be analyzed carefully as we have done here to guide policies aiming to address some of the challenges that may apply to only certain segments of the society.

The analysis and findings in this report need to be interpreted with a couple of caveats in mind, which lead to recommendations for future data collection efforts, research and policy.

Migration in this study is identified using a proxy question in the latest census (2010). Although census has its advantages (even with the 10% sample), it only allows us to define migration in a 5-year window by using differences in the current and past residence (5 years before census) of individuals. This makes it impossible to capture seasonal and temporary migration, which are increasingly becoming important as rural transformation connects hinterlands and urban centers, and shifting the migration discourse more towards human mobility. Information on international migration is also problematic, as is the case for many censuses in the Asia-Pacific region (Huguet 2008; ADB 2012). More investment in collecting detailed migration data is needed.

This is an area for improvement also identified by GIZ (2020) in order to better understand and manage human mobility and climate change: research and data shortcomings need to be addressed (specifically, there is a need to increase emphasis on internal migration and set up related government data management priorities). The recent NMS (PSA & UPPI 2019) is an important progress towards the right direction; however, it is silent on any climate change related issues. Adding climate change related questions and questions to identify seasonal/temporary human mobility to the future rounds of the NMS would address some of these concerns. In this context, the newly approved community-based monitoring system can be used to track internal migration to add contextual richness and analytical rigour to the discourse.

Considering that most slow-onset and extreme weather events (captured here using various calibrations of SPEI for the former, and 21 rainfall and temperature indicators for the latter) have indirect impacts on migration through their impacts on local income sources, future studies should analyze local economy-wide impacts of such indicators to understand which sectors are affected more. Such analysis can help efforts to prepare livelihoods to adjust to both changes in climate as well as the local economy during rural transformation in a sustainable way.

Finally, this report relied on the latest census available that was collected in 2010, and identified migration patterns over the 5-year period before that. Although the climate variables cover a much longer period (1980-2010), the effects identified here can only guide our understanding of future linkages to the extent that future climate change effects fall within the range of those observed during our 40-year period. Subjective evidence suggests that climate induced migration (though likely short-distance and temporary migration) may have intensified over the last decade in the Philippines (GIZ 2020). Given that some climate model projections suggest more damaging shocks would become more frequent between 2020 and 2050 (CCC 2019), what future climate change brings may break from the historical patterns analyzed in this report. In order to understand more recent linkages, it is critical to ensure that the 2020 Census (and follow up NMS rounds) includes relevant migration and mobility questions (even if in a subsample) to better capture seasonal, temporary and international migration. This would facilitate similar analyses with newer data including simulations based on climate scenarios and support rural development and adaptation policies to ensure that the most preferable scenario of the POPCOM called “No forced mobility” becomes a reality.

References

ADB 2012. Addressing Climate Change and Migration in Asia and the Pacific. Asian Development Bank, Mandaluyong City, Philippines: Asian Development Bank.

Amacher, Gregory S., Wilfrido Cruz, Donald Grebner, and William F. Hyde. 1998. “Environmental Motivations for Migration: Population Pressure, Poverty, and Deforestation in the Philippines.” Land Economics 74(1):92–101. doi: 10.2307/3147215.

Arslan, A. Egger, Eva-Maria and Winters, Paul. (2018). "Migration, Demography, and Agri-Food Systems: Challenges and Opportunities," Chapter 3 in Serraj. R and Pingali P. (eds.), *Agriculture & Food Systems to 2050: Global Trends, Challenges and Opportunities*," World Scientific series in grand public policy challenges of the 21st century; volume 2, pp. 87-135.

Beauchemin, Cris. 2010. “Rural-Urban Migration in West Africa: Towards a Reversal? Migration Trends and Economic Situation in Burkina Faso and Côte d'Ivoire.” *Population, Space and Place* 17(1):47–72.

Bell, M. and E. Charles-Edwards. 2013. Cross-national comparisons of internal migration: An update of global patterns and trends. Technical Paper 2013/1. New York: United Nations, Department of Economic and Social Affairs.

Bouroncle, Claudia, Pablo Imbach, Beatriz Rodríguez-Sánchez, Claudia Medellín, Armando Martinez-Valle, and Peter Läderach. 2017. “Mapping Climate Change Adaptive Capacity and Vulnerability of Smallholder Agricultural Livelihoods in Central America: Ranking and Descriptive Approaches to Support Adaptation Strategies.” Climatic Change 141(1):123–37. doi: 10.1007/s10584-016-1792-0.

Castro, Luis J. and Andrei Rogers. 1983. “What the Age Composition of Migrants Can Tell Us.” *Population Bulletin of the United Nations* 15.

CCC (Climate Change Commission) 2019. “Executive Brief: The Philippine National Climate Change Action Plan Monitoring and Evaluation Report, 2011 – 2016.” Manila: Climate Change Commission, 2019. https://climate.gov.ph/our-programs/national-climate-change-action-plan-nccap.

Charles-Edwards, Elin, Martin Bell, Aude Bernard and Yu Zhu. 2017. “Internal migration in the countries of Asia: Levels, ages, and spatial impacts.” Asian Demographic Research Institute: Shanghai University. Working paper series ADRI-WP-2017/001

Choi, G., Collins, D., Ren, G., Trewin, B., Baldi, M., Fukuda, Y., Afzaal, M., Pianmana, T., Gomboluudev, P., Huong, P. T. T., Lias, N., Kwon, W.-T., Boo, K.-O., Cha, Y.-M. and Zhou, Y.: Changes in means and extreme events of temperature and precipitation in the Asia-Pacific Network region, 1955–2007, *Int. J. Climatol*., 29(13), 1906–1925, doi:10.1002/joc.1979, 2009.

Cinco, Thelma A., Rosalina G. de Guzman, Flaviana D. Hilario, and David M. Wilson. 2014. "Long-Term Trends and Extremes in Observed Daily Precipitation and near Surface Air Temperature in the Philippines for the Period 1951–2010." *Atmospheric Research* 145–146:12–26. doi: 10.1016/j.atmosres.2014.03.025.

Collins, M., Knutti, R., Arblaster, J., Dufresne, J.-L., Fichefet, T., Friedlingstein, P., Gao, X., Gutowski, W. J., Johns, T., Krinner, G., Shongwe, M., Tebaldi, C., Weaver, A. J. and Wehner, M. 2013. "Long-term Climate Change: Projections, Commitments and Irreversibility, in Climate Change 2013: The Physical Science Basis." Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited by T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgle, pp. 1029–1136, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

FAO 2018. The State of Food and Agriculture 2018. Migration, agriculture and rural development. Rome. Licence: CC BY-NC-SA 3.0 IGO.

Fick, S. E., & Hijmans, R. J. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. International Journal of Climatology, 37(12), 4302–4315. https://doi.org/10.1002/joc.5086

Funk, C., Peterson, P., Landsfeld, M., Pedreros, D., Verdin, J., Shukla, S., Husak, G., Rowland, J., Harrison, L., Hoell, A., & Michaelsen, J. (2015). The climate hazards infrared precipitation with stations—a new environmental record for monitoring extremes. 2, 150066. http://dx.doi.org/10.1038/sdata.2015.66

GIZ 2020. Home Lands Island and Archipelagic States' Policymaking for Human Mobility in the Context of Climate Change.

Gray, C., Frankenberg, E., Gillespie, T., Sumantri, C., & Thomas, D. (2014). Studying displacement after a disaster using large scale survey methods: Sumatra after the 2004 Tsunami. Annals of the Association of American Geographers, 104(3), 594–612.

Habito, Cielito F., and Roehlano M. Briones. n.d. "Philippine Agriculture over the Years: Performance, Policies and Pitfalls." 38.

Herrin, A. N. 1981. Population and Development Research in the Philippines: A Survey. National Economic and Development Authority, Manila.

Huguet, J. W., ed. 2008. Special Issue: International Migration Data and Sources in Asia. Asia and Pacific Migration Journal 17: 3–4.

IFAD. (2019). Rural development report 2019: Creating Opportunities for Rural Youth, International Fund for Agricultural Development, UN. Rome.

Indra Overland et al. (2017) *Impact of Climate variability on ASEAN International Affairs: Risk and Opportunity Multiplier*, Norwegian Institute of International Affairs and Myanmar Institute of International and Strategic Studies, available at: https://www.researchgate.net/publication/320622312_Impact_of_Climate_Change_on_ASEAN_International_Affairs_Risk_and_Opportunity_MultiplierPublished by the Norwegian Institute of International Affairs and Myanmar Institute of Strategic and International Studies. ISSN: 1894-650X

Israel, D. C. and R. M. Briones (2012), 'Impacts of Natural Disasters on Agriculture, Food Security, and Natural Resources and Environment in the Philippines', in Sawada, Y. and S. Oum (eds.), Economic and Welfare Impacts of Disasters in East Asia and Policy Responses. ERIA Research Project Report 2011-8, Jakarta: ERIA. pp.553-599.

Lantican, Maximina A., Larry C. Guerra, and Sadiqul I. Bhuiyan. 2003. "Impacts of Soil Erosion in the Upper Manupali Watershed on Irrigated Lowlands in the Philippines." Paddy and Water Environment 1(1):19–26. doi: 10.1007/s10333-002-0004-x.

McKee, T. B., Doesken, N. J., & Kliest, J. (1993). The relationship of drought frequency and duration to time scales.

Lansigan, F. P., W. L. de los Santos, and J. O. Coladilla. 2000. "Agronomic Impacts of Climate Variability on Rice Production in the Philippines." Agriculture, Ecosystems & Environment 82(1):129–37. doi: 10.1016/S0167-8809(00)00222-X.

Manton, M. J., P. M. Della-Marta, M. R. Haylock, K. J. Hennessy, N. Nicholls, L. E. Chambers, D. A. Collins, G. Daw, A. Finet, D. Gunawan, K. Inape, H. Isobe, T. S. Kestin, P. Lefale, C. H. Leyu, T. Lwin, L. Maitrepierre, N. Ouprasitwong, C. M. Page, J. Pahalad, N. Plummer, M. J. Salinger, R. Suppiah, V. L. Tran, B. Trewin, I. Tibig, and D. Yee. 2001. "Trends in Extreme Daily Rainfall and Temperature in Southeast Asia and the South Pacific: 1961-1998." International Journal of Climatology 21(3):269–84.

Manton, M. J., P. M. Della-Marta, M. R. Haylock, K. J. Hennessy, N. Nicholls, L. E. Chambers, D. A. Collins, G. Daw, A. Finet, D. Gunawan, K. Inape, H. Isobe, T. S. Kestin, P. Lefale, C. H. Leyu, T. Lwin, L. Maitrepierre, N. Ouprasitwong, C. M. Page, J. Pahalad, N. Plummer, M. J. Salinger, R. Suppiah, V. L. Tran, B. Trewin, I.

Myers, Norman. 1988. "Environmental Degradation and Some Economic Consequences in the Philippines." Environmental Conservation 15(3):205–14. doi: 10.1017/S0376892900029337.

Oren, Ashira M. and Guy Stecklov. 2017. "Rural/Urban Population Age and Sex Composition in Sub-Saharan Africa 1980–2015." *Population and Development Review* 44(1):7–35.

Pati, Romeo C., Danielito T. Franco, Antonio J. Alcantara, and Enrique P. Pacardo. n.d. "Vulnerability to Flooding of the Towns of Mabitac and Santa Maria, Laguna, Philippines." 17(2):12.

Phongpaichit, P. 1992. Female internal migration and the labour market. Selected papers of the pre-conference seminar, Fourth Asian and Pacific Population Conference, 1992 Seoul. United Nations, Economic and Social Commission for Asia and the Pacific [ESCAP]

Reardon, T. (2015). The hidden middle: The quiet revolution in the midstream of agrifood value chains in developing countries. Oxford Rev. Econ. Pol., 31(1), pp. 45–63.

