Environmental Degradation and Out-Migration: New Evidence from Nepal

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Abstract

Although the concept of "environmental refugees" was introduced in the mid-1980s and remains quite popular in many quarters, there is relatively little empirical work demonstrating the existence and nature of a connection between environmental change and human migration. In this study we contribute to this literature by updating and expanding on recent work done in Nepal using data from the Chitwan Valley Family Study. We use event history data to model local, internal, and international migration as a function of environmental deterioration at baseline while controlling for social, economic, and demographic variables that prior work has shown to affect population mobility. We find a strong and consistent relationship between the likelihood of undertaking a local move and population pressure (measured by neighborhood density), deforestation (indicated by rising times required to collect fodder and firewood), and declining agricultural productivity. We also find that the environmental effects on local migration are more prevalent for women than for men. We found little evidence that environmental deterioration promoted migration outside of the local district, either to other districts in Nepal or to international destinations, though increased time to collect firewood was associated with a higher probability of men leaving Chitwan for other countries or other districts in Nepal. In general, our results suggest that the kind of gradual environmental deterioration studied here is more associated with local than distant population mobility.

The term "environmental refugees" was introduced by El-Hinnawi (1985) to describe people forced to leave their places of origin, either temporarily or permanently, because of environmental disruptions triggered by human or natural events. Suhrke (1994) has identified desertification, land degradation, deforestation, and rising sea levels as the most important forms of environmental change leading to out-migration, whereas Hugo (2008) lists environmental disasters, environmental degradation, climate change, and disruptions from large scale human projects as the principal causes of population displacement. Whatever the cause, Jacobson (1988) argues that environmental refugees constitute "the single largest class of displaced persons in the world." Despite this bold claim, however, the view that environmental changes induce people to migrate remains a hotly contested topic (Castles 2002).

On the one hand, Myers and Kent (1995) argue that some 25 million people were environmental refugees in the mid-1990s, and as many as 200 million people faced a significant risk of displacement. On the other hand, Black (2001) questions the very concept of environmental refugees as a myth, and argues that such high counts are inflated by including all sorts of migrants under the label. In the only macro-level study done to date, Afifi and Warner (2008) found a positive association between the size of migration flows between 172 countries and measures they developed of overfishing, desertification, water scarcity, soil salinization, deforestation, air pollution, soil erosion, and soil pollution within sending nations. They also found a positive association between migration and earthquakes, hurricanes, floods, and tsunamis.

Most studies done to date rely on country-specific data, however. In their study of data from Guatemala and Sudan, for example, Bilsborrow and DeLargy (1991) found that environmental changes producing either a decline in the productivity of fixed resources (such as land) or lower returns to household resources (such as labor) tended to foster rural out-migration by reducing farm income. Consistent with this view, Kalipeni (1996) showed that internal migrants in Malawi

generally moved from densely populated to sparsely populated districts. In her study of population mobility in Soviet Kamchatka, Hitztaler (2004) found that villages experiencing a natural resource crisis sustained greater out-migration than those with a relatively intact resource base.

In their recent study of migration in Nepal's Chitwan Valley, Shrestha and Bhandari (2007) found that a decrease in access to firewood increased the likelihood of migration both to domestic and international destinations, controlling for other predictors of migration. In their study of the same region, however, Massey et al. (2007) found that only local moves were predicted by decreasing access to firewood. They also found that local mobility was related to declines in agricultural productivity and decreases in land cover, but that population density and decreasing access to fodder were unrelated to mobility, either over short or long distances. The contradictory results of these two studies might reflect different definitions of migration, however, with Shrestha and Bhandari (2007) considering domestic versus international mobility (i.e. moves within versus outside of Nepal) and Massey et al. (2007) focusing on local versus distance mobility(moves within versus outside of Chitwan).

The relative paucity of studies analyzing the relationship between environmental change and migration partly reflects the focus of prevailing theories on the social and economic roots of population mobility (see Massey et al. 1998) but also stems from a lack of data on the subject. In this paper we expand on the work of Shrestha and Bhandari (2007) and Massey et al. (2007) by analyzing more recent data from the Chitwan Valley Family Study to clarify the effect of environmental degradation on individual migration decisions. Following Suhrke (1994), we hold that if environmental change has any influence on out-migration, it is most likely to be observed in poor agrarian economies where people cannot insure against unexpected natural events, leaving them little choice except to migrate in the face of environmental change. We investigate this hypothesis by specifying and estimating an event history model that links environmental conditions

in 1996 to monthly migration decisions made between 1997 and 2006. In an effort to reconcile the contradictory findings of Shrestha and Bhandari (2007) and Massey et al. (2007) we distinguish between three kinds of moves: those within Chitwan, those outside of Chitwan but within Nepal, and those outside of Nepal.

