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Drought and migration: An analysis of the effects of drought on temporary labor and return migration from a migrant-sending area in Nepal

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Abstract

Although the relationship between drought – a dimension of climate change – and migration has been explored in a number of settings, prior research has largely focused on out-migration and has not considered climate factors at the migrant destination. However, drought may impact not only out-migration, but also return migration, particularly in settings where temporary labor migration and agricultural reliance are common. Thus, considering drought conditions at origin and destinations is necessary to specify the effects of climate on migrant-sending populations. Using detailed data from the Chitwan Valley Family Study, a household panel study in a migrant-sending area in Nepal, we analyze the effect of drought at the neighborhood level on individual-level out-migration and drought at the origin district on return migration among adults from 2011 to 2017, assessing these associations among males and females separately. In mixed-effect discrete-time regressions, we find that neighborhood drought is positively associated with out-migration and return migration, both internally and internationally among males. Among females, drought is positively associated with internal out-migration and return migration, but not international migrations. We did not find an association between drought at the origin and return migration independent of drought status at the destination. Taken together, these findings contribute to our understanding of the complexity of the impacts of precipitation anomalies on population movement over time.

Keywords

migration; drought; climate change; Nepal

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Introduction

Climate change, including increased intensity and frequency of droughts, is increasingly discussed as a significant catalyst for human migration. Both major climate-related disasters and smaller-scale climatic variability may induce individuals to migrate. In settings where labor migration and agriculture reliance are high, climate change has the potential to affect migration rates and patterns, and to significantly shift livelihoods, economic opportunities, and well-being among migrants and those left behind.

Drought—defined as negative deviations from long-term trends in rainfall in a given area —is a key dimension of climate change. As temperatures increase, so does evaporation of water from soil and from lakes, rivers, and other bodies of water. Higher temperatures also alter atmospheric rivers, leading to changes in precipitation patterns across the globe (Hoegh-Guldberg et al., n.d.). Occurrences of drought are becoming more common and are expected to increase: 89.7 million people are exposed to drought each month globally, and projections suggest this will increase to 472.3 million people by 2081–2100 (Smirnov et al., 2016). In Nepal, where rain is the primary water source for 75% of agricultural areas, droughts have become more frequent since 1960 and are projected to increase (USAID, 2017).

Much of the literature has focused on climatic events as migration "push" factors, factors that encourage an individual to migrate away from a place. Therefore, prior studies have primarily analyzed associations between climate at the sending location and migration. However, much less attention has been paid to the relationship between climate and return migration, specifically how climatic shocks or conditions at origin might be associated with migrants' likelihood of returning to their home area. While past studies may have conflated out-migration and return-migration by not specifying whether an individual was already a migrant in their analyses, disentangling associations between climate and migration among those returning home versus migrating out is important as the motivations for migration likely differ between these groups. Yet, very few analyses have explicitly tested the relationships between climate and migration patterns for individuals leaving versus returning to their household of origin (see Entwisle et al. 2020 for an exception). Where circular and temporary migration are common, a more holistic examination of out- *and* return migration better characterizes the effects of climate on population in a specific area over time.

Thus, in this paper, we aim to build on the existing climate and migration literature by examining the relationship between drought, out-migration, and return migration, incorporating data on climate conditions at migrants' destinations in addition to the sending area, while also accounting for important determinants of migration such as gender, education, employment, and agricultural engagement. We have three aims: (1) to evaluate the association between drought status at the neighborhood level and out-migration, (2) to evaluate the association between drought status at migrant's destination and return migration; and (3) to assess relationships between drought status at destination, origin, and timing of return migration. Examining out- and return-migration in tandem provides a more robust analysis of population dynamics and migration patterns from the perspective of a migrant-sending area population, rather than only among migrants themselves. Moreover, the literature suggests that climatic conditions at both origin and destination locations may factor into migrants' decision-making, and these conditions vary over time.

Most of the theory regarding the association between environmental shocks and migration focuses on economic pathways. For example, driven by economic needs or circumstances in their household or community of origin (Lauby and Stark 1988; Lucas and Stark 1985; Stark and Bloom 1985), migrants may be pulled to places that they perceive as lower-risk and that will facilitate higher earning relative to their origin location (Binswanger and Rosenzweig 1986). Drawing on prior literature, Gray and Bilsborrow (2013) describe two different pathways based on the type of climate event (Bates, 2002; Gray, 2009; Laczko and Aghazarm, 2009). The "fast" pathway is one where weather shocks or environmental disasters lead to loss of income or assets. Thus, individuals or households may migrate with the intent to send remittances home, and if shocks are repeated, migration could be a form of diversification (Gray and Bilsborrow, 2013). The second "slow" pathway is the impact of longer-term environmental processes, like depletion of water or forest resources or soil degradation, and is also likely to lead to migration (Massey et al. 2010). While slow pathways are much less studied, they are likely to impact more people in the long run because they may affect bigger geographical areas. For example, using data from Nepal, Massey et al (2010) find that longer-term declines in land cover and agricultural productivity are associated with out-migration, particularly shorter-distance moves.

The theory behind these pathways emphasizes "push" factors rather than "pull" factors, or factors that draw an individual to migrate to a specific destination. However, "push" and "pull" factors are likely both at play when considering out- and return-migration together, with migrants likely factoring in climactic conditions at both origin and destination into decisions about when and where to migrate. Moreover, climatic conditions are dynamic, changing over time. Conditions at the destination could worsen, pushing a migrant to return home. Alternately, conditions at home could improve, pulling the migrant to return. Situating this in previous theory, climate shocks, such as droughts or big natural disasters (fast pathways) that are short term, might lead to fewer barriers to return than slow processes like longer-term climate impacts, which may keep people away permanently. Fundamentally, the same events that make people decide to migrate might also contribute to their decision to return, if either conditions at the origin improve (a "pull" factor), or conditions at the destination worsen (a "push" factor). New economics of labor migration (NELM) perspectives frame migration as a household decision, where migrants base their decision primarily on their household's needs at a given time (Hoddinott 1994; Stark and Bloom 1985). It may be that household needs are a more important determinant of migration timing and destinations than climate-related push/pull factors (Williams and Gray 2020).

For the purposes of this paper, we explore one "fast" pathway—that between drought and migration, including both out- and return migration. Drought may lead to migration through loss of arable land, reduced income, water insecurity, and inadequate food supply (Perch-Nielsen et al., 2008). There is a growing body of literature that suggests that migration is seen as a coping mechanism to reduce income loss associated with climate shocks (Jülich, 2011). Research in Cambodia among communities with repeated climate shocks found that people chose to migrate out for work in order to avoid relying on agriculture-based incomes, and this was true even among those not currently experiencing income loss from the climate event (Bylander, 2015). Other research has found that migration, when used as a coping mechanism post-climate shock, is more likely to benefit those with more resources to begin with—the poorest and most vulnerable often do not benefit as much from migrating (Debnath and Nayak, 2020). There is some evidence that drought leads to other forms of migration not related to labor. For example, a study in Ethiopia found that drought led to decreases in marriage-related moves among women (Gray and Mueller, 2012).