Rigaud, Kanta Kumari de Sherbinin, Alex Jones, Bryan Bergmann, Jonas Clement, Viviane Ober, Kayly Schewe, Jacob Adamo, Susana McCusker, Brent Heuser, Silke Midgley, Amelia. 2018. Groundswell: Preparing for Internal Climate Migration. World Bank.

Rodolfo, Kelvin S., and Fernando P. Siringan. 2006. “Global Sea-Level Rise Is Recognised, but Flooding from Anthropogenic Land Subsidence Is Ignored around Northern Manila Bay, Philippines.” Disasters 30(1):118–39. doi: 10.1111/j.1467-9523.2006.00310.x.

Rofi, Abdur, Shannon Doocy, and Courtland Robinson. 2006. “Tsunami Mortality and Displacement in Aceh Province, Indonesia.” Disasters 30(3):340–50. doi: 10.1111/j.0361-3666.2005.00324.x.

Subedi, B. P. 1997. Population and environment interrelationships: the case of Nepal, New Delhi, Tata Energy Research Institute.

United Nations, Department of Economic and Social Affairs, Population Division. 2019. World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). New York: United Nations.

Vicente-Serrano, S. M., Beguería, S., & López-Moreno, J. I. (2010). A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index. Journal of Climate, 23(7), 1696–1718. https://doi.org/10.1175/2009JCLI2909.1

WFP (World Food Programme). 2017. Food security and nutrition in the Philippines. Strategic Review. https://docs.wfp.org/api/documents/WFP-0000015508/download/

Philippines Statistics Authority (PSA) and University of the Philippines Population Institute (UPPI). 2019. 2018 National Migration Survey. Quezon City, Philippines: PSA and UPPI.

Young, A. 2013. Inequality, the urban-rural gap, and migration. The Quarterly Journal of Economics, 128(4): 1727–1785.

Xenos, P (2004) “Demographic Forces Shaping Youth Populations in Asian Cities”, Chapter 1 in Hanley, L, Ruble, B, and Tulchin, J (eds), Youth, Poverty, and Conflict in Southeast Asian Cities, Woodrow Wilson International Center for Scholars, Washington, DC.

Appendix A

Table A1: Outmigration rates (all ages) by baseline characteristics, annual rainfall, and selected temperature indicators, 1970-2000

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES						
Municipality on the coast	-0.112*	-0.124**	-0.0948	-0.104	-0.113*	-0.110*
	(0.0619)	(0.0562)	(0.0688)	(0.0692)	(0.0662)	(0.0565)
Mean slope of terrain across 90-m transects	-0.0126***	-0.0129***	-0.0127***	-0.0130***	-0.0117**	-0.0130***
	(0.00486)	(0.00370)	(0.00363)	(0.00370)	(0.00519)	(0.00435)
Percent of cultivated land = annual crops	-0.00468***	-0.00409**	-0.00462***	-0.00480***	-0.00474***	-0.00470***
	(0.00168)	(0.00188)	(0.00170)	(0.00168)	(0.00166)	(0.00173)
Percent of cultivated land = perennial crops	0.00150	0.00149	0.00216*	0.00163	0.00161	0.00149
	(0.00111)	(0.00112)	(0.00127)	(0.00115)	(0.00114)	(0.00110)
Population: highest 20% of municipalities	0.132**	0.139**	0.136**	0.135**	0.133**	0.131**
	(0.0551)	(0.0588)	(0.0561)	(0.0559)	(0.0552)	(0.0561)
Proportion indigenous: 3rd quartile	0.159**	0.167**	0.165**	0.162**	0.157**	0.159**
	(0.0702)	(0.0766)	(0.0733)	(0.0730)	(0.0682)	(0.0713)
Proportion indigenous: 2nd quartile	0.275***	0.300***	0.290***	0.278***	0.270***	0.276***
	(0.0792)	(0.108)	(0.0907)	(0.0845)	(0.0733)	(0.0836)
Proportion indigenous: 1st quartile (highest)	0.280***	0.326**	0.346***	0.292***	0.278***	0.280***
	(0.0963)	(0.147)	(0.130)	(0.103)	(0.0930)	(0.101)
Annual Precipitation	-3.17e-05	-5.09e-05	-4.03e-05	-3.38e-05	-2.70e-05	-3.21e-05

	(5.56e-05)	(7.14e-05)	(5.59e-05)	(5.55e-05)	(5.93e-05)	(5.65e-05)
Annual Mean Temperature	0.00327					
	(0.0353)					
Mean Diurnal Range: monthly max temp - min temp		-0.0417				
		(0.0695)				
Isothermality			-0.00917			
			(0.00851)			
Temperature Seasonality				0.000611		
				(0.00123)		
Max Temperature of Warmest Month					0.0120	
					(0.0338)	
Min Temperature of Coldest Month						-0.000157
						(0.0276)
lnalpha	-0.964***	-0.966***	-0.972***	-0.965***	-0.964***	-0.964***
	(0.196)	(0.193)	(0.188)	(0.194)	(0.195)	(0.196)
Constant	3.422***	3.866***	4.132***	3.452***	3.092**	3.519***
	(1.071)	(0.612)	(0.553)	(0.276)	(1.275)	(0.677)
Observations	1,274	1,274	1,274	1,274	1,274	1,274
Pseudo R-squared	0.00986	0.00986	0.00986	0.00986	0.00986	0.00986

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A2: Outmigration rates (all ages) by baseline characteristics, annual rainfall, and selected temperature indicators, 1970-2000

VARIABLES	(1)	(2)	(3)	(4)	(5)
Municipality on the coast	-0.102*	-0.106	-0.113*	-0.117*	-0.108*
	(0.0591)	(0.0664)	(0.0603)	(0.0630)	(0.0638)
Mean slope of terrain across 90-m transects	-0.0129***	-0.0138***	-0.0125***	-0.0116**	-0.0133***
	(0.00373)	(0.00411)	(0.00471)	(0.00553)	(0.00407)
Percent of cultivated land = annual crops	-0.00491***	-0.00474***	-0.00466***	-0.00463***	-0.00473***
	(0.00172)	(0.00165)	(0.00172)	(0.00168)	(0.00167)
Percent of cultivated land = perennial crops	0.00162	0.00144	0.00148	0.00158	0.00149
	(0.00110)	(0.00110)	(0.00110)	(0.00115)	(0.00111)
Population: highest 20% of municipalities	0.130**	0.130**	0.133**	0.135**	0.131**
	(0.0566)	(0.0545)	(0.0553)	(0.0554)	(0.0553)
Proportion indigenous: 3rd quartile	0.157**	0.160**	0.159**	0.159**	0.160**
	(0.0704)	(0.0704)	(0.0710)	(0.0704)	(0.0699)
Proportion indigenous: 2nd quartile	0.269***	0.278***	0.275***	0.273***	0.277***
	(0.0813)	(0.0802)	(0.0813)	(0.0775)	(0.0806)
Proportion indigenous: 1st quartile (highest)	0.274***	0.279***	0.280***	0.284***	0.280***
	(0.0988)	(0.0947)	(0.0966)	(0.102)	(0.0925)
Annual Precipitation	-2.65e-05	-3.62e-05	-3.28e-05	-3.03e-05	-3.27e-05
	(6.41e-05)	(5.57e-05)	(5.62e-05)	(5.60e-05)	(5.52e-05)
Temperature Annual Range	0.0109				
	(0.0298)				

Mean Temperature of Wettest Quarter		-0.00929			
		(0.0270)			
Mean Temperature of Driest Quarter			0.00401		
			(0.0291)		
Mean Temperature of Warmest Quarter				0.0135	
				(0.0428)	
Mean Temperature of Coldest Quarter					-0.00320
					(0.0231)
lnalpha	-0.964***	-0.964***	-0.964***	-0.964***	-0.964***
	(0.196)	(0.196)	(0.196)	(0.194)	(0.196)
Constant	3.378***	3.784***	3.406***	3.114**	3.602***
	(0.471)	(0.814)	(0.875)	(1.346)	(0.672)
Observations	1,274	1,274	1,274	1,274	1,274
Pseudo R-squared	0.00986	0.00986	0.00986	0.00986	0.00986

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A3: Outmigration rates (ages 15-29) by baseline characteristics, annual rainfall, and selected temperature indicators, 1970-2000

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Municipality on the coast	-0.0577	-0.0654	-0.00217	-0.00800	-0.0477	-0.0393
	(0.0753)	(0.0713)	(0.0764)	(0.0772)	(0.0783)	(0.0693)
Mean slope of terrain across 90-m transects	-0.00824	-0.0121***	-0.0116***	-0.0122***	-0.00603	-0.0115**
	(0.00541)	(0.00408)	(0.00400)	(0.00405)	(0.00565)	(0.00500)
Percent of cultivated land = annual crops	-0.00184	-0.000817	-0.00191	-0.00250	-0.00231	-0.00195
	(0.00193)	(0.00218)	(0.00196)	(0.00195)	(0.00189)	(0.00197)
Percent of cultivated land = perennial crops	0.00272**	0.00258**	0.00410***	0.00319**	0.00320**	0.00263**
	(0.00131)	(0.00131)	(0.00140)	(0.00131)	(0.00131)	(0.00130)
Population: highest 20% of municipalities	0.0558	0.0645	0.0608	0.0626	0.0545	0.0495
	(0.0593)	(0.0631)	(0.0597)	(0.0594)	(0.0591)	(0.0599)
Proportion indigenous: 3rd quartile	0.162**	0.178**	0.176**	0.178**	0.155**	0.165**
	(0.0734)	(0.0781)	(0.0737)	(0.0757)	(0.0719)	(0.0744)
Proportion indigenous: 2nd quartile	0.276***	0.332***	0.317***	0.294***	0.255***	0.284***
	(0.0849)	(0.108)	(0.0899)	(0.0897)	(0.0805)	(0.0886)
Proportion indigenous: 1st quartile (highest)	0.252**	0.341**	0.401***	0.300***	0.241**	0.250**
	(0.0999)	(0.142)	(0.127)	(0.106)	(0.0970)	(0.103)
Annual Precipitation	4.10e-05	-2.46e-06	2.24e-05	3.14e-05	6.25e-05	3.40e-05
	(7.85e-05)	(8.67e-05)	(7.27e-05)	(7.61e-05)	(8.23e-05)	(7.95e-05)
Annual Mean Temperature	0.0402					
	(0.0355)					

Mean Diurnal Range: monthly max temp - min temp		-0.0863				
		(0.0710)				
Isothermality			-0.0217***			
			(0.00835)			
Temperature Seasonality				0.00271**		
				(0.00136)		
Max Temperature of Warmest Month					0.0582*	
					(0.0344)	
Min Temperature of Coldest Month						0.00684
						(0.0276)
lnalpha	-0.734***	-0.738***	-0.765***	-0.747***	-0.739***	-0.732***
	(0.156)	(0.154)	(0.146)	(0.154)	(0.154)	(0.158)
Constant	2.163**	4.035***	4.755***	3.016***	1.254	3.151***
	(1.058)	(0.636)	(0.542)	(0.333)	(1.295)	(0.670)
Observations	1,274	1,274	1,274	1,274	1,274	1,274
Pseudo R-squared	0.00571	0.00571	0.00571	0.00571	0.00571	0.00571