STUDY SITE

Nepal is one of the least developed countries in the world. A majority of its inhabitants continue to subsist on agriculture and a threefold increase in population over the past four decades (from 9.4 million in 1961 to 23.2 million in 2001) has placed severe pressure on land and other natural resources. The traditional Nepalese adage, *hariyo ban Nepal ko dhan* ("green forests are Nepal's wealth") may once have accurately reflected the abundance of forests and other natural resources in the country, but it is fast becoming obsolete because of widespread deforestation, soil erosion, and other forms of environmental degradation associated with rising population pressure.

Nepal's Chitwan Valley offers an ideal setting to study environmental effects on migration because of its rapid transformation through economic and demographic growth. As recently as the early 1950s, the valley was covered by dense forests; but these were subsequently cleared by the national government to make land available for farming and settlement. Given the valley's favorable climate, fertile soil, and flat terrain, people from nearby hills and mountains moved in and quickly settled in the valley, placing new pressures on available land and other natural resources. In the late 1970s, Chitwan's largest town was connected by road to major cities throughout the country including Kathmandu, the capital, as well as to India. As a result, the district began to attract investment, government services, and new employers.

In spite this economic growth, the infrastructure in Chitwan is only marginally better than in the rest of Nepal. Except for the national highway, most roads in the district are still unpaved and most jobs are in service-oriented government agencies, with a few more in agricultural industries

(Ghimire and Mohai 2005). Overall, the valley still houses an agrarian society in which the great majority of households rely on subsistence farming and animal husbandry, supplemented by resources gathered from local forests, for survival. Under these circumstances, declining access to natural resources such as fodder and firewood, deteriorating soil fertility and water quality, and other forms of environmental deterioration are of great concern to the valley residents.

DATA AND METHODS

The Chitwan Valley Family Study (CVFS) used a combination of ethnographic and survey methods to gather detailed data on the social, economic, and demographic characteristics of individuals, their households, and the communities where they reside. The migration data, in particular, comes from a monthly panel survey that began in February 1997 and ended in January 2006. Households from 151 neighborhoods were followed for the entire 108 month study period even if they left sample neighborhoods. Respondents were lost to follow up only when the entire household moved out of Nepal and did not return during the study period. Here we focus on those respondents between the ages of 15 and 69 who were residing in the 151 neighborhoods at the beginning of the panel survey and were followed month-to-month thereafter.

We merge these monthly panel data with data on the characteristics of individuals, households, and neighborhoods. Despite the complexities of merging across three levels, fewer than 2% of all person months were lost through list-wise deletion, leading us to discount missing data as a significant source of bias in our analysis. We defined migration using a multinomial variable that equaled 0 if respondent did not move between month t and t+1; 1 if the respondent moved to another neighborhood within Chitwan during this time; 2 if they moved to a district outside Chitwan; and 3 if they moved to another country. All person months spent outside an individual's survey neighborhood were excluded from the analysis, meaning that respondents were only considered to be at risk of migration when living in their places of origin. We followed each

respondent from 1997 until the final survey date in 2006 or the point at which the person left the valley without returning, yielding a total of 295,635 person- months for analysis.

Our independent variables of interest, along with relevant control variables, are defined in Table 1. As can be seen, some variables are fixed effects defined at the baseline survey whereas others are time-varying with values that differ month by month. The environmental variables are all defined at the baseline in 1996. At this time, respondents were asked to answer questions regarding present environmental conditions and those prevailing three years earlier. The responses were then used to derive four potential measures of environmental degradation within Chitwan: change in the time required to collect animal fodder; change in the time required to collect firewood for fuel; change in agricultural productivity; and change in the quality of drinking water. As a final environmental indicator, we included population density in 1996 to assess the effect of population pressure on out-migration. Our selection of these environmental indicators is justified below.

TABLE 1 ABOUT HERE

The livelihood of many households in Chitwan depends on access to fodder, as animal husbandry is a common source of livelihood throughout the valley. Although households typically graze livestock on cleared parcels, they also supplement the animals' diet with fodder gathered from nearby forests. The forests, however, have been declining steadily through deforestation since the1960s (Massey et al. 2007). This depletion of forests increases the time required to gather fodder, and as gathering time increases at some point it becomes easier simply to purchase fodder commercially or to abandon husbandry altogether, making out-migration for wage labor an increasingly attractive alternative. Likewise, the vast majority of households in Chitwan use firewood for heating and cooking and the gathering of firewood is itself a major cause of deforestation throughout the Himalayan region (Ali and Benjaminsen 2004). Although some households buy firewood, most collect it from local forests. As with fodder, deforestation increases

the time required to gather firewood and at some point makes the purchase of firewood using migrant-generated remittances a better alternative.