The relationship between drought and migration remains contested. Some research suggests that drought increases migration. For example, reduced rainfall is associated with increased rural-urban migration in sub-Saharan Africa (Barrios et al., 2006; Weinreb et al., 2020), United States-bound migration from Mexico (Feng et al., 2010; Feng and Oppenheimer, 2012; Munshi, 2003), permanent out-migration in Indonesia (Bohra-Mishra et al., 2014), and labor-related migration in Ethiopia (Gray and Mueller, 2012). However, a different line of research suggests that environmental changes including drought may constrain movement and therefore lead to a reduction in migration for several reasons. First, drought can lead to financial loss, which constrains households' and individuals' abilities to pay for moves. Second, the poor and most vulnerable to the effects of drought may be the least likely candidates to migrate due to financial and other structural constraints (Hunter, 2005; Jülich, 2011).

There is also mixed evidence as to the impact of drought on different types of migration, including international, rural-rural, and rural-urban. A study in India found that frequent droughts were associated more with rural-rural migration (Dallmann and Millock, 2017). Similar findings came from Burkina Faso of increased rural-rural migration, and also found reductions in international migration and migration by women (Henry et al., 2004). Other studies have found that reduced rainfall did not increase long-distance, permanent migration in Mali (Grace et al., 2018) or Burkina Faso (Henry et al., 2004), but rather resulted in short-distance temporary moves in Mali (Findley, 1994). Research in Ecuador found that droughts lead to more international and less internal migration (Gray and Bilsborrow, 2013). Much of the existing literature has focused on the relationship between climate factors and out-migration without consideration of return migration, even in areas where temporary migration is common (Dillon et al., 2011; Leyk et al., 2017; Nawrotzki et al., 2013; Thiede and Gray, 2017). While these papers make important advances in specifying the effects of climate change on migration patterns, identifying the relationship between climate factors and return migration is equally important for understanding longer-term population and economic dynamics in migrant-sending areas affected by climate change. To that end, recent papers examine the associations between climate change and both out- and in-migration (Entwisle et al., 2020; Weinreb et al., 2020), and find that the dynamics driving climate-related migration are embedded within existing migration patterns and networks—that is, in areas where temporary labor migration is common, it can be difficult to de-couple the roles of climate, livelihoods, and other social processes on migration (Entwisle et al., 2020). Specifically related to return migration, Entwisle et al., using an agent based model with data from Thailand on floods and droughts, find negative effects of these environmental events on return migration (and little effect on the initial out-migration) (2020). One approach to further distilling these relationships is to examine climate conditions at the migrant destination in addition to the sending location, which requires pairing high-resolution climate data with precise longitudinal data that include detailed migration histories, as we do in the present analysis.

To investigate the relationships between drought and migration patterns, we focus on rural Nepal, specifically the Chitwan Valley. Similar to many parts of Asia, Chitwan and Nepal have more broadly undergone dramatic social and economic transformation over the past five decades. Drought has been increasingly common in Nepal since 1960, and projections suggest that the number of consecutive dry days will increase by 3 to 7 percent by 2050 (USAID, 2017). Limited evidence from qualitative case studies across Nepal underscore anecdotal observations of climate change-related landslides, rainfall, and drought, inducing emigration from these areas (Chapagain and Gentle, 2015). While smallholder agriculture remains common, temporary labor migration to other areas in Nepal, neighboring India, the Gulf, and other foreign countries has become a common livelihood strategy, especially among young and middle-aged men (Malla and Rosenbaum, 2017; Ministry of Labour and Employment, 2016).

Prior empirical studies have identified a number of individual and contextual factors associated with international and internal labor migration in rural Nepal, including the Chitwan Valley specifically. Consistent with neoclassical economics theory and the new economics of labor migration, these include education and socio-demographic characteristics, land ownership, agricultural engagement and production, presence of and distance to community services, material aspirations, among other factors (Bhandari, 2004; Bhandari and Ghimire, 2016; Bohra and Massey, 2009; Massey et al., 2010; Thornton et al., 2019; Williams, 2009; Williams, 2013). Related to the present analysis, Massey and colleagues (2010) examined the effects of declining land cover, changes in time use and population density, and perceived agricultural productivity on migration. They found these dimensions of environmental change were more predictive of moves within Chitwan Valley than migration elsewhere in Nepal or internationally. They also found differences by gender and socio-economic factors in terms of how environmental factors were associated with migration patterns, emphasizing the need to disaggregate analyses by gender. However, these prior studies of migration-related determinants have not incorporated direct measures of climate change in analyses, nor have they directly examined at return migration.

Data and methods

We combined data from the Chitwan Valley Family Study (CVFS), a household and community panel study conducted in rural Nepal, and rainfall estimates from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) (Funk et al., 2014). The CVFS, described below, offers detailed migration histories with monthly precision from an area with high rates of mobility. CHIRPS combines satellite imagery with weather station data to create raster rainfall estimates in millimeters at 0.05 decimal degree resolution from 1981 onward. Rainfall sources that rely solely on satellite data are biased due to imperfections in estimations in areas with complex terrain, while those that rely solely on on-the-ground stations are inaccurate in areas with sparse station data. By combining both satellite and station data, CHIRPS reduces these biases while producing gridded maps of precipitation high in both spatial and temporal resolution.

The CVFS includes measures of time invariant and time-varying individual, household, and neighborhood characteristics for a general population sample of 151 neighborhood clusters. The original sampling frame included five to 15 households per cluster. Beginning in 1997, prospective monthly migration data has been collected in a household registry for all household members, collecting monthly data on a total of 61,273 individuals in over 4,000 unique households over the course of the study. The CVFS features full lifetime migration histories for all individuals in the household registry, including specific dates and destinations. The CVFS has followed all migrants after leaving the study area, including out-migrants in 53 other countries, maintaining response rates over 97% (Axinn, 2015). In addition to the household registry, all individuals ages 15 to 59 completed interviews in 1996, 2008, and 2016, with other periodic surveys of households and individuals since 1997.

Sample

In the present study, we included data from all individuals in the household registry aged 18–59 at any time from January 1, 2011 to June 1, 2017. Subjects both aged into and out of this sample over time. The full sample included 12,182 adults aged 18–59 in the household registry comprising 669,838 person-months of observation from January 1, 2011 to June 1, 2017. The study period began in 2011 due to the availability of baseline precipitation data and continued until June 1, 2017, the most recent household registry data available for analysis. We excluded two neighborhoods that were washed away by floods before 2011. The dataset represents an unbalanced panel where individuals age into and out of the study population; on average, each individual contributed 50.0 months to the analysis (standard deviation = 27.1).