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A4: Outmigration rates (ages 15-29) by baseline characteristics, annual rainfall, and selected temperature indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)	(5)
Municipality on the coast	-0.000589	-0.0372	-0.0482	-0.0725	-0.0302
	(0.0691)	(0.0792)	(0.0724)	(0.0767)	(0.0754)
Mean slope of terrain across 90-m transects	-0.0119***	-0.0112**	-0.0103*	-0.00453	-0.0125***
	(0.00412)	(0.00457)	(0.00530)	(0.00587)	(0.00468)
Percent of cultivated land = annual crops	-0.00284	-0.00200	-0.00189	-0.00178	-0.00207
	(0.00192)	(0.00190)	(0.00196)	(0.00192)	(0.00191)
Percent of cultivated land = perennial crops	0.00320**	0.00271**	0.00257**	0.00306**	0.00266**
	(0.00132)	(0.00129)	(0.00131)	(0.00131)	(0.00130)
Population: highest 20% of municipalities	0.0413	0.0496	0.0512	0.0663	0.0475
	(0.0596)	(0.0590)	(0.0589)	(0.0599)	(0.0588)
Proportion indigenous: 3rd quartile	0.159**	0.164**	0.164**	0.160**	0.165**
	(0.0746)	(0.0737)	(0.0741)	(0.0730)	(0.0732)
Proportion indigenous: 2nd quartile	0.259***	0.281***	0.282***	0.269***	0.284***
	(0.0866)	(0.0854)	(0.0871)	(0.0827)	(0.0861)
Proportion indigenous: 1st quartile (highest)	0.224**	0.248**	0.251**	0.272***	0.248***
	(0.100)	(0.0978)	(0.0994)	(0.105)	(0.0947)
Annual Precipitation	5.85e-05	3.93e-05	3.23e-05	4.85e-05	3.42e-05
	(8.67e-05)	(7.63e-05)	(7.99e-05)	(7.95e-05)	(7.70e-05)
Temperature Annual Range	0.0417				
	(0.0316)				

Mean Temperature of Wettest Quarter		0.0106			
		(0.0267)			
Mean Temperature of Driest Quarter			0.0187		
			(0.0285)		
Mean Temperature of Warmest Quarter				0.0755*	
				(0.0424)	
Mean Temperature of Coldest Quarter					-0.00293
					(0.0226)
lnalpha	-0.736***	-0.732***	-0.732***	-0.742***	-0.732***
	(0.159)	(0.159)	(0.158)	(0.152)	(0.159)
Constant	2.769***	2.998***	2.796***	1.057	3.382***
	(0.536)	(0.783)	(0.851)	(1.329)	(0.637)
Observations	1,274	1,274	1,274	1,274	1,274
Pseudo R-squared	0.00571	0.00571	0.00571	0.00571	0.00571

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A5: Outmigration rates (ages 30-49) by baseline characteristics, annual rainfall, and selected temperature indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Municipality on the coast	-0.164**	-0.169**	-0.115	-0.125	-0.162**	-0.137**
	(0.0749)	(0.0692)	(0.0748)	(0.0769)	(0.0780)	(0.0673)
Mean slope of terrain across 90-m transects	-0.0159***	-0.0180***	-0.0176***	-0.0183***	-0.0125**	-0.0194***
	(0.00563)	(0.00463)	(0.00446)	(0.00456)	(0.00555)	(0.00563)
Percent of cultivated land = annual crops	-0.00607***	-0.00542**	-0.00607***	-0.00656***	-0.00646***	-0.00636***
	(0.00209)	(0.00242)	(0.00217)	(0.00216)	(0.00207)	(0.00216)
Percent of cultivated land = perennial crops	-9.93e-05	-0.000163	0.00134	0.000424	0.000348	-6.45e-05
	(0.00118)	(0.00118)	(0.00135)	(0.00124)	(0.00119)	(0.00117)
Population: highest 20% of municipalities	0.114*	0.118*	0.117**	0.121**	0.114*	0.107*
	(0.0605)	(0.0631)	(0.0586)	(0.0595)	(0.0600)	(0.0611)
Proportion indigenous: 3rd quartile	0.214***	0.225***	0.225***	0.227***	0.205**	0.217***
	(0.0816)	(0.0874)	(0.0801)	(0.0833)	(0.0800)	(0.0827)
Proportion indigenous: 2nd quartile	0.343***	0.378***	0.380***	0.356***	0.320***	0.345***
	(0.0911)	(0.118)	(0.0976)	(0.0970)	(0.0868)	(0.0950)
Proportion indigenous: 1st quartile (highest)	0.275***	0.329**	0.423***	0.323***	0.266***	0.267***
	(0.0954)	(0.146)	(0.127)	(0.109)	(0.0926)	(0.100)
Annual Precipitation	5.83e-05	3.19e-05	3.72e-05	4.83e-05	7.89e-05	5.64e-05
	(6.53e-05)	(7.86e-05)	(6.35e-05)	(6.59e-05)	(6.86e-05)	(6.68e-05)
Annual Mean Temperature	0.0228					
	(0.0347)					

Mean Diurnal Range: monthly max temp - min temp		-0.0515				
		(0.0704)				
Isothermality			-0.0213***			
			(0.00808)			
Temperature Seasonality				0.00253*		
				(0.00153)		
Max Temperature of Warmest Month					0.0540*	
					(0.0325)	
Min Temperature of Coldest Month						-0.0131
						(0.0291)
lnalpha	-0.848***	-0.850***	-0.885***	-0.862***	-0.855***	-0.848***
	(0.153)	(0.151)	(0.140)	(0.148)	(0.150)	(0.155)
Constant	2.268**	3.348***	4.350***	2.653***	1.022	3.204***
	(1.034)	(0.619)	(0.563)	(0.323)	(1.209)	(0.716)
Observations	1,274	1,274	1,274	1,274	1,274	1,274
Pseudo R-squared	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A6: Outmigration rates (ages 30-49) by baseline characteristics, annual rainfall, and selected temperature indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)	(5)
Municipality on the coast	-0.102	-0.154*	-0.147**	-0.181**	-0.141*
	(0.0659)	(0.0794)	(0.0714)	(0.0763)	(0.0755)
Mean slope of terrain across 90-m transects	-0.0179***	-0.0173***	-0.0184***	-0.0118**	-0.0193***
	(0.00455)	(0.00480)	(0.00583)	(0.00591)	(0.00505)
Percent of cultivated land = annual crops	-0.00741***	-0.00614***	-0.00620***	-0.00598***	-0.00626***
	(0.00219)	(0.00206)	(0.00215)	(0.00208)	(0.00209)
Percent of cultivated land = perennial crops	0.000687	-8.30e-05	-0.000106	0.000191	-0.000107
	(0.00120)	(0.00116)	(0.00117)	(0.00119)	(0.00117)
Population: highest 20% of municipalities	0.0987	0.111*	0.109*	0.123**	0.108*
	(0.0602)	(0.0600)	(0.0605)	(0.0604)	(0.0602)
Proportion indigenous: 3rd quartile	0.204**	0.215***	0.217***	0.211***	0.218***
	(0.0816)	(0.0818)	(0.0825)	(0.0808)	(0.0818)
Proportion indigenous: 2nd quartile	0.307***	0.345***	0.347***	0.335***	0.350***
	(0.0920)	(0.0918)	(0.0933)	(0.0888)	(0.0928)
Proportion indigenous: 1st quartile (highest)	0.238**	0.273***	0.272***	0.292***	0.275***
	(0.0988)	(0.0942)	(0.0957)	(0.101)	(0.0913)
Annual Precipitation	8.94e-05	5.90e-05	5.55e-05	6.45e-05	5.31e-05
	(7.43e-05)	(6.45e-05)	(6.66e-05)	(6.60e-05)	(6.46e-05)
Temperature Annual Range	0.0627*				
	(0.0326)				

Mean Temperature of Wettest Quarter		0.00892			
		(0.0275)			
Mean Temperature of Driest Quarter			-0.00342		
			(0.0291)		
Mean Temperature of Warmest Quarter				0.0626	
				(0.0415)	
Mean Temperature of Coldest Quarter					-0.0118
					(0.0233)
lnalpha	-0.859***	-0.848***	-0.848***	-0.855***	-0.848***
	(0.154)	(0.154)	(0.155)	(0.149)	(0.155)
Constant	2.117***	2.655***	3.005***	1.057	3.230***
	(0.499)	(0.794)	(0.882)	(1.287)	(0.658)
Observations	1,274	1,274	1,274	1,274	1,274
Pseudo R-squared	0.0135	0.0135	0.0135	0.0135	0.0135

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A7: Outmigration rates (ages 50+) by baseline characteristics, annual rainfall, and selected temperature indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Municipality on the coast	-0.226***	-0.206**	-0.182**	-0.194**	-0.227***	-0.197**
	(0.0838)	(0.0850)	(0.0822)	(0.0856)	(0.0850)	(0.0799)
Mean slope of terrain across 90-m transects	-0.0196***	-0.0223***	-0.0224***	-0.0225***	-0.0154**	-0.0235***
	(0.00675)	(0.00566)	(0.00546)	(0.00561)	(0.00650)	(0.00669)
Percent of cultivated land = annual crops	-0.00888***	-0.00917***	-0.00899***	-0.00927***	-0.00930***	-0.00923***
	(0.00242)	(0.00251)	(0.00239)	(0.00242)	(0.00238)	(0.00251)
Percent of cultivated land = perennial crops	-0.00334**	-0.00338**	-0.00237*	-0.00311**	-0.00277**	-0.00335**
	(0.00133)	(0.00135)	(0.00137)	(0.00137)	(0.00129)	(0.00135)
Population: highest 20% of municipalities	0.268***	0.260***	0.273***	0.269***	0.275***	0.258***
	(0.0692)	(0.0700)	(0.0682)	(0.0688)	(0.0690)	(0.0694)
Proportion indigenous: 3rd quartile	0.172*	0.174	0.174*	0.179*	0.154	0.175*
	(0.102)	(0.106)	(0.101)	(0.103)	(0.0991)	(0.103)
Proportion indigenous: 2nd quartile	0.325***	0.325***	0.346***	0.334***	0.292***	0.329***
	(0.106)	(0.119)	(0.110)	(0.110)	(0.103)	(0.109)
Proportion indigenous: 1st quartile (highest)	0.374***	0.363***	0.483***	0.399***	0.360***	0.368***
	(0.0942)	(0.122)	(0.121)	(0.106)	(0.0933)	(0.0967)
Annual Precipitation	4.75e-05	4.71e-05	3.23e-05	4.20e-05	6.94e-05	4.48e-05
	(6.70e-05)	(6.89e-05)	(6.18e-05)	(6.52e-05)	(6.90e-05)	(6.57e-05)
Annual Mean Temperature	0.0263					
	(0.0390)					

Mean Diurnal Range: monthly max temp - min temp		0.00836				
		(0.0461)				
Isothermality			-0.0158**			
			(0.00704)			
Temperature Seasonality				0.00137		
				(0.00135)		
Max Temperature of Warmest Month					0.0643*	
					(0.0366)	
Min Temperature of Coldest Month						-0.0115
						(0.0276)
lnalpha	-0.317**	-0.316**	-0.330***	-0.319**	-0.324**	-0.317**
	(0.130)	(0.131)	(0.127)	(0.130)	(0.129)	(0.131)
Constant	1.863	2.539***	3.688***	2.468***	0.361	2.867***
	(1.183)	(0.460)	(0.566)	(0.338)	(1.345)	(0.744)
Observations	1,274	1,274	1,274	1,274	1,274	1,274
Pseudo R-squared	0.0158	0.0158	0.0158	0.0158	0.0158	0.0158