Many prior studies have used the time required to access natural resources to measure environmental degradation (see Biddlecom et al. 2005, Baland et al. 2006, Shrestha and Bhandari 2007, Filmer and Pritchett 1997, Kumar & Hotchkiss 1988, Massey et al. 2007). The CVFS baseline survey asked respondents to estimate how long it took them to travel to where fodder or firewood was located, collect it, and then bring it home, both at the time of the survey and three years earlier. We took the difference between the two reported times to create a dummy variable indicating whether the collection time increased, leaving no change or a decline as the reference category. We also include in our models separate dummy variables to indicate those households that did not collect fodder or firewood at both or one of the two dates.

The vast majority of households in Chitwan rely on farming for subsistence, and following Ghimire and Mohai (2005) we use data on perceptions of change in agricultural productivity as an additional measure of environmental degradation. The baseline survey asked each respondent: "Compared to three years ago, do you think crop production has increased, decreased, or stayed the same?" We created a dummy variable to indicate whether productivity was perceived to have declined as well as a dichotomous variable to indicate those respondents who did not farm, with no change or increase in productivity as the reference category. A follow up question put to respondents asked about reasons for perceived changes, and 56% of those who perceived a decline attributed it to inadequate irrigation, bad weather, pests, disease, or poor soil, with another 30% mentioning inadequate or poor manure, thus confirming the perception of productivity decline as a valid measure of environmental degradation.

We also measure environmental deterioration using an item on perceived changes in the quality of drinking water. The specific item asked: "Compared to three years ago, do you think

that the clarity of the water you drink has changed?" Among those who responded positively a follow-up question asked: "Do you think that the water you drink has become a little more clear, much more clear, a little more unclear, or much more unclear?" As with our other indicators, we created a dummy variable that equaled 1 if the water was less clear than three years ago and 0 if it was clearer or unchanged.

Finally, to indicate demographic pressure we used neighborhood population density at the time of the baseline survey. Despite mounting pressure on local resources, Chitwan's population has continued to grow, both through in-migration and natural increase, and it is expanding faster than in the rest of the country (Ghimire and Mohai 2005). Using the household census conducted in 1996, we determined the number of people living in each household and summed across households to derive neighborhood population, which was then divided by the total area of each neighborhood and multiplied by 100,000 to convert the ratio into population per 100,000 square feet for ease of interpretation.

It is worth noting that with the exception of neighborhood population density, our environmental measures are based on the individual's own account of environmental conditions, which might raise concerns about possible bias in the assessment of environmental effects. Of course, it is true that if individuals were concerned or aware of environmental degradation in Chitwan, they might be more inclined to give a pessimistic report. However, the questions on which our environmental measures are based do not ask individuals to assess whether environmental conditions became worse or better compared to three years ago. Instead, they are asked to report the amount of time it used to take them to collect firewood or fodder three years ago versus now, quality of water then versus now, and agricultural productivity then versus now, which should generally result in unbiased answers from respondents. Furthermore, only those households who farmed in both years were asked their perception of any change in agriculture productivity and

if they perceived any change in production, they were further probed to identify specific reasons for any change. Of course, these facts do not eliminate the possibility of recall bias or biases stemming from changes in average transport times rather than environmental shifts.

In assessing the effect of environmental conditions on migration, we control for a variety of individual, household, and neighborhood characteristics that prior work has shown to influence migration decisions in the Chitwan Valley (see Bohra-Mishra and Massey 2009; Bohra and Massey 2009). We measure access to physical capital using four indicators defined from the baseline survey: ownership of farmland, quality of household amenities, possession of consumer goods, and ownership of livestock. We indicate ownership of farmland using a dichotomous variable that equals 1 if farmland was owned in 1996 and 0 otherwise. The remaining three indicators were measured using factor scaling methods. Table 2 summarizes each factor model, which relied on principal components analysis to estimate loadings that were applied as weights to z-scores of the constituent variables to create composite scales measuring access to household amenities, consumer goods, and livestock.

TABLE 2 ABOUT HERE

We also developed a factor scale of neighborhood development to control for the quality of local infrastructure and access to economic resources. The baseline neighborhood questionnaire recorded the time it took in 1996 for travel to access various public resources, such as health care centers, bus stops, schools, markets, banks, police stations, and places of employment. In general, the lower the travel time required to these amenities, the greater the local level of development. As before, the various travel times were converted to z-scores and combined using the weights shown in Table 2 (again derived from a principal components analysis) to create a composite index of neighborhood development.