Measures

Out-migration.—Using monthly data from household registries, we defined out-migration as a household member being away from the household of origin for at least three consecutive months. Out-migration was classified as internal (to any destination within Nepal) or international (to any destination outside Nepal).

Return migration.—Return migration was defined as a household member who had been away for at least three consecutive months returning to the household for at least three consecutive months. Return trips are classified as internal returns (from a destination within Nepal) or international returns (from any destination outside Nepal).

The three-month exposure period is contextually appropriate given the high rates of short-term labor migration in this setting. In contrast to a one-month definition, a three-month definition is less likely to capture visits to friend and relatives and/or religious pilgrimages, which are not of interest in the present analysis. We conducted sensitivity analyses defining migration as being away from the household (for out-migration) or present in the household (for return migration) for at least one month, the definition of migration commonly used in other migration studies drawing on CVFS data (e.g., Massey et al. 2010; Piotrowski 2013; Williams 2013).

Drought.—The exposure variable was defined as long-term (annual) precipitation deficits relative to historical trends (within a 30-year time frame), subsequently referred to as drought. Drought was defined as a deviation from long-term precipitation patterns at the neighborhood level in Chitwan (for both out- and return migration, internal and international). Annual cumulative precipitation for the 12 months preceding the month of observation was calculated for each unique household registry month/neighborhood centroid combination. We then ranked this neighborhood-level quantity of precipitation with the prior 29 years and converted this ranking to a percentile. We generated a binary variable of drought, classifying drought as below the 30th rainfall deviation percentile and no drought as above or equal to the 30th rainfall deviation percentile (Burke et al., 2015; Epstein et al., 2020). In addition to the binary classification of drought, we also considered the rainfall deviation percentile exposure as a continuous variable. For analyses assessing the association between drought and return migration from the destination to Chitwan, we had additional information on the conditions at the migrant's destination (district for internal migration and country for international migration). We generated an additional drought variable representing the drought status at the destination district (for models considering internal return migration as outcome) by averaging the rainfall percentile deviation in the destination district in each survey month. For international return migration, we did not generate an analogous measure because we were restricted to this information at the country-level, which would not permit us to generate a high-resolution estimate of drought. Details on migration outcomes and corresponding drought exposures are shown in Table 1.

Controls.—We control for relevant factors identified in previous literature (Bhandari and Ghimire, 2016; Bohra and Massey, 2009; Massey et al., 2010; Williams, 2009). We included time invariant measures of caste/ethnicity (Brahmin-Chhetri, Dalit, Newar, Hill Janajati, or Terai Janajati) because in this setting caste is a salient marker of socio-economic status. We also include a time invariant measure of education, measured as the number of years of school attended, as a marker of household wealth since this is strongly correlated, and because economic stability is likely associated with migration. We include a binary variable indicating whether the house plot is owned by the household, also as a marker of household wealth. Time invariant measures are obtained from individual interviews conducted in 2008 for the majority of those included in the analytic sample. For individuals who did not complete an interview in 2008, we obtained measures from individual interviews conducted in 2016 or household interviews conducted in 2015. Time-varying variables included age and marital status, both lagged by 13 months, to ensure they refer to a period prior to drought (which was measured in the 12 months prior to survey), since younger people and those who are unmarried might be more likely to migrate. To account for potential differences between neighborhoods, we include variables representing neighborhood characteristics, specifically related to ruralness compared to urban-ness. These include the number of minutes it takes to walk from the neighborhood to the nearest bank, employment center, market, money transfer station, or school. Finally, we include a time trend in the model to account for temporal changes in migration patterns and an indicator variable representing calendar month to account for seasonal changes in migration. All results are stratified by sex. While women might be more likely to migrate for marriage, as is common in this predominantly patrilocal culture, we hypothesize that this would be a more permanent form of migration, perhaps with short return visits. Migration during pregnancy and for childbirth (to the woman's natal home) is common in South Asia, and this involves a "return" component, since women return postpartum (Diamond-Smith et al. 2022). Thus, women are likely to have different migration patterns compared to men in this setting.

Analytic strategy

We used event-history methods to model migration. Because the data is precise to the month and the dependent variables are dichotomous, we estimated multilevel discrete-time logistic regressions. We consider adults to be at risk of out-migration when they are residing in the household and at risk of return migration when they have spent at least three consecutive months away from the household. Adults were censored when they die or the date of the last interview. We also censored adults after they migrated; they returned to the analysis when they returned to the respective "at risk" status for out- and return migration. We included random intercepts for neighborhood and individual in order to account for clustering. Random slopes were also considered but were not included in the final models due to results from likelihood ratio tests comparing models with and without random slopes suggesting that random intercepts were sufficient. By including random intercepts, we assume that the individual fixed effects are not correlated with any included explanatory variable in the model. As a sensitivity analysis, we reran the primary analysis with neighborhood-level fixed effects and compared the findings. We assumed that drought exposure is exogenous, since deviations are relative to a location's long-term precipitation history and we have therefore removed variation representing socio-demographic factors that may be associated with historically drier or wetter places and may impact migration status. For the continuous measure of rainfall deviations, we assessed both linear and non-linear relationships (using restricted cubic splines). Spline terms were retained if the p-value for the likelihood ratio test for including the non-linear effects was < 0.05. All results for males and females are presented separately.

Results

Table 2 displays descriptive statistics of the sample in the midpoint of the analysis. This included 4,193 unique males and 4,605 females aged 18–59. Males and females were, on average, 33.4 and 32.1 years of age respectively. A higher percentage of females were married (81.7%) than males (72.3%). Approximately half of the sample was of Brahmin-Chhetri ethnicity. A majority (86.5% and 86.8% for males and females respectively) of households owned their own house plot.

Drought was common in the sample. Of the 669,838 person-months of observation included in this analysis, 251,189 (37.5%) were months where drought occurred over the previous 12 months at the neighborhood level in Chitwan. Figure 1 shows the distribution of drought over time and across space during the study period.

Figure 2 shows the monthly percentage of individuals out-migrating and return migrating, both internally and internationally, by sex. In total, 2,656 (21.8%) of adults ever migrated internally (out-migration, return migration, or both), and 2,112 (17.3%) of adults ever migrated internationally. Internationally, return-migration rates were much higher among females compared to out-migration rates, suggesting that females living in Chitwan were very unlikely to out-migrate internationally, but if they had, their probability of return-migrating was relatively high.

