Temporal Dimensions of Weather Shocks and Migration

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Abstract

Although strong empirical evidence shows that weather shocks, such as floods and droughts, generally influence migration in many countries worldwide, the details of this relationship remain unclear and some disparate empirical results are yet unexplained. In this article, we examine temporal dimensions of the weather-migration relationship. With temporally detailed data from rural Nepal, we find migration responses for up to five years after floods, droughts, heatwaves, and cool snaps. In addition, we find differences in short- and long-term migration responses over time. These results have implications for both academic research and policy, which we discuss in our concluding section.

Introduction

In the past decade, both policymakers and academics have focused serious interest on the relationship between climate change and migration (citations). Governments and international organizations are most concerned, if not alarmed, that rural populations in the developing world are highly vulnerable to weather shocks and will be become increasingly so under climate change. This could result in large-scale involuntary displacements, occurring in relatively short periods of time, with little foresight or planning (citations). In addition to migrant well-being, this has implications for urbanization processes, mega-cities, and security worldwide. Conventional wisdom and general migration theory leads us to believe that changes in weather or natural disasters could indeed have this impact (citations). The underlying narrative is that weather shocks will reduce agricultural harvests and force people to migrate in search of economic gain elsewhere. This idea is backed up by migration theories and empirical evidence that demonstrate a strong connection between livelihoods, economic gain, and migration (Massey et al. 1993; Massey and Espinosa 1997; Sjaastad 1962; Stark and Bloom 1985; Stark and Taylor 1989; Taylor 1987; Todaro 1969).

However, there is a growing body of empirical literature that shows this alarmist scenario not to be the case. Although research has demonstrated that weather shocks can lead to migration in numerous countries worldwide, the connection is much more complicated than originally professed (citations). Some studies find small or even negative migration responses after large and drastic weather changes. A small but growing body of literature shows variations in migration response depending on destination and duration as well as individual, household, and community characteristics of potential migrants (citations). Thus, while there is consistent evidence that weather shocks do influence migration, the details and theoretical specification remain blurry. In other words, it is not entirely clear precisely how and why weather influences the complex process of migration and what types of migration might be most affected. These nuances are important for a clear academic understanding of the mechanisms linking weather and migration and have clear policy relevance.

In this study, our primary objective is to provide a theoretical and empirical investigation of the influence of weather shocks on the temporality of migration. Specifically, we investigate how long it takes weather shocks to result in significant migration changes and whether these changes result in temporary or permanent migration. In doing so, we seek a better understanding of whether changes in weather will result in alarming, large scale, immediate, and unplanned permanent migration streams or if they will result in more sustainable, yet still important, changes to temporary or permanent migration as part of ongoing changes in rural livelihood strategies.

We use a detailed case study approach, investigating these questions in a rural agricultural area of Nepal. We are able to investigate these questions through using exceptionally temporally precise survey data on migration from the prospective and longitudinal Chitwan Valley Family Study in Nepal which features monthly records of migration for almost 7000 individuals over a period of 16 years. Paired with data from a local weather station that provide daily records of temperature and rainfall for the past 50 years, we are able to test our theories with exceptional detail. We further enhance this numerical data with in-depth fieldwork with farmers in the study area, which guides our interpretation of statistical results.

Our detailed temporal analysis reveals a more complex story of weather-induced migration than most previous studies have been able to tell. The effects of weather shocks on migration vary with the duration of migration, the type of shock and the timing of the shock. Shocks have long-term as well as immediate influences on migration. In fact, some of the largest migration changes are more than one year after weather events. Further, while we find both temporary and long-term responses, results show much bigger effects on temporary migration, a flow that most previous demographic studies on this topic have ignored. Together these results suggest that an increased frequency of weather shocks could contribute to a livelihood transition away from subsistence agriculture and towards dependence on migration, particularly short-term moves. If heat shocks increase as expected under climate change, heat-induced movements are likely to be partly counterbalanced by reductions in migration at other intervals. We discuss the implications further in the conclusions of this article.

Theoretical Framework

In this article, we focus on migration in rural, agriculturally-oriented areas. The influence of weather shocks on urban dwellers is certainly important, but the theoretical underpinnings and empirical patterns are likely entirely different than what we expect to find in rural areas.

The basic theoretical grounding for the relationship between weather and migration is that weather shocks will have detrimental effects on crop and animal growth and consequently, rural incomes will temporarily decline after a shock. These temporary declines could occur once, or with regular weather shocks, could make rural livelihoods less or even unsustainable. Given lower incomes, push-pull, neo-classical economics, and new economics of migration theories would predict out-migration in order to search for financial gain and diversification of income sources elsewhere (Massey et al. 1993; Massey and Espinosa 1997; Sjaastad 1962; Stark and Bloom 1985; Stark and Taylor 1989; Taylor 1987; Todaro 1969). This general theoretical connection between weather and migration is based on solid logical reasoning and empirical evidence for the underlying economic arguments for migration, however it is simplistic in many ways, does not accurately reflect the realities of rural livelihoods, and does not take other social and demographic theories into account.

Davis' classic theory of multiphasic demographic response provides some important insights into better understanding this situation (Davis 1963). Davis' theory argues, amongst other things, that in response to a stimulus (or macro-level change), people will change their behaviors in many ways, not just one way. In addition, people will choose to first employ the behaviors that are least disruptive to their lives. Only later, and if needed, will people employ more disruptive responsive behaviors. Ideas based on the theory of multi-phasic demographic response have received empirical support from studies of fertility, migration, and agricultural changes (Bilsborrow 1987; Codjoe and Bilsborrow 2011; Friedlander 1983; Mosher 1980a, 1980b). In this regard, migration can be viewed as one of the many adaptations that rural individuals and households can institute when livelihoods are threatened by climate change.