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A8: Outmigration rates (ages 50+) by baseline characteristics, annual rainfall, and selected temperature indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)	(5)
Municipality on the coast	-0.153*	-0.218**	-0.209**	-0.238***	-0.214**
	(0.0796)	(0.0865)	(0.0813)	(0.0853)	(0.0840)
Mean slope of terrain across 90-m transects	-0.0222***	-0.0204***	-0.0223***	-0.0165**	-0.0216***
	(0.00557)	(0.00592)	(0.00694)	(0.00658)	(0.00639)
Percent of cultivated land = annual crops	-0.0105***	-0.00894***	-0.00904***	-0.00879***	-0.00899***
	(0.00249)	(0.00238)	(0.00249)	(0.00238)	(0.00242)
Percent of cultivated land = perennial crops	-0.00249*	-0.00329**	-0.00339**	-0.00308**	-0.00339**
	(0.00133)	(0.00132)	(0.00136)	(0.00131)	(0.00135)
Population: highest 20% of municipalities	0.254***	0.266***	0.261***	0.279***	0.262***
	(0.0674)	(0.0691)	(0.0689)	(0.0689)	(0.0693)
Proportion indigenous: 3rd quartile	0.151	0.172*	0.176*	0.167*	0.174*
	(0.0996)	(0.102)	(0.103)	(0.100)	(0.102)
Proportion indigenous: 2nd quartile	0.278***	0.324***	0.331***	0.316***	0.329***
	(0.104)	(0.107)	(0.108)	(0.104)	(0.108)
Proportion indigenous: 1st quartile (highest)	0.330***	0.373***	0.372***	0.388***	0.371***
	(0.0965)	(0.0941)	(0.0947)	(0.0972)	(0.0932)
Annual Precipitation	7.79e-05	5.28e-05	4.39e-05	5.24e-05	4.47e-05
	(6.65e-05)	(6.74e-05)	(6.60e-05)	(6.72e-05)	(6.61e-05)
Temperature Annual Range	0.0713**				
	(0.0294)				

Mean Temperature of Wettest Quarter		0.0205			
		(0.0336)			
Mean Temperature of Driest Quarter			-0.000120		
			(0.0314)		
Mean Temperature of Warmest Quarter				0.0560	
				(0.0420)	
Mean Temperature of Coldest Quarter					0.00622
					(0.0293)
lnalpha	-0.327**	-0.317**	-0.316**	-0.321**	-0.316**
	(0.130)	(0.131)	(0.131)	(0.129)	(0.131)
Constant	1.724***	2.014**	2.612***	0.943	2.440***
	(0.443)	(0.998)	(0.969)	(1.312)	(0.861)
Observations	1,274	1,274	1,274	1,274	1,274
Pseudo R-squared	0.0158	0.0158	0.0158	0.0158	0.0158

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix B

Table B1: Outmigration rates (all ages) by baseline characteristics, annual temperature, and selected precipitation indicators, 1970-2000

VARIABLES	(1)	(2)	(3)	(4)
Municipality on the coast	-0.112*	-0.119**	-0.107*	-0.112*
	(0.0619)	(0.0602)	(0.0602)	(0.0589)
Mean slope of terrain across 90-m transects	-0.0126***	-0.0122**	-0.0121**	-0.0114**
	(0.00486)	(0.00491)	(0.00481)	(0.00496)
Percent of cultivated land = annual crops	-0.00468***	-0.00438***	-0.00461***	-0.00432***
	(0.00168)	(0.00165)	(0.00166)	(0.00163)
Percent of cultivated land = perennial crops	0.00150	0.00180	0.00206*	0.00233*
	(0.00111)	(0.00119)	(0.00124)	(0.00133)
Population: highest 20% of municipalities	0.132**	0.139**	0.131**	0.134**
	(0.0551)	(0.0575)	(0.0563)	(0.0573)
Proportion indigenous: 3rd quartile	0.159**	0.159**	0.149**	0.153**
	(0.0702)	(0.0696)	(0.0653)	(0.0664)
Proportion indigenous: 2nd quartile	0.275***	0.273***	0.262***	0.262***
	(0.0792)	(0.0761)	(0.0724)	(0.0708)
Proportion indigenous: 1st quartile (highest)	0.280***	0.270***	0.293***	0.280***
	(0.0963)	(0.0936)	(0.104)	(0.0985)
Annual Mean Temperature	0.00327	0.00556	0.00349	0.00516
	(0.0353)	(0.0357)	(0.0340)	(0.0345)
Annual Precipitation	-3.17e-05			
	(5.56e-05)			
Precipitation of Wettest Month		9.88e-05		
		(0.000195)		
Precipitation of Driest Month			-0.000901	
			(0.000838)	
Precipitation Seasonality (Coefficient of Variation)				0.00173
				(0.00175)
lnalpha	-0.964***	-0.964***	-0.967***	-0.967***
	(0.196)	(0.195)	(0.192)	(0.191)
Constant	3.422***	3.227***	3.370***	3.145***
	(1.071)	(1.098)	(1.015)	(1.097)
Observations	1,274	1,274	1,274	1,274
Pseudo R-squared	0.00988	0.00988	0.00988	0.00988

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table B2: Outmigration rates (all ages) by baseline characteristics, annual temperature, and selected precipitation indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)
Municipality on the coast	-0.119**	-0.106*	-0.116**	-0.110*
	(0.0602)	(0.0604)	(0.0592)	(0.0593)
Mean slope of terrain across 90-m transects	-0.0123**	-0.0120**	-0.0125***	-0.0125***
	(0.00495)	(0.00480)	(0.00481)	(0.00479)
Percent of cultivated land = annual crops	-0.00441***	-0.00463***	-0.00441***	-0.00467***
	(0.00166)	(0.00166)	(0.00168)	(0.00169)
Percent of cultivated land = perennial crops	0.00175	0.00206*	0.00147	0.00171
	(0.00118)	(0.00124)	(0.00114)	(0.00113)
Population: highest 20% of municipalities	0.138**	0.129**	0.132**	0.132**
	(0.0574)	(0.0560)	(0.0566)	(0.0561)
Proportion indigenous: 3rd quartile	0.160**	0.150**	0.155**	0.156**
	(0.0699)	(0.0656)	(0.0674)	(0.0692)
Proportion indigenous: 2nd quartile	0.274***	0.262***	0.275***	0.269***
	(0.0769)	(0.0724)	(0.0787)	(0.0775)
Proportion indigenous: 1st quartile (highest)	0.272***	0.291***	0.283***	0.278***
	(0.0937)	(0.103)	(0.0998)	(0.0959)
Annual Mean Temperature	0.00526	0.00301	-0.00809	0.00499
	(0.0359)	(0.0339)	(0.0306)	(0.0352)
Precipitation of Wettest Quarter	3.55e-05			
	(8.88e-05)			
Precipitation of Driest Quarter		-0.000291		
		(0.000263)		
Precipitation of Warmest Quarter			-0.000384	
			(0.000297)	
Precipitation of Coldest Quarter				-5.81e-05
				(8.62e-05)
lnalpha	-0.963***	-0.968***	-0.969***	-0.964***
	(0.195)	(0.192)	(0.191)	(0.196)
Constant	3.238***	3.390***	3.843***	3.317***
	(1.112)	(1.013)	(0.889)	(1.061)
Observations	1,274	1,274	1,274	1,274
Pseudo R-squared	0.00988	0.00988	0.00988	0.00988

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table B3: Outmigration rates (ages 15-29) by baseline characteristics, annual temperature, and selected precipitation indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)
Municipality on the coast	-0.0577	-0.0650	-0.0396	-0.0427
	(0.0753)	(0.0732)	(0.0724)	(0.0710)
Mean slope of terrain across 90-m transects	-0.00824	-0.00691	-0.00787	-0.00646
	(0.00541)	(0.00539)	(0.00542)	(0.00545)
Percent of cultivated land = annual crops	-0.00184	-0.00136	-0.00209	-0.00166
	(0.00193)	(0.00189)	(0.00188)	(0.00185)
Percent of cultivated land = perennial crops	0.00272**	0.00361***	0.00316**	0.00395***
	(0.00131)	(0.00139)	(0.00140)	(0.00150)
Population: highest 20% of municipalities	0.0558	0.0595	0.0496	0.0506
	(0.0593)	(0.0615)	(0.0598)	(0.0608)
Proportion indigenous: 3rd quartile	0.162**	0.153**	0.148**	0.147**
	(0.0734)	(0.0734)	(0.0677)	(0.0703)
Proportion indigenous: 2nd quartile	0.276***	0.258***	0.259***	0.250***
	(0.0849)	(0.0799)	(0.0786)	(0.0753)
Proportion indigenous: 1st quartile (highest)	0.252**	0.244**	0.274**	0.267***
	(0.0999)	(0.0971)	(0.108)	(0.103)
Annual Mean Temperature	0.0402	0.0428	0.0370	0.0385
	(0.0355)	(0.0353)	(0.0345)	(0.0344)
Annual Precipitation	4.10e-05			
	(7.85e-05)			
Precipitation of Wettest Month		0.000421		
		(0.000261)		
Precipitation of Driest Month			-0.000904	
			(0.000873)	
Precipitation Seasonality (Coefficient of Variation)				0.00292
				(0.00184)
lnalpha	-0.734***	-0.740***	-0.737***	-0.742***
	(0.156)	(0.154)	(0.154)	(0.152)
Constant	2.163**	1.976*	2.388**	2.067*
	(1.058)	(1.082)	(1.020)	(1.087)
Observations	1,274	1,274	1,274	1,274
Pseudo R-squared	0.00591	0.00591	0.00591	0.00591

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table B4: Outmigration rates (ages 15-29) by baseline characteristics, annual temperature, and selected precipitation indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)
Municipality on the coast	-0.0634	-0.0392	-0.0503	-0.0502
	(0.0733)	(0.0722)	(0.0725)	(0.0710)
Mean slope of terrain across 90-m transects	-0.00708	-0.00789	-0.00829	-0.00833
	(0.00543)	(0.00541)	(0.00545)	(0.00541)
Percent of cultivated land = annual crops	-0.00141	-0.00211	-0.00198	-0.00203
	(0.00191)	(0.00188)	(0.00188)	(0.00192)
Percent of cultivated land = perennial crops	0.00351**	0.00314**	0.00258*	0.00265**
	(0.00140)	(0.00140)	(0.00132)	(0.00133)
Population: highest 20% of municipalities	0.0580	0.0480	0.0506	0.0518
	(0.0616)	(0.0596)	(0.0596)	(0.0595)
Proportion indigenous: 3rd quartile	0.155**	0.149**	0.157**	0.159**
	(0.0736)	(0.0682)	(0.0701)	(0.0721)
Proportion indigenous: 2nd quartile	0.264***	0.260***	0.274***	0.274***
	(0.0806)	(0.0785)	(0.0850)	(0.0842)
Proportion indigenous: 1st quartile (highest)	0.250**	0.272**	0.261**	0.258***
	(0.0979)	(0.107)	(0.102)	(0.0998)
Annual Mean Temperature	0.0420	0.0364	0.0332	0.0384
	(0.0356)	(0.0344)	(0.0310)	(0.0361)
Precipitation of Wettest Quarter	0.000170			
	(0.000119)			
Precipitation of Driest Quarter		-0.000278		
		(0.000277)		
Precipitation of Warmest Quarter			-0.000161	
			(0.000340)	
Precipitation of Coldest Quarter				-5.00e-06
				(0.000103)
lnalpha	-0.740***	-0.737***	-0.734***	-0.733***
	(0.154)	(0.155)	(0.155)	(0.156)
Constant	1.988*	2.409**	2.540***	2.320**
	(1.096)	(1.015)	(0.888)	(1.072)
Observations	1,274	1,274	1,274	1,274
Pseudo R-squared	0.00591	0.00591	0.00591	0.00591