Figure 3 shows the destinations where individuals out-migrated, both internally and internationally. Internal migrants most commonly migrated to nearby districts (Nawalparasi, Kaski, Tanahu, and Gorkha) and Kathmandu. Common international destinations include India, Qatar, Saudi Arabia, and the United Arab Emirates.

In Table 3, we present the estimates of the relationship between drought and out-migration, both internally and internationally. Drought was positively, significantly associated with internal out-migration among males (adjusted odds ratio [aOR] = 1.19, 95% CI 1.06, 1.35) and among females (aOR = 1.14, 95% CI 1.02, 1.27), with similar effect sizes. Drought was positively, significantly associated with international out-migration among males (aOR = 1.18, 95% CI 1.07, 1.30) but not females (aOR = 1.11, 95% CI 0.93, 1.34).

Table 4 shows estimates for the relationship between drought and return migration internally and internationally. In adjusted models that included drought at the origin as the exposure variable, drought was positively associated with internal return migration among males (aOR = 1.17, 95% CI 1.01, 1.34) and females (aOR = 1.18, 95% CI 1.02, 1.36). In adjusted models that included drought at the sending district as the exposure variable, we found drought was positively associated with internal return migration among both males (aOR = 1.18, 95% CI 1.00, 1.42) and females (aOR = 1.22, 95% CI 1.02, 1.47). However, in adjusted models that included both drought variables (drought at the Chitwan neighborhood and the sending district), the relationship between drought at the origin remained associated with return migration, while drought at the sending district did not. This pattern held true for both males and females. For international migration drought was positively associated with return migration among males (aOR = 1.15, 95% CI 1.04, 1.28), but not females (aOR = 0.97, 95% CI 0.72, 1.31).

Figure 4 presents predicted probabilities of out-migration with rainfall deviation percentiles modeled using restricted cubic splines. These models revealed significant non-linearities determined by likelihood ratio tests, except for international out-migration among females, for which there was no evidence for a deviation percentile-drought association (consistent with the binary definition). Figure 4 indicates the probability of out-migration was highest at the lowest rainfall deviation percentile and flattened at approximately the 40^{th} percentile for internal and international out-migration among males and internal out-migration among females. While we did find evidence for significant linear associations between rainfall deviations and return migration (both internal and international), we did not find evidence for non-linearities (Supplemental Table 1). These results were consistent with the binary specification of drought.

We conducted several sensitivity analyses for our primary analysis (assessing the association between the binary categorization of drought and out/return migration). First, instead of adjusting for neighborhood-level variables, we specified models with neighborhood-level fixed effects (Supplemental Tables 2 and 3). Second, we redefined migration as being away for at least 1 month (as opposed to the 3-month definition used for our primary analysis) (Supplemental Tables 4 and 5). Third, we repeated the analyses including a covariate adjusting for education level, available for only a subset of study participants (Supplemental Tables 6 and 7). Finally, we conducted the same analyses with a more conservative definition of drought (rainfall deviation percentile < 0.15, Supplemental Tables 8 and 9). In all sensitivity analyses, findings were generally consistent with the primary findings, with point estimates for the association between drought and migration falling within the 95% CI for results of the primary analyses. One exception was the shorter 1-month definition of drought, where findings were generally consistent but attenuated. This may be because not all migration episodes of one month were in fact labor-related migration episodes; rather, many of these shorter trips may have been for other reasons not impacted by drought, such as visiting friends or relatives.

Discussion

These analyses provide evidence that drought may be a driver not only of out-migration but also, potentially, a driver of return migration. We found that drought over the previous year at the destination was positively associated with out-migration and positively associated with return migration, both internally and internationally among males and internally among females. Where we have data on drought at the sending area (for internal migration), we did not find evidence of an association.

Our findings about the impact of drought on out-migration, both internal to Nepal and international, support previous studies that found that drought is associated with both internal and international migration (Barrios et al., 2006; Bohra-Mishra et al., 2014; Feng et al., 2010; Feng and Oppenheimer, 2012; Gray and Mueller, 2012; Munshi, 2003; Weinreb et al., 2020). The limited research on climate and return migration has argued that this relationship is more complex, involving factors other than just climate (Entwisle et al., 2020). We build on Entwisle et al's novel agent-based modeling study of climate and return migration by directly examining real-world migration responses to climate. It appears from our findings that when there is drought "at home," adults may be more likely to return to their household of origin. In some ways this may be counter to our expectations—if people leave because conditions are poor for work or agriculture, then we would expect them to stay out if these conditions persist or worsen. Possibly when conditions are bad at home, men and women need to return home to take care of their families (Hermans and Garbe 2019). Our results suggest that older individuals are more likely to return in drought, compared to younger individuals being more likely to out-migrate. This could suggest substitution effects, whereas certain household members migrate out (younger), other, older, household members might return migrate to replace those (substitute for them). Past literature from sub-Saharan Africa that looked at the age and sex distribution of migrants (in and out) did not find direct evidence of age-substitution (Weinreb et al. 2020). Future research, perhaps using qualitative methods, could explore more about who and why people choose to migrate and return, which would shed light on forces behind return migration.

We observed positive correlation between drought at the migrant destination and drought in Chitwan (corr = 0.25, $p < 0.001$). We also observed a negative association between rainfall deviations at the sending location and return migration independent of drought status in the Chitwan neighborhood, suggesting that drier conditions at the migrant destination was associated with return migration to Chitwan. This could suggest that men and women may prefer returning home even if drought persists at their origin in addition to their destination. A study examining other dimensions of environmental change—specifically, declines in land cover and agricultural productivity—in Chitwan found that social factors remained important in predicting migration in addition to climate conditions (Massey et al. 2010). Our findings related to return migration provide further evidence that social and environmental factors both drive decisions to migrate in this setting.

We also find that drought in the migrant destination is not associated with individuals' likelihood to migrate back to their origin when controlling for drought status at origin. We might have expected that if conditions were poor at the destination that there would be fewer employment opportunities, if those employment opportunities were agriculturally-based. However, if instead when men and women migrate, they mostly go to urban areas or places where they find jobs that are not related to environmental conditions, then this could help explain our finding. Unfortunately, we do not have data on the occupation of individuals who are migrating in our sample to help us better understand if type of job could help explain the lack of association.

Overall, patterns were similar and significant for men and women for the association between drought and internal migration. However, female international migration patterns were not associated with drought, while male international migration was. Part of this could be that women are less likely to migrate internationally for work compared to men, and might be more likely to be migrating to meet their male partner, which could happen at different timings than the initial migration (i.e., women might migrate to meet their husband after he has already migrated). Also, fewer women overall migrated internationally, so it also could be that our sample was too small to detect smaller associations. It was interesting that internal migration associations were similar between men and women, since we hypothesized that women might migrate for different reasons, for example, migration during pregnancy for childbirth, or to visit parents living in a different region.