Neoclassical economic theory views migration as a strategy used by individuals to maximize

returns to human capital (see Sjaastad 1962; Todaro and Maruszko 1987), which we measure using three indicators: years of education in 1996, the holding of a salaried job in 1996 (a measure of occupational status), and age during the person-month under observation (to capture experience), along with a squared term added to capture nonlinear curvature in the relationship. According to social capital theory, having a social tie with a current or former migrant reduces the costs and risks of movement to promote migration (Massey et al. 1998). We thus defined three dummy variables to indicate the presence of other household members with migratory experience in 1996: whether anyone in the household had ever migrated within Chitwan, whether anyone had migrated to other districts in Nepal, and whether anyone had migrated outside of Nepal. These indicators are expected to yield strong destination-specific effects, with ties to local migrants predicting local moves, ties to internal migrants predicting internal moves, and ties to international migrants predicting international moves.

The time period covered by our analysis is unusual in the sense that Nepal was in the midst of a decade-long civil conflict waged by Maoist guerillas. The insurgency was launched on February 13, 1996 and finally ended on November 21, 2006 with the signing of a Comprehensive Peace Agreement. Between these dates, a total of 13,347 people were killed by government or rebel forces (Informal Sector Service Center 2008). Although the insurgency began in 1996, for the first five years the conflict was low intensity and mainly involved guerillas and the police. After the failure of the peace talks in November of 2001, however, the government proclaimed a state of emergency and labeled the Maoist rebels as terrorists, leading to a high intensity conflict that pitted Maoist insurgents against the Royal Nepalese Army (Murshed and Gates 2005, and Bohra-Mishra and Massey 2009). By the end of 2002, armed fighting was reported in 73 of Nepal's 75 districts (Kok 2003).

In their analysis of the effect of violence on out-migration from Chitwan, Bohra-Mishra and Massey (2009) found a threshold effect, such that only after violence escalated in November 2001 was an effect detected. Hence, here we control for the effect of violence using a dummy variable to indicate months after November 2001. Given well-known effects of demographic factors on patterns and processes of migration, we also introduce controls for gender, marital status, household size, and ethnicity. Gender is relevant in this context as some environmentally linked tasks (such as the gathering of fodder) are gendered, and also because Nepalese government imposed a ban on the migration of female workers to the Gulf in 1998 (see Graner 2001). Previous studies of migration from Chitwan have also documented significant effects of ethnicity (see Bohra-Mishra and Massey 2009, and Bohra and Massey 2009) and so we include a series of dummy variables to identify high caste Hindus, low caste Hindus, Newar, and the Hill Tibeto-Burmese, leaving Terai Tibeto-Burmese, the indigenous people of the Chitwan Valley, as the reference category.

We measure environmental effects on migration using a multinomial logit model to predict out-migration to one of three possible destinations from the foregoing indicators of environmental degradation while holding constant the effect of the control variables just defined. As already noted, the model contains both fixed and time-varying effects, defined either for 1996 or person month t, and these are regressed on migratory outcomes defined for month t+1. Table 3 contains means, standard deviations, and ranges for variables used in the composite indicators of physical capital and neighborhood development; and Table 4 presents means, standard deviations, and ranges for the variables used to predict migration and the frequency of migration to different destinations.

TABLES 3 AND 4 ABOUT HERE

Out of 295,635 person months contained in the event history file, we observed 1,748 moves within the Chitwan Valley, 1,335 moves to other districts in Nepal, and 357 moves to a foreign

country. In terms of environmental conditions in 1996, some 4% of respondents reported an increase in the time required to collect fodder compared with three years earlier, 9% reported an increase in the time required to collect firewood, 50% perceived a decline in crop production, and 23% perceived a decline in water quality. Neighborhood density varied widely from 0.89 to 1339 persons per 100,000 square feet with a mean of 37 and a standard deviation of 120.