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table B5: Outmigration rates (ages 30-49) by baseline characteristics, annual temperature, and selected precipitation indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)
Municipality on the coast	-0.164**	-0.176**	-0.141**	-0.142**
	(0.0749)	(0.0730)	(0.0716)	(0.0689)
Mean slope of terrain across 90-m transects	-0.0159***	-0.0139**	-0.0154***	-0.0128**
	(0.00563)	(0.00542)	(0.00559)	(0.00534)
Percent of cultivated land = annual crops	-0.00607***	-0.00539***	-0.00649***	-0.00586***
	(0.00209)	(0.00193)	(0.00210)	(0.00195)
Percent of cultivated land = perennial crops	-9.93e-05	0.00130	0.000451	0.00206
	(0.00118)	(0.00122)	(0.00129)	(0.00138)
Population: highest 20% of municipalities	0.114*	0.120**	0.103*	0.105*
	(0.0605)	(0.0611)	(0.0605)	(0.0595)
Proportion indigenous: 3rd quartile	0.214***	0.200**	0.192***	0.185**
	(0.0816)	(0.0798)	(0.0743)	(0.0749)
Proportion indigenous: 2nd quartile	0.343***	0.316***	0.317***	0.298***
	(0.0911)	(0.0860)	(0.0830)	(0.0793)
Proportion indigenous: 1st quartile (highest)	0.275***	0.262***	0.305***	0.300***
	(0.0954)	(0.0936)	(0.104)	(0.0999)
Annual Mean Temperature	0.0228	0.0255	0.0177	0.0183
	(0.0347)	(0.0344)	(0.0335)	(0.0333)
Annual Precipitation	5.83e-05			
	(6.53e-05)			
Precipitation of Wettest Month		0.000650***		
		(0.000235)		
Precipitation of Driest Month			-0.00119	
			(0.000873)	
Precipitation Seasonality (Coefficient of Variation)				0.00504***
				(0.00173)
lnalpha	-0.848***	-0.866***	-0.853***	-0.875***
	(0.153)	(0.148)	(0.150)	(0.145)
Constant	2.268**	2.005*	2.606***	2.118**
	(1.034)	(1.053)	(0.992)	(1.046)
Observations	1,274	1,274	1,274	1,274
Pseudo R-squared	0.0134	0.0134	0.0134	0.0134

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table B6: Outmigration rates (ages 30-49) by baseline characteristics, annual temperature, and selected precipitation indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)
Municipality on the coast	-0.164**	-0.176**	-0.141**	-0.142**
	(0.0749)	(0.0730)	(0.0716)	(0.0689)
Mean slope of terrain across 90-m transects	-0.0159***	-0.0139**	-0.0154***	-0.0128**
	(0.00563)	(0.00542)	(0.00559)	(0.00534)
Percent of cultivated land = annual crops	-0.00607***	-0.00539***	-0.00649***	-0.00586***
	(0.00209)	(0.00193)	(0.00210)	(0.00195)
Percent of cultivated land = perennial crops	-9.93e-05	0.00130	0.000451	0.00206
	(0.00118)	(0.00122)	(0.00129)	(0.00138)
Population: highest 20% of municipalities	0.114*	0.120**	0.103*	0.105*
	(0.0605)	(0.0611)	(0.0605)	(0.0595)
Proportion indigenous: 3rd quartile	0.214***	0.200**	0.192***	0.185**
	(0.0816)	(0.0798)	(0.0743)	(0.0749)
Proportion indigenous: 2nd quartile	0.343***	0.316***	0.317***	0.298***
	(0.0911)	(0.0860)	(0.0830)	(0.0793)
Proportion indigenous: 1st quartile (highest)	0.275***	0.262***	0.305***	0.300***
	(0.0954)	(0.0936)	(0.104)	(0.0999)
Annual Mean Temperature	0.0228	0.0255	0.0177	0.0183
	(0.0347)	(0.0344)	(0.0335)	(0.0333)
Annual Precipitation	5.83e-05			
	(6.53e-05)			
Precipitation of Wettest Month		0.000650***		
		(0.000235)		
Precipitation of Driest Month			-0.00119	
			(0.000873)	
Precipitation Seasonality (Coefficient of Variation)				0.00504***
				(0.00173)
lnalpha	-0.848***	-0.866***	-0.853***	-0.875***
	(0.153)	(0.148)	(0.150)	(0.145)
Constant	2.268**	2.005*	2.606***	2.118**
	(1.034)	(1.053)	(0.992)	(1.046)
Observations	1,274	1,274	1,274	1,274
Pseudo R-squared	0.0134	0.0134	0.0134	0.0134

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table B7: Outmigration rates (ages 50+) by baseline characteristics, annual temperature, and selected precipitation indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)
Municipality on the coast	-0.226***	-0.241***	-0.207**	-0.211***
	(0.0838)	(0.0837)	(0.0814)	(0.0796)
Mean slope of terrain across 90-m transects	-0.0196***	-0.0176***	-0.0192***	-0.0166***
	(0.00675)	(0.00635)	(0.00661)	(0.00613)
Percent of cultivated land = annual crops	-0.00888***	-0.00814***	-0.00931***	-0.00863***
	(0.00242)	(0.00217)	(0.00239)	(0.00216)
Percent of cultivated land = perennial crops	-0.00334**	-0.00201	-0.00272**	-0.00130
	(0.00133)	(0.00133)	(0.00136)	(0.00141)
Population: highest 20% of municipalities	0.268***	0.280***	0.259***	0.267***
	(0.0692)	(0.0681)	(0.0680)	(0.0665)
Proportion indigenous: 3rd quartile	0.172*	0.150	0.148	0.130
	(0.102)	(0.0982)	(0.0936)	(0.0913)
Proportion indigenous: 2nd quartile	0.325***	0.289***	0.301***	0.271***
	(0.106)	(0.101)	(0.100)	(0.0953)
Proportion indigenous: 1st quartile (highest)	0.374***	0.357***	0.405***	0.395***
	(0.0942)	(0.0939)	(0.0994)	(0.0971)
Annual Mean Temperature	0.0263	0.0319	0.0227	0.0260
	(0.0390)	(0.0354)	(0.0353)	(0.0325)
Annual Precipitation	4.75e-05			
	(6.70e-05)			
Precipitation of Wettest Month		0.000626***		
		(0.000231)		
Precipitation of Driest Month			-0.00125	
			(0.000894)	
Precipitation Seasonality (Coefficient of Variation)				0.00490***
				(0.00174)
lnalpha	-0.317**	-0.329***	-0.321**	-0.335***
	(0.130)	(0.128)	(0.129)	(0.126)
Constant	1.863	1.509	2.139**	1.594
	(1.183)	(1.060)	(1.044)	(0.991)
Observations	1,274	1,274	1,274	1,274
Pseudo R-squared	0.0164	0.0164	0.0164	0.0164

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table B8: Outmigration rates (ages 50+) by baseline characteristics, annual temperature, and selected precipitation indicators, 1970-2000.

VARIABLES	(1)	(2)	(3)	(4)
Municipality on the coast	-0.238***	-0.204**	-0.219***	-0.201**
	(0.0835)	(0.0811)	(0.0849)	(0.0819)
Mean slope of terrain across 90-m transects	-0.0178***	-0.0191***	-0.0197***	-0.0196***
	(0.00645)	(0.00659)	(0.00673)	(0.00669)
Percent of cultivated land = annual crops	-0.00819***	-0.00937***	-0.00908***	-0.00961***
	(0.00219)	(0.00240)	(0.00234)	(0.00246)
Percent of cultivated land = perennial crops	-0.00216	-0.00265*	-0.00350**	-0.00294**
	(0.00133)	(0.00136)	(0.00137)	(0.00133)
Population: highest 20% of municipalities	0.278***	0.256***	0.259***	0.252***
	(0.0685)	(0.0677)	(0.0695)	(0.0677)
Proportion indigenous: 3rd quartile	0.154	0.146	0.168*	0.149
	(0.0990)	(0.0934)	(0.0994)	(0.0960)
Proportion indigenous: 2nd quartile	0.297***	0.299***	0.327***	0.298***
	(0.101)	(0.100)	(0.107)	(0.103)
Proportion indigenous: 1st quartile (highest)	0.367***	0.405***	0.387***	0.392***
	(0.0945)	(0.0991)	(0.0944)	(0.0963)
Annual Mean Temperature	0.0300	0.0215	0.0177	0.0253
	(0.0367)	(0.0350)	(0.0369)	(0.0367)
Precipitation of Wettest Quarter	0.000256**			
	(0.000102)			
Precipitation of Driest Quarter		-0.000441		
		(0.000281)		
Precipitation of Warmest Quarter			-0.000207	
			(0.000291)	
Precipitation of Coldest Quarter				-0.000179*
				(0.000104)
lnalpha	-0.327**	-0.322**	-0.317**	-0.321**
	(0.128)	(0.129)	(0.129)	(0.130)
Constant	1.543	2.184**	2.324**	2.086*
	(1.103)	(1.040)	(1.110)	(1.081)
Observations	1,274	1,274	1,274	1,274
Pseudo R-squared	0.0164	0.0164	0.0164	0.0164

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix C

Table C1: Outmigration rates (ages 15-29) by change in selected precipitation indicators, 3-year measures.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Municipality on the coast	0.110	0.147*	0.122*	0.141*	0.145*	0.135*	0.137*
	(0.0729)	(0.0795)	(0.0717)	(0.0769)	(0.0788)	(0.0746)	(0.0748)
Mean slope of terrain across 90-m transects	-0.00403	-0.00517	-0.00464	-0.00467	-0.00550	-0.00604	-0.00452
	(0.00429)	(0.00410)	(0.00422)	(0.00410)	(0.00409)	(0.00406)	(0.00410)
Percent of cultivated land = annual crops	0.00192	0.00276	0.00277	0.00275	0.00269	0.00245	0.00243
	(0.00190)	(0.00198)	(0.00197)	(0.00197)	(0.00200)	(0.00198)	(0.00196)
Percent of cultivated land = perennial crops	0.00172	0.00316**	0.00302**	0.00309**	0.00290**	0.00263*	0.00324**
	(0.00126)	(0.00139)	(0.00140)	(0.00132)	(0.00135)	(0.00135)	(0.00133)
Population: highest 20% of municipalities	-0.0160	-0.0474	-0.0352	-0.0354	-0.0329	-0.0257	-0.0240
	(0.0646)	(0.0554)	(0.0568)	(0.0568)	(0.0573)	(0.0575)	(0.0597)
Proportion indigenous: 3rd quartile	0.161**	0.169**	0.161**	0.171**	0.187***	0.192***	0.187***
	(0.0716)	(0.0677)	(0.0691)	(0.0680)	(0.0695)	(0.0700)	(0.0693)
Proportion indigenous: 2nd quartile	0.227***	0.240***	0.243***	0.257***	0.265***	0.271***	0.255***
	(0.0832)	(0.0757)	(0.0783)	(0.0761)	(0.0800)	(0.0817)	(0.0752)
Proportion indigenous: 1st quartile (highest)	0.192*	0.240**	0.265***	0.267***	0.258***	0.263***	0.253***
	(0.0996)	(0.0972)	(0.100)	(0.100)	(0.0954)	(0.0975)	(0.0911)
Diurnal temperature range (Celsius)	0.0204	0.0238	0.0285	0.0232	0.0260	0.0250	0.0267
	(0.0187)	(0.0178)	(0.0180)	(0.0176)	(0.0190)	(0.0183)	(0.0189)
Provincial outmigration rate, 1995-2000	15.75***	14.89***	14.70***	14.28***	15.07***	15.33***	14.89***
	(3.534)	(3.323)	(3.331)	(3.215)	(3.256)	(3.255)	(3.294)