Despite its strengths in incorporating measures of conditions at migrant destinations, this study has limitations. As noted above, we did not have detailed, time-varying measures of individual occupations or reasons for migration. Additionally, while we know that people migrated internationally, we did not look at different outcomes for those that migrated to close international destinations (e.g., India) compared that those that migrated farther away (e.g., Gulf States). Again, reasons for migration, type of labor, and impact of drought on migration likely differed by international location. Relatedly, we were not able to estimate the effect of drought at international destinations on likelihood of returning home since we did not know exact locations within each international location and therefore could not estimate drought conditions with adequate precision. Other types of climate change, particularly excess rainfall and heat, may also influence decisions to migrate out of an area, including in Nepal (Williams and Gray 2020). Evaluating these additional dimensions of climate change on return migration patterns is beyond the scope of the current paper, but an important future analysis. Given the correlation between heat and drought, we may have introduced some bias into the main drought-migration findings (Auffhammer et al. 2013). Finally, migration episodes of significantly longer duration (e.g., five years) may have a different relationship with climate change than the relatively short migration episodes we examine here. Given the relatively short period for which we have both climate and migration data (2011 to 2017), we are currently unable to examine long-term migration episodes.

Our study underscores the importance of considering conditions at migrant destinations when assessing the effects of climate change on migration for a specific population. Future work should aim to identify factors that moderate the association between drought and migration, including those that indicate resiliency or vulnerability to climate shocks. As climate change increases in many settings globally, including those where labor migration is already prevalent or becoming a more common livelihood strategy, continued examination of the effects of climate on migration will be critical for developing and implementing timely policy responses to support migrants, families, and population well-being.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Availability of data and material:

Data for the Chitwan Valley Family Study is available through the Inter-university Consortium for Political and Social Research (ICPSR) at the University of Michigan. CHIRPS precipitation data is publicly available at https://www.chc.ucsb.edu/data/chirps

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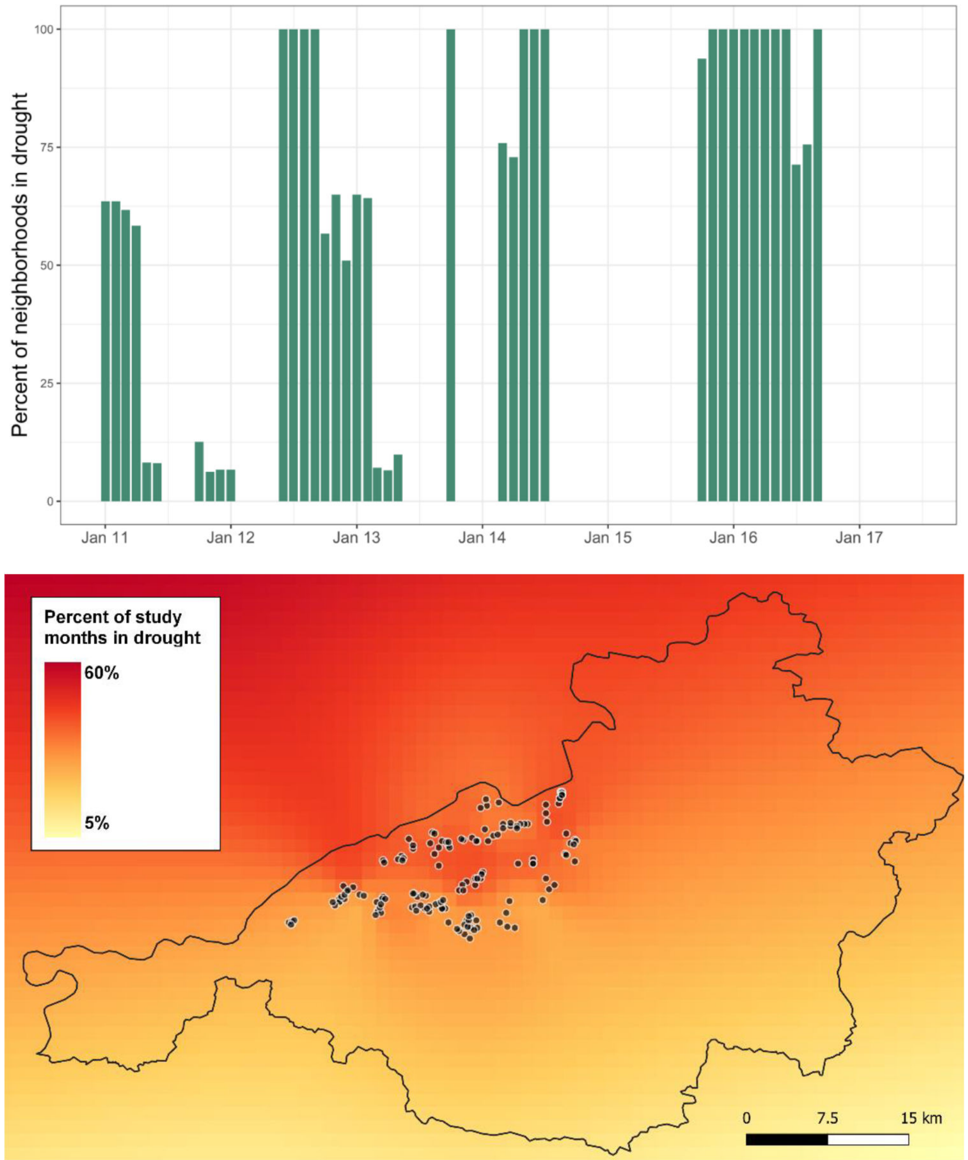

Figure 1.

Drought distribution over time (above) and across space (below) in Chitwan neighborhoods. The map shows Chitwan district and the location of village centroids (note: coordinates for centroids have been offset for privacy purposes).