In terms of physical capital, 80% of the households owned farmland. Among variables used in the index of amenities, 49% of all households reported a durable roof of slate, tin or concrete, 25% had a floor of concrete as opposed to dirt, 46% had no source of potable water, 36% had no toilet, and just 34% had electricity. Among variables used in the index of consumer goods, 62% owned a bicycle and 52% owned a radio, but only 12% had a TV, 7% a cart, 5% a biogas plant, 3% a motorcycle or irrigation pump and just 1% had a tractor. On average, each household owned 20.2 chickens and ducks, 1.15 pigeons, 0.57 bullocks, 0.36 cows, 0.16 male buffaloes, 1.25 female buffaloes, 1.46 sheep and goats, and 0.06 pigs. Among variables used in the neighborhood development index, distance by bus to the district capital averaged 80.5 minutes and average foot travel times to the nearest bank and police station were 58.2 and 64.3 minutes, respectively. Other resources were more accessible, with average foot travel times of 9.2, 20.5, 12.3, 12.1 and 20.6 minutes to the nearest school, healthcare facility, bus stop, market, and nearest place of employment, respectively.

As can be seen, educational levels were generally quite low among respondents. Even though total schooling ranged from 0 to 16 years, the average was just 3.6 years. Likewise, only 6% held a salaried job, and during the typical person-month a respondent was 38.7 years of age. With respect to social capital, 7% of respondents lived in a household where someone had migrated within Chitwan by 1996, 10% lived in a household where someone had gone to another district in Nepal, and 11% lived in a household where someone had migrated internationally. Some 41% of

the person months under observation were lived during the period of heightened violence after November of 2001, 57% were lived by women, 87% by a married individual, and the average household size was 6.7 persons. Finally, the largest share of respondents were upper caste Hindus as they contributed 47% of the person months in the event history, followed by Terai Tibeto-Burmese at 22%, Hill Tibeto-Burmese at 14%, and Lower Caste Hindus at 10%, with the Newar and other castes making up only 7% of person months under observation.

One caveat in the analysis arises because the environmental variables were measured in 1996 while the impact of these environmental measures are assumed to influence migration pattern for the subsequent 10 years – from 1997 to 2006. Ideally, it would be interesting to predict the effect of monthly or yearly change in the environmental variables on the monthly migration pattern over the ten year period. However, given data limitations, we have to make the assumption that the environmental factors in the baseline period do a fair job of predicting migration pattern in the subsequent periods.

EFFECTS OF ENVIORNMENTAL DEGRADATION ON MIGRATION

Table 5 presents the results of a multinomial logit model estimated to predict the effects of environmental degradation on individual decisions to migrate to one of three possible destinations, along with relevant controls. Of the five environmental indicators, four are significantly related to the likelihood of moving within Chitwan. An increase in the time required to collect fodder raised the odds of undertaking a local move by 25% [exp(0.221)=1.25]; an increase in the time required to gather firewood increased the odds by 42% [exp(0.348)=1.42]; a perceived decrease in crop production raised them by 18% [exp(0.168)=1.18]; and each additional person per 100,000 square feet raised the odds of local movement by 0.2% [exp(0.002)=1.002].

TABLE 5 ABOUT HERE

Of all the environmental indicators, only a perceived decline in water quality was unrelated to the likelihood of undertaking a local move within Chitwan. In addition, those persons who did not collect fodder, and did not farm were all more likely to migrate, suggesting perhaps that people who might earlier have given up these activities owing to environmental deterioration were more likely to become local migrants. In general, the estimates provide strong and consistent evidence that environmental degradation is associated with an increase in local population mobility. In particular, to the extent that deforestation raises the time required to gather fodder and firewood, and to the degree that population pressure increases and farm productivity declines, people can be expected to respond by looking for opportunities elsewhere within the Valley.

In contrast, only one environmental factor---an increased time to collect fodder---was related to out-migration to other districts in Nepal. According to our estimates, a perceived increase in the time required to collect fodder raised the odds of internal migration within Nepal by 34% [exp(0.294)=1.34]. None of the other dimensions of environmental change appeared to play a role in fomenting internal migration, though people from households that did not farm were more likely to move to other districts in Nepal, which could be an indirect effect of prior environmental deterioration, but we have little evidence of a direct effect.

Similarly, there is little evidence of a relationship between environmental degradation and international migration. Although an increase in the time required to collect fodder has a strong and significant effect on the likelihood of leaving Nepal, the direction is quite strongly negative. In this case, a perceived increase in the time required to gather fodder yields a 74% reduction in the odds of leaving Chitwan for another country [exp(-1.359)=0.26]. Although the negative effect of an increased time to collect fodder on international migration is somewhat unexpected, one explanation for this could be that, unlike migration to locations within Chitwan or within Nepal, international migration involves a lot more preparation and time commitment (e.g. gathering information on

available foreign jobs, contacting manpower agencies, applying for visas, etc.). An increase in time to gather fodder could take away time individuals could have otherwise devoted on preparing for international migration. The need for additional labor hours to collect fodder might therefore significantly lower the probability of people moving abroad. There is however, a significant but very small impact of population density on international migration with each additional person per 100,000 square feet raising the odds of international movement by 0.15% [exp(0.0015)=1.0015].