Consecutive wet days Days	-0.00781				
	(0.0102)				
Change in consecutive wet days	0.0160*				
	(0.00935)				
Annual total wet-day precipitation mm		3.95e-05			
		(7.28e-05)			
Change in annual total wet-day precipitation		-0.000642**			
		(0.000298)			
Number of heavy precipitation days Days			-0.00290		
			(0.00271)		
Change in heavy precipitation days			-0.0171***		
			(0.00610)		
Number of very heavy precipitation days Days				0.00188	
				(0.00349)	
Change in very heavy precipitation days				-0.0263**	
				(0.0104)	
Very wet days mm					0.000233*
					(0.000123)
Change in very et days					-0.000545**
					(0.000273)
Extremely wet days mm						0.000367**
						(0.000168)
Change in extremely wet days						-0.000646**
						(0.000308)

Simple daily intensity index mm/day							0.0271**
							(0.0107)
Change in simple daily intensity index							-0.0609*
							(0.0342)
lnalpha	-0.838***	-0.849***	-0.851***	-0.865***	-0.853***	-0.854***	-0.859***
	(0.140)	(0.137)	(0.136)	(0.135)	(0.136)	(0.135)	(0.138)
Constant	2.538***	2.163***	2.486***	2.272***	2.005***	2.033***	1.899***
	(0.324)	(0.419)	(0.355)	(0.359)	(0.441)	(0.425)	(0.449)
Observations	1,240	1,240	1,240	1,239	1,240	1,240	1,240
Pseudo R-squared	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table C2: Outmigration rates (ages 30-49) by change in selected precipitation indicators, 3-year measures.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES							
Municipality on the coast	0.110	0.147*	0.122*	0.141*	0.145*	0.135*	0.137*
	(0.0729)	(0.0795)	(0.0717)	(0.0769)	(0.0788)	(0.0746)	(0.0748)
Mean slope of terrain across 90-m transects	-0.00403	-0.00517	-0.00464	-0.00467	-0.00550	-0.00604	-0.00452
	(0.00429)	(0.00410)	(0.00422)	(0.00410)	(0.00409)	(0.00406)	(0.00410)
Percent of cultivated land = annual crops	0.00192	0.00276	0.00277	0.00275	0.00269	0.00245	0.00243
	(0.00190)	(0.00198)	(0.00197)	(0.00197)	(0.00200)	(0.00198)	(0.00196)
Percent of cultivated land = perennial crops	0.00172	0.00316**	0.00302**	0.00309**	0.00290**	0.00263*	0.00324**
	(0.00126)	(0.00139)	(0.00140)	(0.00132)	(0.00135)	(0.00135)	(0.00133)
Population: highest 20% of municipalities	-0.0160	-0.0474	-0.0352	-0.0354	-0.0329	-0.0257	-0.0240
	(0.0646)	(0.0554)	(0.0568)	(0.0568)	(0.0573)	(0.0575)	(0.0597)
Proportion indigenous: 3rd quartile	0.161**	0.169**	0.161**	0.171**	0.187***	0.192***	0.187***
	(0.0716)	(0.0677)	(0.0691)	(0.0680)	(0.0695)	(0.0700)	(0.0693)
Proportion indigenous: 2nd quartile	0.227***	0.240***	0.243***	0.257***	0.265***	0.271***	0.255***
	(0.0832)	(0.0757)	(0.0783)	(0.0761)	(0.0800)	(0.0817)	(0.0752)
Proportion indigenous: 1st quartile (highest)	0.192*	0.240**	0.265***	0.267***	0.258***	0.263***	0.253***
	(0.0996)	(0.0972)	(0.100)	(0.100)	(0.0954)	(0.0975)	(0.0911)
Diurnal temperature range (Celsius)	0.0204	0.0238	0.0285	0.0232	0.0260	0.0250	0.0267
	(0.0187)	(0.0178)	(0.0180)	(0.0176)	(0.0190)	(0.0183)	(0.0189)
Provincial outmigration rate, 1995-2000	15.75***	14.89***	14.70***	14.28***	15.07***	15.33***	14.89***
	(3.534)	(3.323)	(3.331)	(3.215)	(3.256)	(3.255)	(3.294)

Consecutive wet days Days	-0.00781				
	(0.0102)				
Change in consecutive wet days	0.0160*				
	(0.00935)				
Annual total wet-day precipitation mm		3.95e-05			
		(7.28e-05)			
Change in annual total wet-day precipitation		-0.000642**			
		(0.000298)			
Number of heavy precipitation days Days			-0.00290		
			(0.00271)		
Change in heavy precipitation days			-0.0171***		
			(0.00610)		
Number of very heavy precipitation days Days				0.00188	
				(0.00349)	
Change in very heavy precipitation days				-0.0263**	
				(0.0104)	
Very wet days mm					0.000233*
					(0.000123)
Change in very et days					-0.000545**
					(0.000273)
Extremely wet days mm						0.000367**
						(0.000168)
Change in extremely wet days						-0.000646**
						(0.000308)

Simple daily intensity index mm/day							0.0271**
							(0.0107)
Change in simple daily intensity index							-0.0609*
							(0.0342)
lnalpha	-0.838***	-0.849***	-0.851***	-0.865***	-0.853***	-0.854***	-0.859***
	(0.140)	(0.137)	(0.136)	(0.135)	(0.136)	(0.135)	(0.138)
Constant	2.538***	2.163***	2.486***	2.272***	2.005***	2.033***	1.899***
	(0.324)	(0.419)	(0.355)	(0.359)	(0.441)	(0.425)	(0.449)
Observations	1,240	1,240	1,240	1,239	1,240	1,240	1,240
Pseudo R-squared	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table C3: Outmigration rates (ages 50+) by change in selected precipitation indicators, 3-year measures.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Municipality on the coast	-0.0405	-0.00591	-0.0350	-0.00709	0.00178	-0.0192	0.00498
	(0.0727)	(0.0687)	(0.0708)	(0.0680)	(0.0715)	(0.0709)	(0.0672)
Mean slope of terrain across 90-m transects	-0.0133***	-0.0142***	-0.0136***	-0.0137***	-0.0139***	-0.0138***	-0.0135***
	(0.00417)	(0.00413)	(0.00416)	(0.00409)	(0.00418)	(0.00417)	(0.00417)
Percent of cultivated land = annual crops	-0.00408**	-0.00374*	-0.00396**	-0.00380**	-0.00403**	-0.00415**	-0.00421**
	(0.00191)	(0.00198)	(0.00193)	(0.00192)	(0.00202)	(0.00205)	(0.00196)
Percent of cultivated land = perennial crops	-0.00381***	-0.00336**	-0.00405***	-0.00332**	-0.00332**	-0.00374***	-0.00295**
	(0.00132)	(0.00140)	(0.00139)	(0.00137)	(0.00138)	(0.00136)	(0.00139)
Population: highest 20% of municipalities	0.183***	0.176***	0.182***	0.187***	0.175***	0.179***	0.183***
	(0.0629)	(0.0624)	(0.0622)	(0.0626)	(0.0627)	(0.0628)	(0.0615)
Proportion indigenous: 3rd quartile	0.121	0.136	0.136	0.134	0.137	0.139	0.140*
	(0.0864)	(0.0855)	(0.0856)	(0.0863)	(0.0850)	(0.0853)	(0.0841)
Proportion indigenous: 2nd quartile	0.204**	0.233**	0.227**	0.243***	0.233**	0.232**	0.231**
	(0.0916)	(0.0935)	(0.0933)	(0.0942)	(0.0943)	(0.0955)	(0.0917)
Proportion indigenous: 1st quartile (highest)	0.230**	0.303***	0.267***	0.322***	0.313***	0.292***	0.322***
	(0.0924)	(0.0930)	(0.0956)	(0.0955)	(0.0933)	(0.0960)	(0.0909)
Diurnal temperature range (Celsius)	0.0142	0.0252	0.0197	0.0260	0.0289	0.0246	0.0310*
	(0.0185)	(0.0168)	(0.0170)	(0.0167)	(0.0177)	(0.0175)	(0.0183)
Provincial outmigration rate, 1995-2000	15.93***	15.05***	15.52***	14.57***	15.35***	15.66***	14.95***
	(2.511)	(2.607)	(2.594)	(2.573)	(2.588)	(2.582)	(2.517)
Consecutive wet days Days	0.00829						

	(0.00582)					
Change in consecutive wet days	0.00839					
	(0.00871)					
Annual total wet-day precipitation mm		5.96e-05				
		(5.89e-05)				
Change in annual total wet-day precipitation		-0.000468**				
		(0.000191)				
Number of heavy precipitation days Days			0.000961			
			(0.00149)			
Change in heavy precipitation days			-0.00429			
			(0.00540)			
Number of very heavy precipitation days Days				0.00228		
				(0.00276)		
Change in very heavy precipitation days				-0.0187***		
				(0.00578)		
Very wet days mm					9.85e-05	
					(0.000109)	
Change in very et days					-0.000409**	
					(0.000182)	
Extremely wet days mm						0.000109
						(0.000152)
Change in extremely wet days						-0.000281
						(0.000232)

Simple daily intensity index mm/day							0.0194**
							(0.00851)
Change in simple daily intensity index							-0.0680***
							(0.0219)
lnalpha	-0.422***	-0.427***	-0.420***	-0.434***	-0.426***	-0.421***	-0.436***
	(0.121)	(0.120)	(0.119)	(0.120)	(0.120)	(0.119)	(0.121)
Constant	1.641***	1.443***	1.607***	1.553***	1.479***	1.566***	1.336***
	(0.253)	(0.333)	(0.302)	(0.303)	(0.333)	(0.329)	(0.344)
Observations	1,240	1,240	1,240	1,239	1,240	1,240	1,240
Pseudo R-squared	0.0285	0.0285	0.0285	0.0285	0.0285	0.0285	0.0285

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix D

Table D1: Outmigration rates (ages 15-29) by change in selected temperature indicators, 3-year measures.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Municipality on the coast	0.0923	0.0763	0.0928	0.0572	0.0736	0.0107
	(0.0656)	(0.0592)	(0.0825)	(0.0658)	(0.0628)	(0.0643)
Mean slope of terrain across 90-m transects	-0.00441	-0.00569	-0.00190	-0.00483	-0.00507	-0.00631
	(0.00433)	(0.00434)	(0.00496)	(0.00485)	(0.00442)	(0.00417)
Percent of cultivated land = annual crops	0.00268	0.00256	0.00236	0.00252	0.00292	0.000991
	(0.00202)	(0.00211)	(0.00190)	(0.00242)	(0.00213)	(0.00195)
Percent of cultivated land = perennial crops	0.00225*	0.00282**	0.00266**	0.00243	0.00251*	0.00274*
	(0.00136)	(0.00131)	(0.00130)	(0.00151)	(0.00132)	(0.00142)
Population: highest 20% of municipalities	-0.00252	0.0144	-0.0128	-0.00699	-0.00276	0.00561
	(0.0612)	(0.0641)	(0.0599)	(0.0617)	(0.0602)	(0.0584)
Proportion indigenous: 3rd quartile	0.179**	0.176***	0.175***	0.147*	0.175***	0.115
	(0.0698)	(0.0682)	(0.0675)	(0.0751)	(0.0676)	(0.0757)
Proportion indigenous: 2nd quartile	0.269***	0.246***	0.250***	0.215***	0.251***	0.223***
	(0.0856)	(0.0794)	(0.0731)	(0.0755)	(0.0766)	(0.0819)
Proportion indigenous: 1st quartile (highest)	0.246**	0.217**	0.230***	0.235**	0.234***	0.206**
	(0.100)	(0.0915)	(0.0847)	(0.101)	(0.0889)	(0.0851)
Simple daily intensity index mm/day	0.0233**	0.0185*	0.0196**	0.0171	0.0218**	0.0103
	(0.0106)	(0.00982)	(0.00971)	(0.0104)	(0.0103)	(0.00948)