A key component of this theory is that people will undertake less disruptive changes before more disruptive changes. Migration, which involves changing one's place of residence, employment, living situation, and social milieu is a costly and drastic change. Furthermore, permanent migration of a whole household, or giving up on a rural livelihood, is a more drastic change than temporary or circular migration of a single household member, or adjusting a rural livelihood. As such we expect that people will employ migration well after many other easier adaptations and that they will employ temporary migration before resorting to permanent household re-location. In other words, we expect the influence of weather shocks to have a larger positive effect on short-term than long-term migration and that these effects will not be evidenced immediately.

A closer examination of the costs of migration provides further theoretical insight into the temporalities of migration. At first consideration, and as often assumed, migration can be used immediately after a poor agricultural season to make up for the income that was lost. This argument, where the motivation to migrate increases, would suggest migration occurring very soon after each weather shock. However, again, migration is costly and evidence shows that the poorest households often cannot undertake migration even if they could benefit from it (citations). Indeed, some of the earliest nuance added to classic migration theory is the idea that independent of the motivation to migrate, the cost of migration is a key factor in whether the actual behavior takes place (citations). As such, a poor agriculture season and decreased incomes could leave a household without the funds to undertake a migration. In this case, where the ability to migrate is affected, we could expect to see initial decreases in migration after a weather shock. With these two opposing considerations in mind, we argue that large weather shocks, which result in larger decreases to household incomes, will result in initial decreases in migration followed by later increases. In comparison, smaller weather shocks, with smaller negative effects on incomes, we expect to influence smaller or no initial decreases in migration.

Given these theoretical specificities, our empirical investigation, which follows, examines how weather shocks differentially influence short- and long-term migration. We also focus on the time between weather shocks and changes in migration behavior, including the possibility that migration might decrease as well as increase in response to weather shocks.

Setting

The empirical data in this study come from the Chitwan Valley, located in south-central Nepal. The administrative district of Chitwan borders India and is about 100 miles from Kathmandu. There is one large city, Narayanghat, and the rest of Chitwan's population, like much of Nepal, lives in small, rural villages. Agriculture is the dominant occupation, with about 80% of households in the study area involved in farming or animal husbandry. Most of these households operate on a subsistence level, owning or farming small amounts of land and livestock. Many of the households involved in agriculture in this study area own their land, but sharecropping, mortgaging, or rental agreements are also common. In many cases, a family is involved in a mix of these, owning some of the land they farm and renting or sharecropping additional land.

The main subsistence crops in this area include rice, wheat, buckwheat, maize, pulses, and a variety of vegetables. Common livestock, which are kept for meat, milk, or as draft animals, include water buffaloes, cows, goats, pigs, and chickens. Recently, some households have begun to engage in market agriculture. Small fruit orchards and chicken farms are the most common enterprises, although vegetables such as cabbage and even aloe vera are starting to appear throughout the valley.

As Chitwan is subject to annual monsoons, weather patterns vary dramatically throughout the year and heavily determine farming seasons. In turn, farming seasons, or more precisely, planting and harvest times, determine when labor is most needed. As shown in Figure 1, the monsoon generally starts around May, with heavy rains of over 600 mm per month and hot weather reaching 30 degrees Celsius. After September, the rains subside to almost nothing each month and the temperature usually decreases to 20 or 25 degrees Celsius. Accordingly, most farming households plant rice, which is the most important crop of the year, in June and harvest around November. Wheat, pulses, and vegetables are grown from November through April, and maize is grown February through June.

[Figure 1 about here.]

Our fieldwork in the study area, which consisted of open-ended in-depth interviews with farmers, reveals several key insights about how different kinds of weather shocks influence different crops and livestock. Farmers consistently report that dry weather causes decreases in crop growth. Droughts can have disastrous effects, killing an entire rice crop, if they occur precisely when rice is being planted. However during any other period of time, droughts simply slow crop growth, but do not kill plants. In addition, irrigation from canals or wells can ameliorate the effect of a drought. Floods can also be a problem, but result in slowed crop growth and not complete loss of a harvest. Heat waves appear to be more problematic. Such events can kill both rice and bean crops, as well as animals, and there is no way to ameliorate the effects of excessive heat. Cool snaps can also cause decreased crop growth, but not crop or livestock death.

Historically, there has been significant migration from the Chitwan Valley to other areas of Nepal and nearby areas of India. Nepal and India share an open border, so there are no restrictions on Nepalese cross-border travel to India, making international migration no more difficult than internal migration. More recently, with new government legislation and encouragement of labor contracting organizations, migration to more distant parts of the world has increased dramatically. Estimates suggest that perhaps 1.5 million Nepalis live and work in India, although two to three million might work there seasonally (NIDS 2004; Thieme 2006). At least 800,000 Nepalis live and work in the Persian Gulf (NIDS 2011). Other destinations include Malaysia, South Korea, and over 100 other countries around the world.

Much of the migration is impermanent and viewed as a strategy to supplement regular farm and household incomes (Kollmair et al 2006; Thieme and Wyss 2005). Because of the short-term nature of migration as a livelihood strategy, most migrants move alone and remit large amounts of money, while other family members stay at home to care for children, land, and livestock (Gill 2003; Thieme and Wyss 2005; Kollmair et al. 2006). As shown in Figure 2, migration varies by month and by year. In addition, it is much more common amongst men, who migrate at almost twice the rate of women.