The control variables mainly function as one would expect from prior theory and research. Indicators of human capital such as education increase the likelihood of all forms of out-migration, and occupational skill increases the odds of local and internal migration. As expected, social capital has strong destination-specific effects, and the period of violence is associated with reduced migration probabilities across all categories, with the effect growing stronger as distance of the move increases. Marriage raises the odds of out-migration to all destinations whereas larger household size decreases them, but other things equal females are much less likely to migrate internationally. Over the observed age range from 15-69 the likelihood of migration falls with age at a decelerating rate. Consistent with the earlier studies, different ethnic groups evinced different probabilities of migration. In general, those ethnic groups with prior migratory experience were consistently more likely to migrate than the Terai Tibeto-Burmese, the indigenous people of the valley.

Neighborhood development increases the likelihood of local mobility but has no effects on migration to destinations outside the valley. Land ownership reduces the odds of migration within Chitwan and to other districts but has no effect on international moves, whereas greater access to household amenities decreases the odds of movement to all destinations. Access to consumer goods raises the odds of movement to other districts and other countries, while the ownership of livestock increases the odds of internal migration within Nepal. These results lend credence to precepts

derived from both neoclassical economics and the new economics of labor migration and provide strong support for social capital theory.

In order to assess gender interactions in the process of environment-linked migration, we estimated separate event history models for males and females. Given the very small number of women who migrated internationally, however, we had to collapse the internal and international categories into a single indicator that captured distant migration outside of Chitwan. These results are presented in Table 6. As can be seen, among women, all the indicators of environmental degradation have strong positive effects on local mobility, again with the sole exception of changes in water quality. Thus, a perceived increase in the time required to collect fodder increases the odds of moving within Chitwan by 28% [exp(0.244)=1.28], a perceived increase in the time to gather firewood raises the odds by 44% [exp(0.362)=1.44], and a perceived decline in agricultural productivity raises them by 19% [exp(0.173)=1.19]. Likewise, rising population pressure as indicated by a one person increase in the number of residents per 100,000 square feet raises the odds of moving within Chitwan by 0.2% [exp(0.002)=1.002]. None of these environmental indicators has any effect on the odds that a woman would move to more distant locations outside of the Chitwan Valley, however. Among women, links between environmental degradation and migration are strong, but only for local moves.

TABLE 6 ABOUT HERE

Among men, the principal link between environmental change and migration is through the time required to gather firewood, which is consistent with the fact that in Chitwan the collection of firewood is more of a male than a female task, as opposed to the gathering of fodder, which is stereotypically female (Bhandari 2004; Kumar and Hotchkiss 1988). As a result, increasing time to gather fodder has no significant effect on the migration of males, but an increase in the time required to collect firewood is significant in predicting both local and distant moves by men. A

perceived increase in the time to gather firewood is associated with a 39% increase in the odds of male migration within Chitwan [exp(0.328)=1.39] and a 24% increase in the odds of male migration to other districts within Nepal or to other countries [exp(0.215)=1.24]. As with females, rising population density increases the odds of local but not distant mobility, increasing the odds of moving within Chitwan by 0.2% with each additional person per 100,000 square feet.

SUMMARY AND CONCLUSION

Although the concept of environmental refugees has been around since the 1980s and remains quite popular with many scholars and activists, empirical demonstrations of environmental effects on population mobility have been rare. In this analysis, we took advantage of newly available data from the Chitwan Valley Family Study to examine how environmental degradation along several dimensions affected the propensity to migrate locally within Nepal's Chitwan Valley, internally to other districts in Nepal, and internationally to foreign destinations. In the baseline survey, respondents were asked to compare conditions in 1996 to conditions three years earlier with respect to four outcomes: the time required to gather fodder, the time required to collect firewood, change in agricultural productivity, and change in water quality. We measured environmental degradation using dummy variables indicating an increase in time required to gather fodder and firewood, a decline in agricultural productivity, and a decrease in water quality. We measured demographic pressure in 1996 by computing neighborhood density in persons per 100,000 square feet.

We examined the effect of these indicators on the monthly probability of making a local, internal, and international move over the ensuing 108 months, controlling for the effects of human, physical, and social capital, as well as demographic background. We found no evidence that changes in water quality had any effect on migration to any destination. However, we did find that increases in the time required to collect fodder and firewood, as well as perceived decline in

agricultural productivity and higher population densities, were associated with greater population mobility; but these effects were confined almost entirely to moves within the Chitwan Valley and tended to be more pervasive among women than among men.