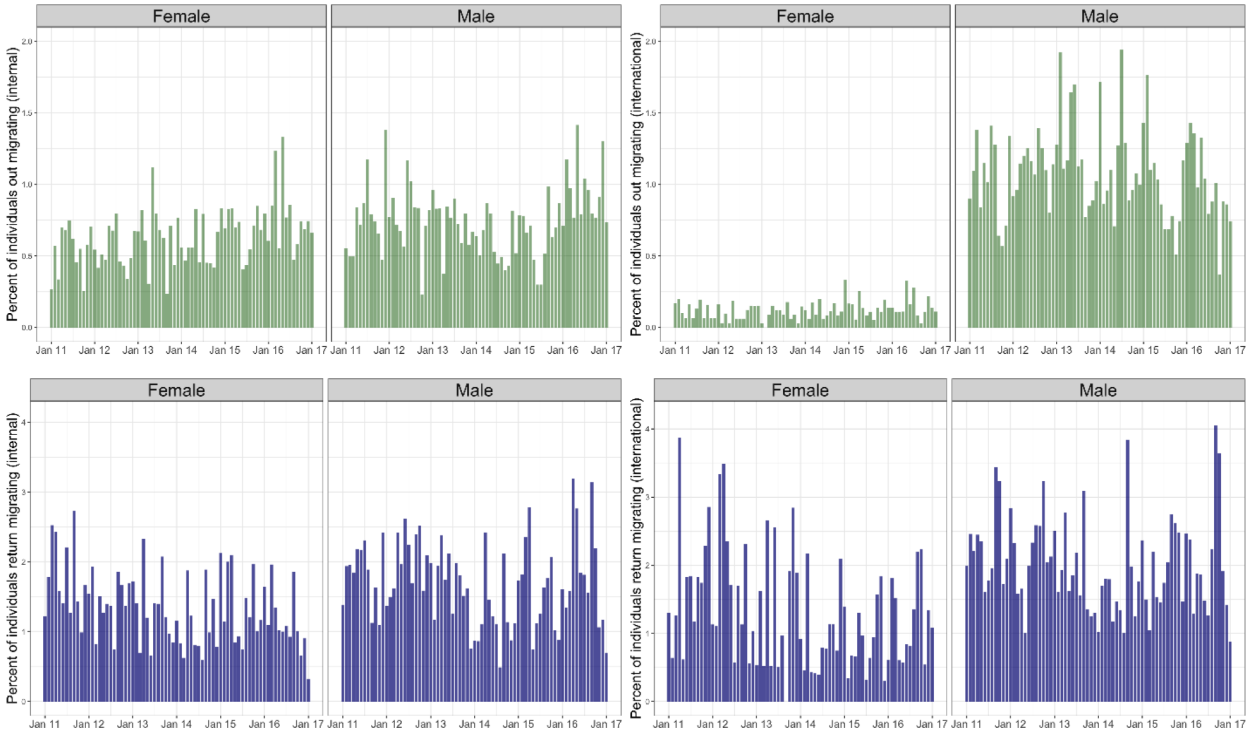

Figure 2.
Monthly percent of at-risk individuals out-migrating (above) and return migrating (below) by sex.

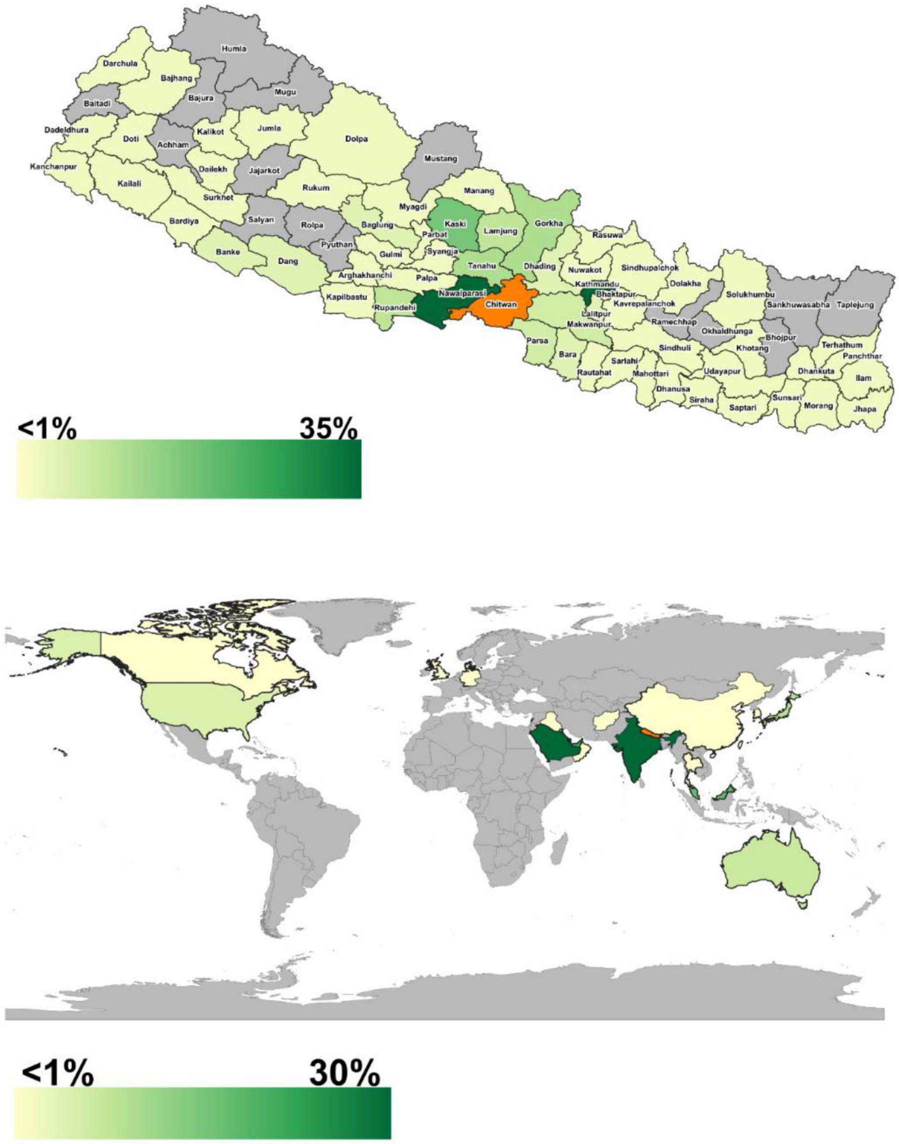

Figure 3.

Distributions of percent of migrants who went to each destination. Destinations for internal migrations (above) and international migrations (below). Internal migrations are shown at the district-level. International migrations are shown at the country-level; Nepal is indicated in orange.