[Figure 2 about here.]

Data and Measures

Data for this study come from two sources—individual survey data from the Chitwan Valley Family Study (CVFS) and a weather data from a local weather station in Chitwan. The CVFS is a large-scale multidisciplinary study of the western Chitwan Valley of Nepal, designed to investigate the impact of macro-level socioeconomic changes on micro-level behavior. Amongst other data, the CVFS includes an individual interview and life history calendar that were collected in 1996 and a prospective demographic event registry that has been collected monthly since 1997[1]. The primary data on migration comes from the prospective registry. The prospective nature of this data set makes it ideal for studying migration, by providing information on a representative sample of all people exposed to the possibility of migration and following them until the present to record who migrates, who returns, and who migrates again.

Our sample, based on the demographic event registry includes 151 separate neighborhoods that were selected with an equal probability, systematic sample. All individuals between the ages of 15 and 59 within these neighborhoods were included in the survey. Our data cover 16 years, from 1997 to 2012. Given that it was collected on a monthly basis, the exceptional temporal precision in the demographic event registry is what makes possible the exceptional precision in our migration measures and the rare opportunity to carefully address monthly changes in migration due to precise temporal changes in weather.

Weather data come from a local weather station run by the National Maize Research Program and obtained from the Department of Hydrology and Meteorology of the Government of Nepal. They include daily records of rainfall and high and low temperatures since the 1960's. In this study, we use weather records from 1990 through 2012.

Measures of migration and other demographic characteristics

[1] There was a protocol change in data collection in February 2000 that affected how migration was recorded. This results in an inordinately high migration rate for that one month, after which records of migration resume more usual rates. For this reason, we delete February 2000 from our data analysis, so that all our data are collected under the same system are comparable across months.

Migration is measured from the CVFS prospective demographic event registry which provides residence records on a regular basis. Migration is defined as a one month or longer absence from an individual's original 1996 neighborhood. We separate short- and long-term migration by defining short-term migration as being absent from the original neighborhood from one to 11 months and long-term migration as being absent for 12 months or more. The use of a prospective demographic event registry collected on a monthly basis allows for this precise recording of migration.

We control for a variety of individual, household, and community characteristics that might influence the migration outcome or confound the migration-weather relationship. Age, educational attainment (number of years ever enrolled), current educational enrollment, number of children, marital status, and the number of migrations a respondent has undertaken in their life are all time-varying and have been shown to influence migration in Chitwan and other settings (Donato 1993; Findley 1987; Massey et al. 2010; Massey and Espinosa 1997; Massey et al. 1987; Massey 1990; Pedraza 1991; VanWey 2005; Williams 2009; Williams 2013). Gender and ethnicity are not time-varying, but are also key predictors of migration in Chitwan (citations). Whether a respondent has ever held a salaried or wage labor job, and the distance of their neighborhood from Narayanghat, the one urban area in the study site, are also not time-varying, and are important to measure access to or experience with alternate off-farm income sources or employment.

Because weather shocks, our primary focus, are measured as temporal changes, it is essential to address other temporal changes that could confound the weather-migration relationship. In order to control for regular seasonal migration patterns in the Chitwan Valley, particularly in relation to the harvesting and planting cycles, we include in all models a series of eleven dichotomous variables for each month of the year, with July as a reference. We control for the period of armed conflict, which affected Chitwan from 2001-2006 and include a continuous variable for the number of months since the beginning of the study period to control for duration effects or the selectivity of migration over time. This is a relatively conservative strategy that controls for other exogenous changes over time as well as survey attrition, leaving a greater chance that the effects over time that are observed are due to variations in weather.

Measures of weather change

In accordance with the theoretical connection between migration and particularly disadvantageous spells of weather, our primary measures of weather change use thresholds to designate particularly bad spells of weather, including floods, droughts, heatwaves, and cool periods. We define these periods where the rainfall or temperature are one standard deviation above or below the mean for that month, calculated from 1980 to 2012. Thus a January would be defined as a flood month if it experienced one standard deviation higher rainfall than the mean of all Januaries in the past 32 years. We then aggregate these monthly measures to create count variables of the number of drought, flood, heat, or cool months in the past year. In order to investigate the long-term influence of weather, we create such variables for the number of floods, droughts, heatwaves, and cool periods in the past year, two years ago, three years ago, etc.

We also test measures of rainfall and temperature that rely on continuous, and not threshold, measurement. These are simply the average amount of rain and the average temperature for the past year (one to 12 months previous) for two years ago (13-24 months previous), for three years ago, etc. Hereinafter, we refer to this as the linear specification.

Analytic Strategy

To investigate the influences of weather shocks on migration while controlling for potential confounders, we estimate a series of multinomial discrete-time event history models where the unit of analysis is the person-month. Migration is defined as a departure from the neighborhood for one or more months, including both first order and subsequent moves. Individuals are excluded from the person-month dataset for the period in which they are absent, and re-enter it during their first month of renewed residence. We additionally decompose migration into a multinomial outcome where zero is no migration, one is a departure for 1-11 months (short-term migration), and two is a departure for 12 or more months (long-term migration).

Weather shocks and control variables at various scales are included as independent variables (Table 1). The values of control variables are lagged by one month to avoid endogeneity with the migration. To capture the full annual monsoon cycle, weather shocks as defined above are aggregated over 12 month periods beginning one month prior to the month of potential migration and extending to 60 months prior (i.e., 1-12, 13-24, 25-36, 37-48, and 49-60 months prior to migration). Given that year-to-year weather fluctuations are expected to be uncorrelated (citations), we include each of these specifications in a separate model. To account for the use of a single weather station and consequent temporal clustering, all standard errors are corrected for clustering on the month (citations). The results presented here are also robust to alternatively correcting for clustering at the neighborhood scale.