Among women, rising collection times for fodder and firewood were both associated with significant increases in the odds of local mobility. Since fodder and firewood are gathered from local forests, these results imply that deforestation is a significant cause of increased female mobility within the Chitwan Valley. Female mobility within Chitwan was also predicted by higher population densities and declining agricultural productivity, suggesting that rising pressure on farmland from demographic growth also represents an important cause of local migration by women. Population density also predicted the mobility of men, but declining agricultural productivity and rising collection time for fodder did not, suggesting that farm work and gathering fodder are gendered tasks assigned disproportionately to women. The gathering of firewood, however, is done by males and increase in the time required for this task not only raised the odds of male movement within the Chitwan Valley, but also to other districts within Nepal and to other countries.

Even though we could not estimate a model predicting internal and international trips separately for men and women, the overall model we estimated found very little evidence of a significant effect of environmental deterioration on internal and international migration. Only an increase in time to collect fodder promoted out-migration to other districts in Nepal while population density somewhat influenced international migration. The only other clear effect of environmental factor on international migration was an increase in the time required to collect fodder, which was strongly negative, sharply reducing the odds of international movement.

In sum, we find strong evidence that deforestation, population pressure, and agricultural decline produce elevated rates of local population mobility among women, and to a lesser extent

among men, but little evidence that these environmental changes lead to significant increases in internal or international migration, though there is some indication that deforestation may increase internal migration by men by raising the time costs of firewood collection. To the extent that environmental deterioration leads to greater migration, therefore, the effects appear to be highly localized.

Of course, the environmental changes we measure in Chitwan are of a particular type---a slow, gradual depletion of resources through demographic and economic pressure rather than a sudden, dramatic shift in environmental circumstances as a result of some dramatic human or natural event. Although the term "environmental refugees" may create images of destitute people clamoring at the gates of the developed world to many in the Western World, our findings suggest that gradual environmental depredations from processes such as deforestation, desertification, salinization, draught, and soil erosion are much more likely to produce local rather than international migrations, simply because the people most affected by these changes---poor agrarian families---lack the resources to finance international trips.

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TABLE 1

Definition of Variables

VARIABLE	DEFINITION
OUTCOME VARIABLE	
Migration to three competing destinations	Whether respondent migrates to three locations in month t+1: within Chitwan = 1, to other districts = 2, to other countries = 3, and 0 if doesn't migrate at all
Migration to two competing destinations	Whether respondent migrates to two locations in month t+1: within Chitwan = 1, to other districts or other countries = 2, and 0 if doesn't migrate at all
ENVIRONMENTAL VARIABLES	
Increase in time to collect fodder compared to 3 years ago	1 if time to collect fodder increased now compared to three years ago, 0 otherwise*
Did not collect fodder in both years	1 if household did not collect fodder now and three years ago either because it did not own livestock or it chose to buy all of the fodder it needed*
Increase in time to collect firewood compared to 3 years ago	1 if time to collect firewood increased now compared to three years ago, 0 otherwise*
Did not collect firewood in both years	1 if household did not collect firewood now and three years ago either because it did not use firewood or bought all the firewood it used*
Perception of decrease in crop production compared to 3 years ago	1 if the household thinks crop production has decreased compared to three years ago, 0 otherwise*
Does not farm	1 if the household does not farm and is not asked question regarding crop production or if the household reports it does not know if the production has changed (only 2.3% report this)
Water less clear compared to 3 years ago	1 if the household thinks that their drinking water has become less clear compared to three years ago (or report they don't know if it has changed - only 1.3% report this) , 0 otherwise*
Neighborhood population density	Number of people in the neighborhood per 100,000 square feet*
CONTROLS	
Physical Capital	
Owns farmland	1 if respondent's household owns farmland, 0 otherwise*
Standardized Index of household amenities	A composite index of household amenities derived through factor analysis using data on the materials used to build the floor and roof of the respondent's house; and whether household has a toilet, access to own drinking water source, and electricity*
Standardized index of goods owned	A composite index of assets owned derived through factor analysis using data on durables owned by the household such as ownership of a radio, TV, bicycle, motorcycle, cart, tractor, pumpset, and bio gas plant*
Standardized index of livestock owned	A composite index of livestock owned derived through factor analysis using data on number of chicken, pigeons, buffalo, cows, sheep, goats, pigs, etc. owned by households*
Neighborhood Development	
Standardized index of neighborhood development	A composite index of neighborhood level of development derived through factor analysis using data on average hours on foot to nearest resources such as health care, bus service, school, market, bank, employment and police station*
Human Capital	
Education	Number of years of schooling completed by the respondent*
Salary job	1 if respondent holds a salary job, 0 otherwise*
Age	Respondent's age, monthly event
Age squared	Respondent's age square, monthly event
Social Capital	
House member migrated within Chitwan	1 if any member from the respondent's household has migrated within Chitwan in 1996 before the respondents are observed, 0 otherwise
House member migrated to other districts	1 if any member from the respondent's household has migrated to other districts in 1996 before the respondents are observed, 0 otherwise
House member an international migrant	1 if any member from the respondent's household has migrated to other countries in 1996 before the respondents are observed, 0 otherwise
House member migrated to other districts or other countries	1 if any member from the respondent's household has migrated to other districts or other countries in 1996 before the respondents are observed, 0 otherwise
Level of Violence	
Violence from Maoist insurgency	1 for all months after November 2001 to capture the elevated level of violence from Maoist insurgency, 0 for months before that
Demographic Variables	
Female	1 if respondent is a female, 0 otherwise
Married	1 if respondent was ever married, 0 otherwise, monthly event
Number of household members	Number of people in the household*
Ethnicity	
Hindu upper caste	1 if hindu upper caste, 0 otherwise
Hindu lower caste	1 if hindu lower caste, 0 otherwise
Hill Tibetoburmese	1 if hill tibetoburmese caste, 0 otherwise
Newar and other	1 if newar or other caste, 0 otherwise
Terai Tibetoburmese	1 if terai tibetoburmese caste, 0 otherwise