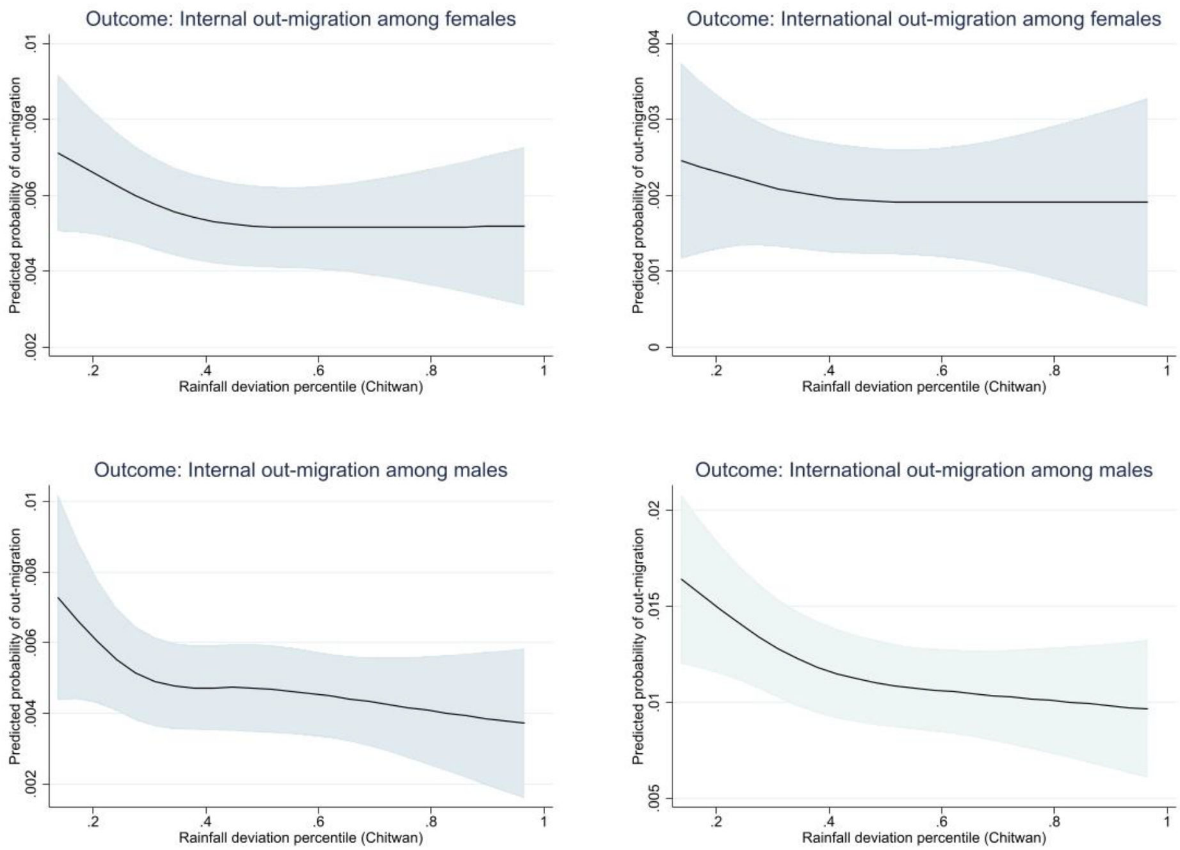

Fig. 4.
Non-linear adjusted relationship between rainfall deviations (in percentiles) and the predicted probability of out-migration among females and males.

Table 1.

Definition of migration outcomes and drought exposures included in analysis.

Migration Outcome	From	To	Origin Information Available	Destination Information Available	Drought Exposure(s)
Internal out migration	Chitwan	Elsewhere in Nepal	Chitwan neighborhood	District within Nepal	Drought at origin (Chitwan neighborhood)
International out migration	Chitwan	Outside Nepal	Chitwan neighborhood	Country	Drought at origin (Chitwan neighborhood)
Internal return migration	Elsewhere in Nepal	Chitwan	District within Nepal	Chitwan neighborhood	Drought at origin (district within Nepal); Drought at destination (Chitwan neighborhood); Interaction between drought at origin and drought at destination
International return migration	Outside Nepal	Chitwan	Country	Chitwan neighborhood	Drought at destination (Chitwan neighborhood)

Table 2.

Descriptive statistics of adults aged 18–59. Mid person-month observed (April 2014). Chitwan, Nepal.

	Males (n=4,193)	Females (n=4,605)
Age (time varying, 13 month lag), mean (SD)	33.4 (11.4)	32.1 (11.3)
Married (time varying, 13 month lag), % (n)	72.3 (3,072)	81.7 (3,764)
Ethnicity, % (n)		
Brahmin-Chhetri	45.0 (1,887)	44.9 (2067)
Dalit	11.6 (488)	10.8 (499)
Newar	6.3 (265)	6.7 (306)
Terai Janajati	17.5 (734)	18.4 (849)
Hill Janajati	18.7 (782)	18.4 (849)
Household owns house plot, % (n)	86.5 (3,627)	86.8 (3,997)
Neighborhood walking distance in minutes, mean (SD)		
Bank	30.9 (24.5)	30.8 (24.0)
Employment center	9.1 (8.1)	8.9 (8.0)
Market	5.8 (6.6)	5.8 (6.5)
Money transfer	24.8 (19.5)	24.7 (19.3)
School	7.6 (5.2)	7.7 (5.3)

Table 3:

Mixed-effects regression models of odds of out-migration among adult males and adult females.

	Out-migration (internal)		Out-migration (international)	
	Males	**Females**	**Males**	**Females**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Drought in past 12 months (Chitwan neighborhood)	1.19** (1.06, 1.35)	1.14* (1.02, 1.27)	1.18** (1.07, 1.30)	1.11 (0.93, 1.34)
Age (time varying, 13 month lag)	0.95* (0.90, 0.99)	0.67*** (0.64, 0.70)	1.21*** (1.16, 1.26)	0.91*** (0.86, 0.96)
Age-squared (time varying, 13 month lag)	1.00 (0.99, 1.00)	1.00*** (1.00, 1.00)	0.99*** (0.98, 0.99)	1.00* (1.00, 1.00)
Married (time varying, 13 month lag)	0.99 (0.81, 1.20)	5.87*** (4.66, 7.43)	1.69*** (1.45, 1.95)	2.26*** (1.71, 2.99)
Ethnicity				
Brahmin-Chhetri	REF	REF	REF	REF
Dalit	1.16 (0.93, 1.46)	0.75* (0.58, 0.97)	1.49*** (1.27, 1.76)	0.92 (0.68, 1.24)
Newar	1.11 (0.84, 1.48)	0.88 (0.63, 1.24)	0.81 (0.64, 1.05)	0.75 (0.48, 1.16)
Terai Janajati	0.75** (0.61, 0.92)	0.74* (0.58, 0.94)	1.00 (0.84, 1.19)	0.66** (0.48, 0.90)
Hill Janajati	0.82 (0.67, 1.01)	0.74* (0.59, 0.93)	1.24** (1.07, 1.44)	1.33 (0.88, 2.03)
Household owns house plot	1.05 (0.86, 1.28)	1.32* (1.05, 1.66)	1.47*** (1.26, 1.71)	1.00 (0.78, 1.30)
Neighborhood walking distance in minutes				
Bank	1.00 (1.00, 1.00)	0.99 (0.99, 1.00)	1.00 (1.00, 1.01)	1.00 (1.00, 1.01)
Employment center	1.01 (0.99, 1.03)	1.01 (0.99, 1.04)	1.00 (0.98, 1.02)	1.00 (0.97, 1.02)
Market	1.00 (0.97, 1.02)	1.00 (0.98, 1.03)	1.01 (0.99, 1.04)	1.00 (0.99, 1.00)
Money transfer	1.00 (0.99, 1.01)	0.99** (0.98, 0.99)	1.02*** (1.01, 1.02)	0.99 (0.99, 1.00)
School	1.02 (0.99, 1.06)	0.99 (0.96, 1.02)	0.95* (0.93, 0.99)	1.02 (0.98, 1.05)
Constant	0.024*** (0.011, 0.051)	0.85 (0.40, 1.82)	0.00060*** (0.00031, 0.0012)	0.0048*** (0.0018, 0.013)
Log likelihood	−6970.02	−8856.95	−10006.82	−3750.04
Individuals aged 18–59	5,009	5,936	5,009	5,936
Person-months	169,841	258,326	169,850	257,975

All models also include indicator variable for month and year.