Results

Complete results for the first specification (weather shocks in the last 1-12 months) are presented in Table 2, and key results of all specifications (weather shocks in the past 13-24, 25-36, 37-48, and 49-60 months) are presented in Table 3. Figures 3 and 4 graphically present these same results, with statistically significant odds ratios plotted and non-statistically significant odds ratios plotted at 1.0. Weather shocks have complex effects that vary by the duration of migration, the type of shock, and the temporal lag. Consistent with our theoretical discussion and contextual description above, the effects are generally strongest for short-term versus long-term migration, for temperature shocks versus precipitation shocks, for cold shocks versus warm shocks, and for lagged time periods versus the year prior to migration.

We first examine how weather shocks in the past year influence migration. As shown in Table 2, recent droughts decrease short-term migration, have no significant effect on long-term migration, and we find no significant responses to recent floods. Cool temperature snaps increase short-term moves while both hot and cold temperature snaps decrease long-term migration.
This negative effect of droughts supports the theory that income declines from weather shocks make it more difficult to undertake a costly migration, regardless of any changes to motivation or desire to do so. This is also the case for the pattern of positive and negative effects of temperature changes on short- and long-term migration respectively. The lack of significant effects for recent floods and long-term migration after recent droughts could suggest credence to the multi-phasic demographic theory. Our confidence in supporting these theories is increased when we examine patterns of migration response to weather shocks that occurred further in the past. We turn to this now.

[Table 2 about here.]

Considering short-term migration (Figure 3), these moves consistently increase with cold shocks, peaking for shocks four years prior to migration, with an odds ratio of 1.33 as shown in Table 3. Heat shocks also increase short term moves but the magnitudes are slightly smaller, with an odds ratio of 1.17, and the effects peak at three years prior. Turning to the linear specification (a continuous measure of average annual temperature), shown in Models 6-10 Table 3, the positive effects of both heat and cold result in a complex temporal pattern in the linear specification, with negative effects of temperature in years one and four only. In this case, the threshold measures of heat and cool periods result in a clearer pattern of results.

[Table 3 about here.]

[Figure 3 about here.]

The effects of flood and drought shocks on short-term moves are generally weaker but are statistically significant for time multiple lags. Drought initially decreases these moves by about 5% (with an odds ratio of 0.95), but moves subsequently increase in year four, with an odds ratio of 1.04. Flooding increases short-term moves after three years, with a similar odds ratio of 1.05, but moves subsequently decline at four and five years. In the linear specification, the balance of these effects results in a positive effect of rainfall on short-term moves in year three, with marginally significant positive effects in years one and two. Again, we find a clearer and more detailed understanding of the migration-weather relationship from the threshold effect specification.

Compared to short-term moves, the effects of temperature shocks on long-term moves occur more quickly and are often negative. Cold shocks decrease long-term moves in years one and two, with odds ratios of 0.79 and 0.82, and subsequently increase them, in years three and four, with odds ratios of 1.10 and 1.23. Heat shocks act more quickly but with similar magnitudes. They decrease moves in year one, with odds of migration at 0.86, and increase them in year two, with an increase in odds of 1.14. The net effect of these two shocks contributes a linear effect of temperature that increases long-term moves in years one and two and decreases them in year four.

[Figure 4 about here.]

Flood and drought have much slower effects on long-term migration. We find no statistically significant effects for years one through 3. In years four and five, floods have a positive effect on long-term migration (odds ratios of 1.06 and 1.13) and it is not until year five that drought influence long-term migration with an odds ratio of 1.07. In the linear specification, long-term moves increase with rainfall in year four. Once again, the linear specification provides a less clear understanding of weather effects, especially in the case where both low rainfall (droughts) and high rainfall (floods) produce the same effect on migration.

Comparing the effects of shocks on short-term and long-term moves, we find some notable differences that suggest one type of move occurs at the expense of another. For example, temperature shocks initially (in years one and two) initially decrease long-term moves while increasing short-term moves. In year three, heat waves have no effect on long-term migration and a still positive effect on short-term migration. At the same time, cool snaps increase both short- and long-term migration in years three and four. In summary, we find initial short-term moves increasing at the expense of long-term moves after temperature shocks, but as time goes on, we find cool snaps positively increasing both kinds of moves and heat shocks progressively affecting neither.

In the face of rain shocks, we find a similar pattern of one kind of migration changing at the expense of another. Specifically, we find early (year two) and late (year five) decreases in short-term migration in response to floods, paired with late (years four and five) increases in long-term migration after floods.

Conclusion

In a recently burgeoning literature on the relationship between weather and climate change and migration, there is a strong empirical record showing that there is a relationship between the two processes in various countries around the world but that it seldom adheres to general theories that predict catastrophic responses to expected climate change (citations). However, while there is consistent agreement on the broad character of the migration-climate relationship, there still remain questions about the nuances of the relationship—how different kinds of weather differentially affect different kinds of migration, and at different time scales. In this article, we contribute a detailed empirical investigation of the temporality of different kinds of weather shocks. Although this study is based in rural Nepal, the results support general demographic theories that can also be applied in other geographic areas worldwide.