Provincial outmigration rate, 1995-2000	15.00***	15.49***	14.92***	14.49***	14.97***	12.70***
	(3.261)	(3.376)	(3.147)	(3.063)	(3.348)	(2.294)
Diurnal temperature range (Celsius)	0.0241					
	(0.0191)					
Change in diurnal temperature range	0.439					
	(0.407)					
Monthly minimum value of daily minimum temp.		-0.0186				
		(0.0131)				
Change in monthly min. value of daily min. temp.		-0.216				
		(0.138)				
Monthly maximum value of daily maximum temp.			0.0170			
			(0.0237)			
Change in monthly max. value of daily max. temp.			0.242**			
			(0.122)			
Number of cool days				0.00705		
				(0.00616)		
Change in number of cool days				-0.00984		
				(0.0124)		
Number of cool nights					-0.00254	
					(0.00309)	
Change in number of cool nights					0.000968	
					(0.00358)	

Number of warm days						-0.00641
						(0.0192)
Change in number of warm days						0.0405*
						(0.0220)
lnalpha	-0.851***	-0.856***	-0.862***	-0.939***	-0.846***	-0.999***
	(0.136)	(0.139)	(0.134)	(0.154)	(0.141)	(0.158)
Constant	1.959***	2.533***	1.567	2.277***	2.200***	2.596***
	(0.445)	(0.456)	(1.074)	(0.394)	(0.435)	(0.313)
Observations	1,240	1,240	1,240	928	1,240	811
Pseudo R-squared	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table D2: Outmigration rates (ages 30-49) by change in selected temperature indicators, 3-year measures.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Municipality on the coast	0.00143	0.0209	-0.0162	-0.0277	-0.0201	-0.0679
	(0.0617)	(0.0565)	(0.0728)	(0.0608)	(0.0564)	(0.0609)
Mean slope of terrain across 90-m transects	-0.00911***	-0.0111***	-0.00703*	-0.00943**	-0.00964***	-0.00958***
	(0.00349)	(0.00358)	(0.00403)	(0.00428)	(0.00365)	(0.00347)
Percent of cultivated land = annual crops	-0.000807	-0.00125	-0.000895	-0.000823	-0.000547	-0.00217
	(0.00176)	(0.00190)	(0.00169)	(0.00224)	(0.00188)	(0.00175)
Percent of cultivated land = perennial crops	-0.000274	0.000217	-5.90e-05	-0.000124	-0.000189	-0.000435
	(0.00119)	(0.00117)	(0.00117)	(0.00138)	(0.00117)	(0.00126)
Population: highest 20% of municipalities	0.0416	0.0487	0.0377	0.0537	0.0452	0.0488
	(0.0558)	(0.0584)	(0.0544)	(0.0533)	(0.0551)	(0.0517)
Proportion indigenous: 3rd quartile	0.207***	0.202***	0.207***	0.180**	0.205***	0.186**
	(0.0720)	(0.0715)	(0.0691)	(0.0785)	(0.0699)	(0.0818)
Proportion indigenous: 2nd quartile	0.291***	0.272***	0.290***	0.284***	0.287***	0.270***
	(0.0896)	(0.0834)	(0.0779)	(0.0870)	(0.0805)	(0.0942)
Proportion indigenous: 1st quartile (highest)	0.236**	0.207**	0.241***	0.252**	0.244***	0.250**
	(0.101)	(0.0944)	(0.0861)	(0.110)	(0.0900)	(0.0978)
Simple daily intensity index mm/day	0.0251***	0.0215***	0.0224***	0.0228**	0.0240***	0.0119
	(0.00872)	(0.00795)	(0.00806)	(0.00919)	(0.00846)	(0.00846)
Provincial outmigration rate, 1995-2000	16.21***	16.72***	16.08***	16.11***	16.24***	14.40***
	(2.503)	(2.552)	(2.275)	(2.386)	(2.564)	(1.893)

Diurnal temperature range (Celsius)	0.0205					
	(0.0173)					
Change in diurnal temperature range	0.116					
	(0.386)					
Monthly minimum value of daily minimum temp.		-0.0271**				
		(0.0130)				
Change in monthly min. value of daily min. temp.		-0.0914				
		(0.127)				
Monthly maximum value of daily maximum temp.			0.00965			
			(0.0207)			
Change in monthly max. value of daily max. temp.			0.216*			
			(0.110)			
Number of cool days				0.00710		
				(0.00613)		
Change in number of cool days				-0.00722		
				(0.0125)		
Number of cool nights					-0.00297	
					(0.00306)	
Change in number of cool nights					0.00120	
					(0.00295)	
Number of warm days						-0.0246
						(0.0191)

Change in number of warm days						0.0470**
						(0.0221)
lnalpha	-1.037***	-1.046***	-1.048***	-1.130***	-1.037***	-1.189***
	(0.119)	(0.121)	(0.116)	(0.131)	(0.122)	(0.127)
Constant	1.507***	2.235***	1.349	1.692***	1.740***	2.120***
	(0.398)	(0.424)	(0.931)	(0.371)	(0.397)	(0.281)
Observations	1,240	1,240	1,240	928	1,240	811
Pseudo R-squared	0.0334	0.0334	0.0334	0.0334	0.0334	0.0334

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table D4: Outmigration rates (ages 50+) by change in selected temperature indicators, 3-year measures.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Municipality on the coast	-0.0391	-0.0277	-0.0408	-0.133**	-0.0847	-0.127**
	(0.0684)	(0.0645)	(0.0705)	(0.0628)	(0.0635)	(0.0643)
Mean slope of terrain across 90-m transects	-0.0133***	-0.0150***	-0.0107**	-0.0107*	-0.0134***	-0.0141***
	(0.00423)	(0.00465)	(0.00478)	(0.00558)	(0.00458)	(0.00472)
Percent of cultivated land = annual crops	-0.00387**	-0.00421**	-0.00393**	-0.00244	-0.00352*	-0.00520***
	(0.00194)	(0.00211)	(0.00190)	(0.00256)	(0.00205)	(0.00198)
Percent of cultivated land = perennial crops	-0.00389***	-0.00345**	-0.00360***	-0.00340**	-0.00370***	-0.00375***
	(0.00143)	(0.00139)	(0.00138)	(0.00151)	(0.00138)	(0.00143)
Population: highest 20% of municipalities	0.198***	0.198***	0.197***	0.200***	0.200***	0.212***
	(0.0633)	(0.0646)	(0.0630)	(0.0703)	(0.0633)	(0.0687)
Proportion indigenous: 3rd quartile	0.144	0.139	0.137	0.180*	0.149*	0.177*
	(0.0876)	(0.0863)	(0.0846)	(0.102)	(0.0866)	(0.103)
Proportion indigenous: 2nd quartile	0.243**	0.224**	0.226**	0.257**	0.242***	0.261**
	(0.0975)	(0.0949)	(0.0916)	(0.110)	(0.0936)	(0.102)
Proportion indigenous: 1st quartile (highest)	0.294***	0.274***	0.299***	0.386***	0.315***	0.353***
	(0.0973)	(0.0957)	(0.0904)	(0.118)	(0.0929)	(0.103)
Simple daily intensity index mm/day	0.0147	0.0121	0.0124	0.0164	0.0136	0.000200
	(0.00908)	(0.00894)	(0.00879)	(0.0101)	(0.00885)	(0.0104)
Provincial outmigration rate, 1995-2000	15.39***	15.67***	15.07***	15.43***	15.38***	13.18***
	(2.581)	(2.550)	(2.507)	(2.313)	(2.603)	(2.226)
Diurnal temperature range (Celsius)	0.0252					

	(0.0187)					
Change in diurnal temperature range	0.195					
	(0.318)					
Monthly minimum value of daily minimum temp.		-0.0219*				
		(0.0131)				
Change in monthly min. value of daily min. temp.		-0.0101				
		(0.0962)				
Monthly maximum value of daily maximum temp.			0.0251			
			(0.0196)			
Change in monthly max. value of daily max. temp.			0.0649			
			(0.111)			
Number of cool days				2.60e-05		
				(0.00460)		
Change in number of cool days				-0.00384		
				(0.00883)		
Number of cool nights					0.000296	
					(0.00309)	
Change in number of cool nights					0.00219	
					(0.00423)	
Number of warm days						-0.0180
						(0.0242)
Change in number of warm days						0.0296
						(0.0251)

lnalpha	-0.424***	-0.425***	-0.427***	-0.553***	-0.422***	-0.616***
	(0.118)	(0.120)	(0.118)	(0.138)	(0.120)	(0.149)
Constant	1.395***	2.044***	0.713	1.445***	1.615***	2.010***
	(0.364)	(0.459)	(0.839)	(0.367)	(0.378)	(0.286)
Observations	1,240	1,240	1,240	928	1,240	811
Pseudo R-squared	0.0270	0.0270	0.0270	0.0270	0.0270	0.0270

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix E

Table E1: Outmigration rates (ages 15-29) by change in selected drought indicators, 3-year measures.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Municipality on the coast	0.137*	0.134*	0.124*	0.147**	0.154**	0.147*	0.137*	0.0942
	(0.0715)	(0.0743)	(0.0738)	(0.0714)	(0.0717)	(0.0763)	(0.0765)	(0.0706)
Mean slope of terrain across 90-m transects	-0.00520	-0.00406	-0.00461	-0.00418	-0.00431	-0.00582	-0.00575	-0.00230
	(0.00393)	(0.00420)	(0.00408)	(0.00403)	(0.00405)	(0.00399)	(0.00409)	(0.00418)
Percent of cultivated land = annual crops	0.00178	0.00262	0.00222	0.00241	0.00250	0.00200	0.00188	0.00245
	(0.00191)	(0.00204)	(0.00191)	(0.00189)	(0.00194)	(0.00194)	(0.00202)	(0.00194)
Percent of cultivated land = perennial crops	0.00239**	0.00247*	0.00282**	0.00323**	0.00313**	0.00283**	0.00239*	0.00329**
	(0.00121)	(0.00142)	(0.00139)	(0.00138)	(0.00132)	(0.00135)	(0.00136)	(0.00139)
Population: highest 20% of municipalities	-0.0551	-0.0490	-0.0265	-0.0339	-0.0464	-0.0439	-0.0348	-0.0286
	(0.0592)	(0.0620)	(0.0600)	(0.0579)	(0.0576)	(0.0583)	(0.0593)	(0.0591)
Proportion indigenous: 3rd quartile	0.163**	0.151**	0.147**	0.147**	0.153**	0.169**	0.172**	0.142**
	(0.0677)	(0.0684)	(0.0684)	(0.0680)	(0.0689)	(0.0688)	(0.0698)	(0.0681)
Proportion indigenous: 2nd quartile	0.241***	0.212***	0.193***	0.186***	0.199***	0.225***	0.227***	0.197***
	(0.0721)	(0.0717)	(0.0727)	(0.0714)	(0.0729)	(0.0727)	(0.0749)	(0.0744)
Proportion indigenous: 1st quartile (highest)	0.274***	0.189**	0.163**	0.175**	0.189**	0.209**	0.199**	0.187**
	(0.0960)	(0.0901)	(0.0831)	(0.0830)	(0.0828)	(0.0844)	(0.0866)	(0.0895)
Diurnal temperature range (Celsius)	0.0350*	0.0204	0.0196	0.0194	0.0219	0.0247	0.0247	0.0158
	(0.0190)	(0.0188)	(0.0185)	(0.0175)	(0.0176)	(0.0175)	(0.0178)	(0.0179)