* $p<0.05$

** $p<0.01$

*** $p<0.001$

Table 4:

Mixed-effects regression models of odds of return migration among adult males and adult females.

	Return migration (internal)		Return migration (internal)		Return migration (internal)		Return migration (international)	
	Males	Females	Males	Females	Males	Females	Males	Females
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Drought in past 12 months (Chitwan neighborhood)	1.17* (1.01, 1.34)	1.18* (1.02, 1.36)			1.13* (1.00, 1.33)	1.13* (1.00, 0.35)	1.15** (1.04, 1.28)	0.97 (0.72, 1.31)
Drought in past 12 months (sending district)			1.18* (1.00, 1.42)	1.22* (1.02, 1.47)	1.10 (0.89, 1.36)	1.13 (0.91, 1.41)		
Age (time varying, 13 month lag)	0.90*** (0.86, 0.96)	0.89*** (0.84, 0.95)	0.91*** (0.86, 0.96)	0.89*** (0.84, 0.95)	0.91*** (0.86, 0.96)	0.89*** (0.84, 0.95)	0.92*** (0.88, 0.96)	0.79*** (0.70, 0.88)
Age-squared (time varying, 13 month lag)	1.00** (1.00, 1.00)	1.01*** (1.00, 1.01)	1.00** (1.00, 1.00)	1.00*** (1.00, 1.01)	1.00** (1.00, 1.00)	1.01*** (1.00, 1.01)	1.00*** (1.00, 1.01)	1.01*** (1.00, 1.01)
Married (time varying, 13 month lag)	1.09 (0.87, 1.37)	0.63*** (0.51, 0.77)	1.09 (0.87, 1.37)	0.63*** (0.50, 0.77)	1.09 (0.87, 1.37)	0.63*** (0.51, 0.77)	1.05 (0.90, 1.21)	1.24 (0.75, 2.05)
Ethnicity								
Brahmin-Chhetri	REF	REF	REF	REF	REF	REF	REF	REF
Dalit	0.94 (0.71, 1.25)	1.08 (0.80, 1.46)	0.94 (0.71, 1.25)	1.07 (0.80, 1.47)	0.94 (0.71, 1.24)	1.08 (0.80, 1.46)	1.25** (1.07, 1.47)	2.71** (1.52, 4.79)
Newar	1.20 (0.95, 1.71)	0.99 (0.67, 1.47)	1.20 (0.95, 1.71)	1.00 (0.68, 1.48)	1.21 (0.85, 1.71)	0.99 (0.67, 1.47)	0.93 (0.70, 1.21)	1.18 (0.56, 2.48)
Terai Janajati	1.57** (1.21, 2.04)	0.75* (0.55, 0.99)	1.57** (1.21, 2.04)	0.75* (0.55, 0.99)	1.57** (1.20, 2.04)	0.75* (0.55, 0.99)	1.54*** (1.31, 1.81)	2.15* (1.11, 4.16)
Hill Janajati	1.03 (0.79, 1.35)	1.13 (0.88, 1.47)	1.03 (0.79, 1.35)	1.13 (0.88, 1.47)	1.03 (0.79, 1.35)	1.13 (0.88, 1.47)	1.00 (0.86, 1.15)	1.39 (0.88, 2.19)
Household owns house plot	0.78 (0.60, 1.01)	0.86 (0.66, 1.13)	0.78 (0.61, 1.01)	0.86 (0.66, 1.13)	0.78 (0.60, 1.02)	0.86 (0.66, 1.13)	1.13 (0.96, 1.35)	1.00 (0.58, 1.72)
Neighborhood walking distance in minutes								
Bank	1.00 (0.99, 1.01)	1.00 (1.00, 1.01)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	1.00 (1.00, 1.01)	1.00 (1.00, 1.01)	1.00 (0.99, 1.01)
Employment center	0.98 (0.95, 1.02)	0.99 (0.98, 1.01)	0.98 (0.95, 1.02)	0.99 (0.98, 1.01)	0.98 (0.95, 1.02)	0.99 (0.98, 1.01)	1.00 (0.99, 1.01)	1.01 (0.99, 1.04)
Market	1.04 (1.00, 1.08)	1.00 (0.99, 1.02)	1.04 (1.00, 1.08)	1.00 (0.99, 1.02)	1.04 (1.00, 1.08)	1.00 (0.99, 1.02)	1.00 (0.99, 1.02)	1.00 (0.97, 1.04)
Money transfer	0.99 (0.99, 1.01)	1.00 (0.99, 1.01)	0.99 (0.99, 1.01)	1.00 (0.99, 1.01)	0.99 (0.99, 1.01)	1.00 (0.99, 1.01)	1.00 (1.00, 1.01)	1.00 (0.99, 1.01)
School	0.99 (0.95, 1.04)	1.00 (0.97, 1.02)	0.99 (0.95, 1.04)	1.00 (0.97, 1.02)	0.99 (0.95, 1.04)	1.00 (0.97, 1.02)	0.99 (0.98, 1.01)	0.96 (0.91, 1.02)

	Return migration (internal)		Return migration (internal)		Return migration (internal)		Return migration (international)	
	Males	Females	Males	Females	Males	Females	Males	Females
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Constant	0.075*** (0.029, 0.19)	0.13*** (0.048, 0.35)	0.075*** (0.030, 0.19)	0.13*** (0.049, 0.35)	0.075*** (0.029, 0.19)	0.13*** (0.048, 0.35)	0.063*** (0.030, 0.13)	0.19 (0.022, 1.66)
Log likelihood	−4821.44	−4665.54	−4821.95	−4665.73	−4821.04	−4664.95	−8212.67	−1117.12
Individuals aged 18–59	2,048	2,472	2,048	2,472	2,048	2,472	2,311	672
Person-months	58,735	70,583	58,735	70,583	58,735	70,583	86,579	18,407

All models also include indicator variable for month and year.

* $p<0.05$

** $p<0.01$

*** $p<0.001$