In general, we find long-term consequences of climate changes, with migration responses to weather shocks up to five years in the past. In fact, the largest effects we find are four years after the shock. We also find a general progression with some weather shocks first influencing higher short-term migration at the expense of lower long-term migration. Over years, long-term migration then increases while short-term moves return to normal levels.

We also examine four different kinds of weather shocks- floods, droughts, heatwaves, and cool snaps and compare these with expectations from theory and from interviews with farmers in the study area. Our results show that temperature shocks have bigger consequences for migration than rainfall shocks. This is not surprising, given the possibility in this area of irrigating or improving drainage to cope with variance in rainfall. However, we do find the surprising result that cool periods have the largest impact on migration, even compared with heat waves. Further research in other areas and qualitative work will help to explain these differences.

Together, the temporal patterns we find, for all four types of weather shocks and two types of migration we examine, consistently support the multi-phasic demographic theory which predicts that people will undertake other less disruptive adaptive behaviors in response to weather shocks, before migrating (citations). They also support the idea that migration is costly and weather shocks can initially decrease the ability to migrate, contrary to popular assumptions.

As mentioned already, this study is based only in Nepal, and further research in other areas will be necessary to confirm if any of these patterns are evidenced more broadly and to be more confident in our theoretical conclusions. At the same time, our results in this study suggest some reasons why studies in various parts of the world find disparate results. Here, we find more consistent and clear patterns of weather effects on migration when we look several years into the past, separate short- and long-term migration. We also find much clearer results when we use threshold measures of weather shocks, instead of continuous measures of rainfall and temperature. Thresholds are a more straightforward operationalization of the theoretical connection between weather and migration and are especially important when there are similar migration responses to both high and low changes in weather. It is possible that these operationalizations of data could improve the clarity and consistency of patterns we find in other geographic areas.

In addition, the empirical support of the multiphasic demographic theory suggests some possible directions for future research. If it is the case that household undertake other less drastic behaviors before migration, and if we are interested in understanding immediate responses to climate shocks, then we would do well to look at other behaviors besides migration. In other words, if we believe that weather shocks really are detrimental to rural livelihoods and we believe that people do not often respond immediately by migrating, then it would behoove the research and policy communities to begin investigating what exactly are their immediate responses.

In terms of policy-makers, and especially concerns about burgeoning urbanization with continued climate change in the future, our results suggest that weather shocks might not in fact produce a full scale abandonment of rural agriculture livelihoods and areas for urban living. In fact, it is more likely that continued weather shocks, in the long-term, will increase temporary migration of some household members, in an effort to diversify rural livelihood strategies. In short, our results suggest a scenario of rural people adapting and diversifying in place, in contrast to giving up entirely and moving to urban areas. In addition, the long time periods we find between weather shocks and migration responses (up to five years) suggest that when people do migrate, they will do so with advance planning and preparation. This study suggests that it is unlikely that we will find large streams of reactionary and unprepared migrants immediately after a general weather shock.

As a final note, we emphasize that this article theoretically and empirically examines weather shocks, or periods where rainfall and temperature are out of the ordinary, but are not entirely catastrophic. Our results and conclusions do not address natural disasters, such as typhoons or tsunamis. A key difference is that weather shocks, as we use the term, can decrease income, but do not make rural residences unliveable. In the case of disasters, it is quite possible that migration responses could be immediate, reactionary, large-scale, or unprepared. Of course further research will be necessary in this case as well, to confirm or deny these assumptions.

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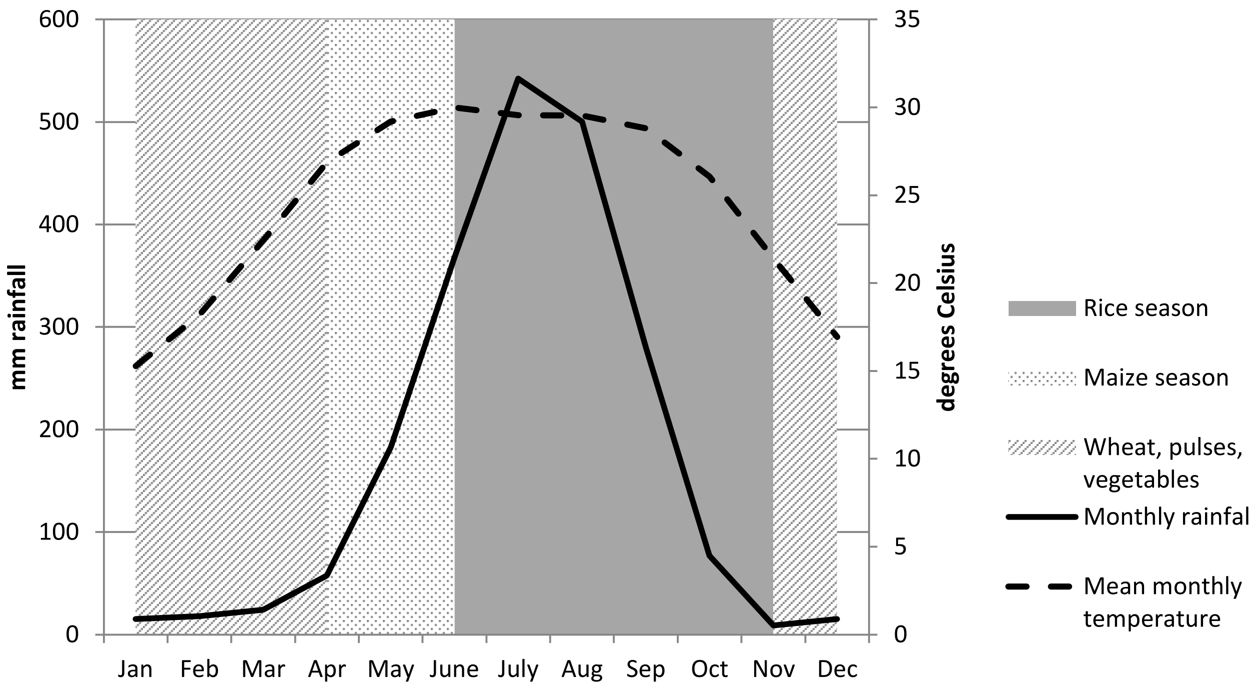