Provincial outmigration rate, 1995-2000	15.86***	16.05***	15.81***	15.23***	14.79***	14.71***	14.66***	15.53***
	(3.581)	(3.591)	(3.632)	(3.556)	(3.593)	(3.599)	(3.682)	(3.536)
SPEI index - 1 month calibration	-2.058***							
	(0.712)							
Change in SPEI index - 1 month calibration	0.821							
	(0.606)							
SPEI index - 3 month calibration		-1.428						
		(0.884)						
Change in SPEI index - 3 month calibration		1.261*						
		(0.718)						
SPEI index - 6 month calibration			-0.499					
			(0.561)					
Change in SPEI index - 6 month calibration			0.684					
			(0.480)					
SPEI index - 9 month calibration				-0.186				
				(0.555)				
Change in SPEI index - 9 month calibration				0.522				
				(0.450)				
SPEI index - 12 month calibration					0.0281			
					(0.392)			
Change in SPEI index - 12 month calibration					0.312			
					(0.300)			

SPEI index - 18 month calibration						0.335		
						(0.302)		
Change in SPEI index - 18 month calibration						0.0502		
						(0.221)		
SPEI index - 24 month calibration							0.133	
							(0.264)	
Change in SPEI index - 24 month calibration							0.125	
							(0.197)	
Consecutive dry days								0.00415***
								(0.00142)
Change in consecutive dry days								-0.00252
								(0.00528)
lnalpha	-0.863***	-0.842***	-0.837***	-0.843***	-0.842***	-0.847***	-0.844***	-0.843***
	(0.136)	(0.137)	(0.139)	(0.140)	(0.142)	(0.141)	(0.141)	(0.140)
Constant	3.680***	3.481***	2.847***	2.636***	2.461***	2.263***	2.407***	2.251***
	(0.450)	(0.607)	(0.405)	(0.412)	(0.385)	(0.350)	(0.326)	(0.362)
Observations	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240
Pseudo R-squared	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table E2: Outmigration rates (ages 30-49) by change in selected drought indicators, 3-year measures.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)
VARIABLES									
Municipality on the coast	0.0392	0.0217	0.0294	0.0587	0.0623	0.0556	0.0379	-0.0136	0.0392
	(0.0673)	(0.0712)	(0.0687)	(0.0673)	(0.0653)	(0.0717)	(0.0732)	(0.0689)	(0.0673)
Mean slope of terrain across 90-m transects	-0.00908***	-0.00849***	-0.00897***	-0.00865***	-0.00873***	-0.00962***	-0.00923***	-0.00615*	-0.00908***
	(0.00329)	(0.00349)	(0.00334)	(0.00333)	(0.00333)	(0.00333)	(0.00341)	(0.00342)	(0.00329)
Percent of cultivated land = annual crops	-0.00145	-0.00103	-0.00121	-0.00118	-0.00117	-0.00135	-0.00125	-0.00124	-0.00145
	(0.00176)	(0.00173)	(0.00166)	(0.00167)	(0.00173)	(0.00178)	(0.00182)	(0.00165)	(0.00176)
Percent of cultivated land = perennial crops	-0.000326	5.82e-05	0.000397	0.000744	0.000507	7.52e-05	-0.000386	0.000865	-0.000326
	(0.00113)	(0.00127)	(0.00127)	(0.00131)	(0.00124)	(0.00123)	(0.00123)	(0.00125)	(0.00113)
Population: highest 20% of municipalities	-0.00271	0.0125	0.0272	0.0132	-0.000983	0.00346	0.0128	0.0226	-0.00271
	(0.0555)	(0.0583)	(0.0559)	(0.0545)	(0.0541)	(0.0557)	(0.0561)	(0.0550)	(0.0555)
Proportion indigenous: 3rd quartile	0.177**	0.166**	0.168**	0.166**	0.173**	0.189***	0.189***	0.161**	0.177**
	(0.0697)	(0.0690)	(0.0696)	(0.0688)	(0.0695)	(0.0702)	(0.0700)	(0.0691)	(0.0697)
Proportion indigenous: 2nd quartile	0.250***	0.226***	0.211***	0.207***	0.227***	0.250***	0.251***	0.220***	0.250***
	(0.0795)	(0.0761)	(0.0753)	(0.0732)	(0.0756)	(0.0770)	(0.0782)	(0.0752)	(0.0795)
Proportion indigenous: 1st quartile (highest)	0.226**	0.180**	0.162**	0.180**	0.191**	0.199**	0.192**	0.195**	0.226**
	(0.0934)	(0.0868)	(0.0823)	(0.0861)	(0.0856)	(0.0862)	(0.0889)	(0.0859)	(0.0934)
Diurnal temperature range (Celsius)	0.0244	0.0186	0.0196	0.0201	0.0208	0.0221	0.0203	0.0157	0.0244

	(0.0180)	(0.0173)	(0.0171)	(0.0166)	(0.0171)	(0.0172)	(0.0176)	(0.0168)	(0.0180)
Provincial outmigration rate, 1995-2000	16.85***	17.25***	16.59***	16.26***	16.05***	16.21***	16.34***	16.54***	16.85***
	(2.600)	(2.695)	(2.731)	(2.686)	(2.738)	(2.712)	(2.764)	(2.627)	(2.600)
SPEI index - 1 month calibration	-1.425***								-1.425***
	(0.550)								(0.550)
Change in SPEI index - 1 month calibration	0.890*								0.890*
	(0.469)								(0.469)
SPEI index - 3 month calibration		-0.669							
		(0.736)							
Change in SPEI index - 3 month calibration		0.996							
		(0.643)							
SPEI index - 6 month calibration			0.0400						
			(0.546)						
Change in SPEI index - 6 month calibration			0.499						
			(0.447)						
SPEI index - 9 month calibration				-0.203					
				(0.562)					
Change in SPEI index - 9 month calibration				0.641					
				(0.439)					
SPEI index - 12 month calibration					-0.303				
					(0.396)				
Change in SPEI index - 12 month calibration					0.559**				
					(0.284)				

SPEI index - 18 month calibration						0.0277			
						(0.290)			
Change in SPEI index - 18 month calibration						0.251			
						(0.225)			
SPEI index - 24 month calibration							-0.0739		
							(0.263)		
Change in SPEI index - 24 month calibration							0.210		
							(0.214)		
Consecutive dry days								0.00551***	
								(0.00126)	
Change in consecutive dry days								-0.00306	
								(0.00487)	
lnalpha	-1.028***	-1.024***	-1.029***	-1.036***	-1.030***	-1.028***	-1.021***	-1.039***	-1.028***
	(0.120)	(0.121)	(0.122)	(0.121)	(0.123)	(0.122)	(0.122)	(0.123)	(0.120)
Constant	2.932***	2.541***	2.061***	2.254***	2.297***	2.053***	2.097***	1.787***	2.932***
	(0.369)	(0.497)	(0.392)	(0.403)	(0.332)	(0.289)	(0.269)	(0.302)	(0.369)
Observations	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240
Pseudo R-squared	0.0335	0.0335	0.0335	0.0335	0.0335	0.0335	0.0335	0.0335	0.0335

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table E3: Outmigration rates (ages 50+) by change in selected drought indicators, 3-year measures.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Municipality on the coast	0.000722	-0.0157	-0.0302	-0.0169	0.0175	0.0143	-0.00872	-0.0653
	(0.0691)	(0.0749)	(0.0703)	(0.0664)	(0.0667)	(0.0735)	(0.0753)	(0.0720)
Mean slope of terrain across 90-m transects	-0.0140***	-0.0129***	-0.0137***	-0.0136***	-0.0135***	-0.0143***	-0.0138***	-0.0112***
	(0.00417)	(0.00424)	(0.00421)	(0.00418)	(0.00418)	(0.00429)	(0.00431)	(0.00416)
Percent of cultivated land = annual crops	-0.00470**	-0.00400**	-0.00453**	-0.00451**	-0.00422**	-0.00440**	-0.00431**	-0.00441**
	(0.00195)	(0.00192)	(0.00188)	(0.00186)	(0.00189)	(0.00196)	(0.00199)	(0.00186)
Percent of cultivated land = perennial crops	-0.00361***	-0.00405***	-0.00368**	-0.00334**	-0.00287**	-0.00336**	-0.00382***	-0.00253*
	(0.00139)	(0.00146)	(0.00145)	(0.00148)	(0.00145)	(0.00142)	(0.00142)	(0.00138)
Population: highest 20% of municipalities	0.168***	0.166***	0.180***	0.179***	0.169***	0.172***	0.179***	0.193***
	(0.0612)	(0.0615)	(0.0614)	(0.0618)	(0.0615)	(0.0623)	(0.0628)	(0.0609)
Proportion indigenous: 3rd quartile	0.111	0.127	0.122	0.121	0.116	0.133	0.136	0.102
	(0.0838)	(0.0854)	(0.0844)	(0.0833)	(0.0843)	(0.0838)	(0.0844)	(0.0848)
Proportion indigenous: 2nd quartile	0.206**	0.220**	0.207**	0.202**	0.193**	0.216**	0.221**	0.185**
	(0.0899)	(0.0905)	(0.0905)	(0.0888)	(0.0894)	(0.0900)	(0.0919)	(0.0905)
Proportion indigenous: 1st quartile (highest)	0.297***	0.271***	0.252***	0.264***	0.274***	0.276***	0.272***	0.264***
	(0.0951)	(0.0908)	(0.0888)	(0.0896)	(0.0926)	(0.0912)	(0.0917)	(0.0895)
Diurnal temperature range (Celsius)	0.0288	0.0228	0.0237	0.0226	0.0265	0.0276	0.0258	0.0212
	(0.0182)	(0.0182)	(0.0179)	(0.0172)	(0.0166)	(0.0169)	(0.0172)	(0.0177)
Provincial outmigration rate, 1995-2000	15.48***	15.82***	16.04***	15.60***	14.86***	15.10***	15.24***	15.02***
	(2.510)	(2.559)	(2.610)	(2.611)	(2.644)	(2.646)	(2.623)	(2.433)

SPEI index - 1 month calibration	-1.550***					
	(0.519)					
Change in SPEI index - 1 month calibration	1.164**					
	(0.587)					
SPEI index - 3 month calibration		-1.054				
		(0.659)				
Change in SPEI index - 3 month calibration		0.745				
		(0.564)				
SPEI index - 6 month calibration			-0.768			
			(0.563)			
Change in SPEI index - 6 month calibration			0.684			
			(0.431)			
SPEI index - 9 month calibration				-0.544		
				(0.596)		
Change in SPEI index - 9 month calibration				0.594		
				(0.431)		
SPEI index - 12 month calibration					-0.272	
					(0.388)	
Change in SPEI index - 12 month calibration					0.540**	
					(0.271)	
SPEI index - 18 month calibration						-0.0351

						(0.316)		
Change in SPEI index - 18 month calibration						0.286		
						(0.218)		
SPEI index - 24 month calibration							-0.0248	
							(0.280)	
Change in SPEI index - 24 month calibration							0.157	
							(0.194)	
Consecutive dry days								0.00518***
								(0.00141)
Change in consecutive dry days								0.000125
								(0.00529)
lnalpha	-0.429***	-0.422***	-0.422***	-0.423***	-0.429***	-0.427***	-0.422***	-0.435***
	(0.121)	(0.119)	(0.119)	(0.119)	(0.120)	(0.120)	(0.120)	(0.121)
Constant	2.758***	2.465***	2.298***	2.160***	1.969***	1.788***	1.746***	1.513***
	(0.443)	(0.469)	(0.431)	(0.441)	(0.310)	(0.243)	(0.251)	(0.254)
Observations	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240
Pseudo R-squared	0.0283	0.0283	0.0283	0.0283	0.0283	0.0283	0.0283	0.0283

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1