Figure 1. Average monthly rainfall, temperature, and crop seasons, Chitwan Nepal 1990-2006

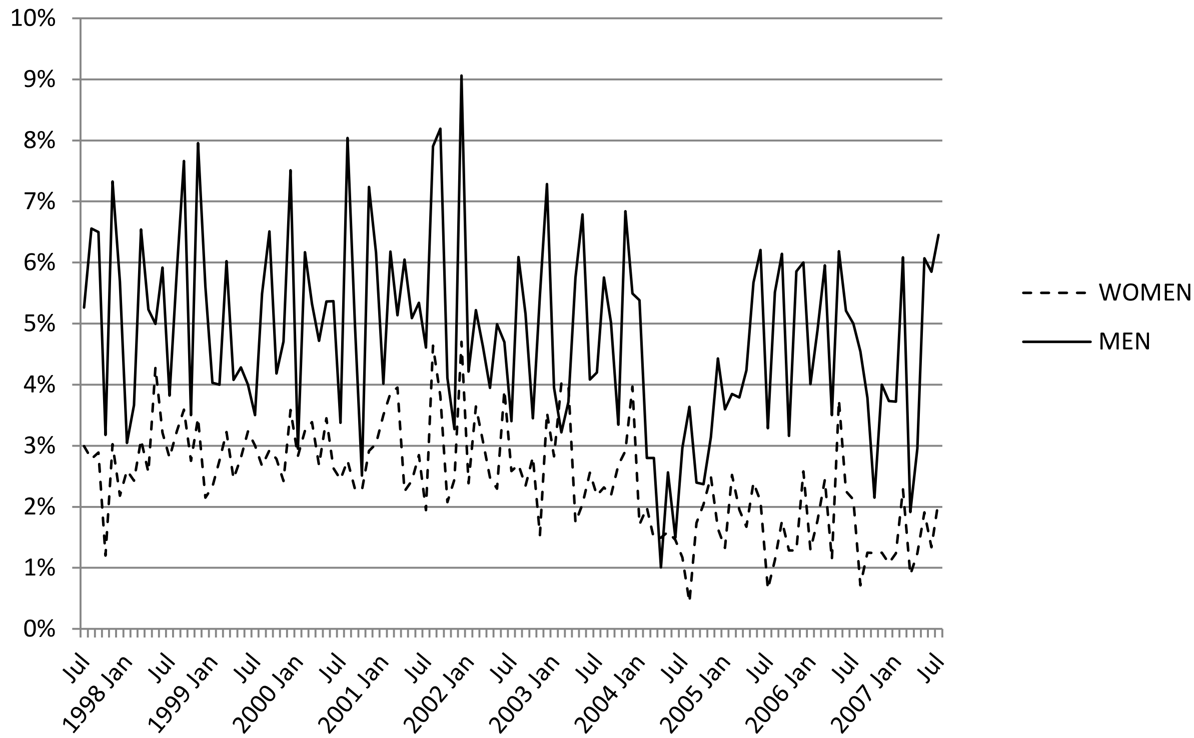

Figure 2. Percent of resident population migrated out of Chitwan, 1997-2006

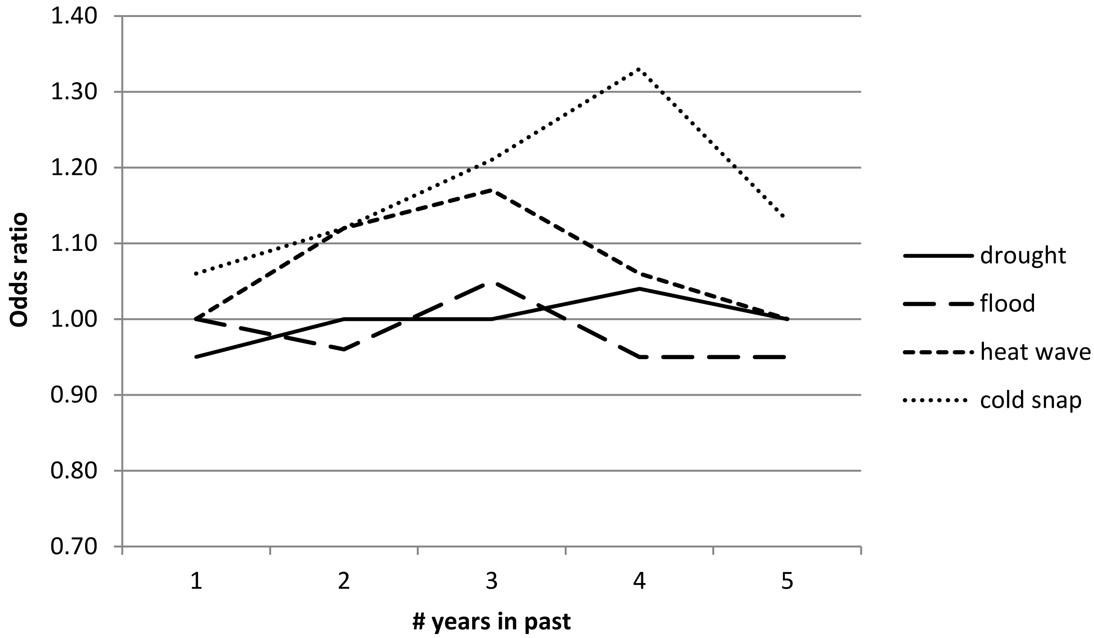

Figure 3. Effects of weather shocks on short-term migration, by number of years in the past the weather shock occurred.

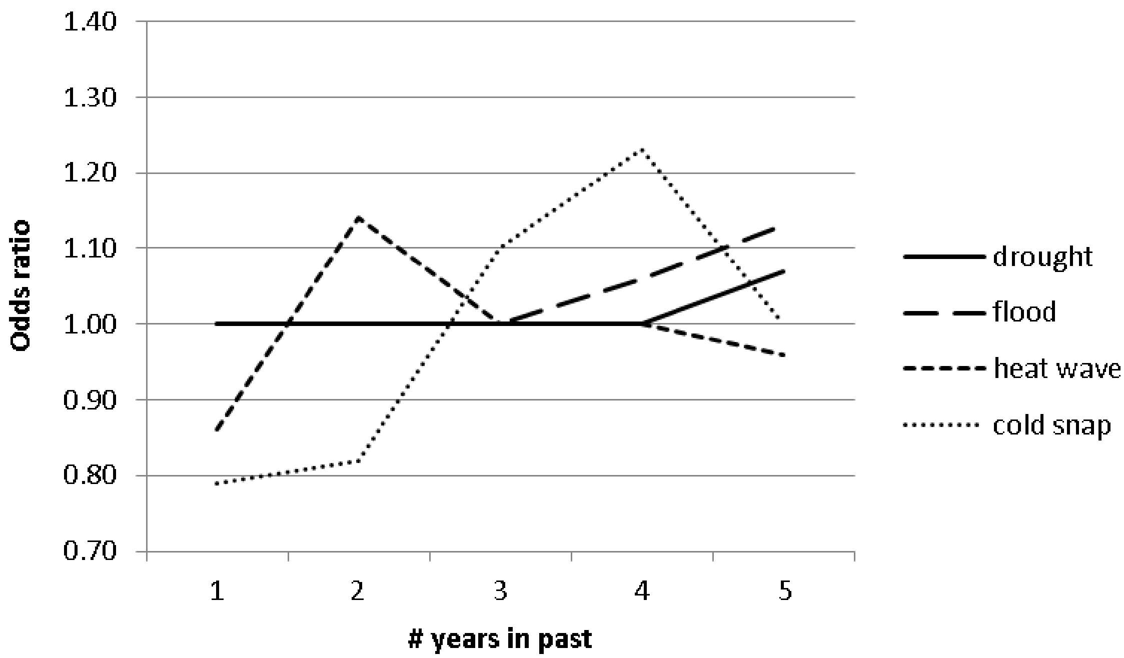

Figure 4. Effects of weather shocks on long-term migration, by number of years in the past the weather shock occurred.

Table 1. Descriptive statistics of CVFS data

Variable	Unit	Level	Time-varying	Mean	SD	Min	Max
Outcome							
Short-term move (by number of person-months)	0/1	Indiv	Yes	0.011	0.106	0	1
Long-term move (by number of person-months)	0/1	Indiv	Yes	0.006	0.078	0	1
Measures of weather							
Number of droughts in the last 12 months	#	Month	Yes	2.90	1.71	0	7
Number of floods in the last 12 months	#	Month	Yes	1.95	1.31	0	6
Number of heat waves in the last 12 months	#	Month	Yes	1.84	1.52	0	7
Number of cool snaps in the last 12 months	#	Month	Yes	1.35	2.34	0	9
Average rainfall in the last 12 months	dm	Month	Yes	1.78	0.36	0.90	2.49
Average temperature in the last 12 months	C°	Month	Yes	24.4	0.5	22.5	25.4
Measures of demographic and temporal characteristics							
Gender	0/1	Indiv	No	0.60	0.49	0	1
Age	years	Indiv	Yes	33.1	9.4	15	50
Number of children	#	Indiv	Yes	2.20	2.04	0	13
Educational attainment	#	Indiv	Yes	5.97	5.46	0	34
Current enrollment	0/1	Indiv	Yes	0.17	0.38	0	1
Salaried job ever	0/1	Indiv	No	0.20	0.40	0	1
Wage work ever	0/1	Indiv	No	0.41	0.49	0	1
Distance to Narayanghat	#	Neigh	No	8.53	4.07	0	18
Number of migrations ever	#	Indiv	Yes	0.96	1.68	0	22
Marital status – single	0/1	Indiv	Yes	0.17	0.37	0	1
Marital status – married not living w/ spouse	0/1	Indiv	Yes	0.17	0.38	0	1
Marital status- divorced, separated, widowed	0/1	Indiv	Yes	0.03	0.16	0	1
Marital status- missing data	0/1	Indiv	Yes	0.0	0.0	0.0	1
Ethnicity – Dalit	0/1	Indiv	No	0.10	0.30	0	1
Ethnicity – Newar	0/1	Indiv	No	0.06	0.24	0	1
Ethnicity – Hill Indigenous	0/1	Indiv	No	0.15	0.36	0	1
Ethnicity – Terai Indigenous	0/1	Indiv	No	0.23	0.42	0	1
Conflict period	0/1	Month	Yes	0.32	0.47	0	1
Month since study began	#	Month	Yes	96.8	59.3	2	191
January	0/1	Month	Yes	0.07	0.26	0	1
February	0/1	Month	Yes	0.09	0.29	0	1
March	0/1	Month	Yes	0.09	0.28	0	1
April	0/1	Month	Yes	0.09	0.28	0	1
May	0/1	Month	Yes	0.09	0.28	0	1
June	0/1	Month	Yes	0.08	0.28	0	1
July	0/1	Month	Yes	0.08	0.28	0	1
August	0/1	Month	Yes	0.08	0.28	0	1
September	0/1	Month	Yes	0.08	0.28	0	1
October	0/1	Month	Yes	0.08	0.28	0	1
November	0/1	Month	Yes	0.08	0.28	0	1
December	0/1	Month	Yes	0.07	0.26	0	1

N = 522,300 person-months

1/0 indicates a dichotomous variable; # indicates a count variable.

Indiv = Individual, Neigh=Neighborhood

Table 2. Results of multi-level multinomial hazard models of long- and short-term migration after weather shocks in the past 12 months Chitwan, Nepal

Predictor	**Short-term migration**		**Long-term migration**	
Number of droughts in the last 12 months	0.95	**	1.03	
Number of floods in the last 12 months	0.97		1.03	
Number of heat waves in the last 12 months	1.00		0.86	***
Number of cool snaps in the last 12 months	1.06	***	0.79	***
Gender	0.63	***	0.47	***
Age	0.97	***	0.95	***
Number of children	0.91	***	0.83	***
Educational attainment	1.03	***	1.02	***
Currently enrollment	1.49	***	1.87	***
Salaried job ever	1.08	+	1.31	***
Wage work ever	0.89	***	0.97	
Distance to Narayanghat	1.02	***	1.02	**
Number of migrations ever	1.29	***	1.25	***
Marital status – single[1]	0.78	***	0.54	***
Marital status – married not living w/ spouse	1.32	***	1.62	***
Marital status – divorced, separated, widowed	1.27	*	1.24	
Marital status – missing data	1.63	+	1.58	
Ethnicity – Dalit [2]	1.18	***	1.19	*
Ethnicity – Newar	1.12	+	1.20	*
Ethnicity – Hill Indigenous	1.12	**	1.24	***
Ethnicity – Terai Indigenous	0.77	***	0.80	***
Conflict period	1.32	**	1.37	***
Month since study began	0.99	***	1.00	***
January	0.73	+	1.06	
February	0.88		0.78	
March	0.77	+	0.73	+
April	0.91		0.99	
May	0.93		0.94	
June	0.76	*	0.86	
July	1.02		0.71	+
August	0.63	**	0.70	*
October	0.93		1.02	
November	1.06		0.95	
Decemer	0.69	*	0.80	
Constant	0.04	***	0.05	***

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[1] Reference category is Marital status – married living with spouse

[2] Reference category is Ethnicity – Brahmin/Chetri

Table 3. Results of multi-level multinomial hazard models of long- and short-term migration after weather shocks in the past 1-60 months Chitwan, Nepal

Model	Predictor	Short term migration		Long term migration		Joint test	
1	Number of droughts in the last 1-12 months	0.95	**	1.03		88.5	***
	Number of floods in the last 1-12 months	0.97		1.03			
	Number of heat waves in the last 1-12 months	1.00		0.86	***		
	Number of cool snaps in the last 1-12 months	1.06	***	0.79	***		
2	Number of droughts in the last 13-24 months	1.01		0.97		145.6	***
	Number of floods in the last 13-24 months	0.96	+	1.03			
	Number of heat waves in the last 13-24 months	1.12	***	1.14	***		
	Number of cool snaps in the last 13-24 months	1.12	***	0.82	***		
3	Number of droughts in the last 25-36 months	0.99		0.99		132.4	***
	Number of floods in the last 25-36 months	1.05	*	0.98			
	Number of heat waves in the last 25-36 months	1.17	***	1.04			
	Number of cool snaps in the last 25-36 months	1.21	***	1.10	*		
4	Number of droughts in the last 37-48 months	1.04	*	0.97		218.1	***
	Number of floods in the last 37-48 months	0.95	*	1.06	*		
	Number of heat waves in the last 37-48 months	1.06	***	0.99			
	Number of cool snaps in the last 37-48 months	1.33	***	1.23	***		
5	Number of droughts in the last 49-60 months	0.99		1.07	*	34.3	***
	Number of floods in the last 49-60 months	0.95	+	1.13	***		
	Number of heat waves in the last 49-60 months	0.99		0.96	+		
	Number of cool snaps in the last 49-60 months	1.13	**	0.96			
6	Average rainfall in the last 1-12 months (decimeters)	1.21	+	1.16		42.5	***
	Average temperature in the last 1-12 months	0.74	***	1.35	**		
7	Average rainfall in the last 13-24 months (decimeters)	1.19	+	1.06		57.8	***
	Average temperature in the last 13-24 months	1.10		2.14	***		
8	Average rainfall in the last 25-36 months (decimeters)	1.36	**	1.16		12.5	*
	Average temperature in the last 25-36 months	1.21	+	0.98			
9	Average rainfall in the last 37-48 months (decimeters)	0.99		1.97	***	71.2	***
	Average temperature in the last 37-48 months	0.71	**	0.55	***		
10	Average rainfall in the last 49-60 months (decimeters)	0.87		0.81		9.5	+
	Average temperature in the last 49-60 months	0.86		1.23	+		