*As reported in the baseline survey conducted in 1996

TABLE 2

Index Weights for the Composite Index of Physical Capital and Neighborhood Characteristic Variables

	Index Weights
Physical Capital Variables	
Household Amenities	
Roof of house is made of slate, tin, or concrete	0.27
Floor of house is made of concrete	0.26
No own drinking water source	-0.21
No toilet	-0.22
Has electricity	0.24
Variance explained by first factor	*0.69*
Goods owned	
Household has a radio	0.19
Household has a TV	0.20
Household has a bicycle	0.18
Household has a motorcycle	0.20
Household has a cart	0.16
Household has a tractor	0.18
Household has a pumpset for irrigation	0.14
Household has a bio gas plant	0.21
Variance explained by first factor	*0.46*
Livestock owned	
Number of Chickens and ducks	0.08
Number of pigeons household has	0.24
Number of bullocks household has	0.30
Number of cows household has	0.27
Number of male buffaloes household has	0.21
Number of female buffaloes household has	0.33
Number of sheep and goats household has	0.42
Number of pigs household has	0.14
Variance explained by first factor	*0.22*
Neighborhood Characteristic Variables	
Neighborhood Development	
Minutes on foot to nearest school	0.19
Minutes on foot to nearest healthcare	0.23
Minutes on foot to nearest bus service	0.23
Distance by bus to Narayanghat	0.19
Minutes on foot to nearest market	0.18
Minutes on foot to nearest bank	0.25
Minutes on foot to nearest place of employment	0.21
Minutes on foot to nearest police station	0.15
Variance explained by first factor	*0.36*

TABLE 3

Descriptive Statistics for the Measures used to Create Compositve Index of Physical Capital and Neighborhood Characteristics

	Count	Min	Max	SD	Mean
Physical Capital					
Household Amenities					
Roof of house is made of slate, tin, or concrete	1391	0	1	0.50	0.49
Floor of house is made of concrete	1391	0	1	0.43	0.25
No own drinking water source	1391	0	1	0.50	0.46
No toilet	1391	0	1	0.48	0.36
Has electricity	1391	0	1	0.47	0.34
Goods Owned					
Household has a radio	1391	0	1	0.50	0.52
Household has a TV	1391	0	1	0.33	0.12
Household has a bicycle	1391	0	1	0.48	0.62
Household has a motorcycle	1391	0	1	0.18	0.03
Household has a cart	1391	0	1	0.26	0.07
Household has a tractor	1391	0	1	0.09	0.01
Household has a pumpset for irrigation	1391	0	1	0.18	0.03
Household has a bio gas plant	1391	0	1	0.21	0.05
Livestock Owned					
Number of Chickens and ducks	1391	0	2210	121.64	20.16
Number of pigeons household has	1391	0	150	7.01	1.15
Number of bullocks household has	1391	0	7	0.94	0.57
Number of cows household has	1391	0	8	0.91	0.36
Number of male buffaloes household has	1391	0	4	0.51	0.16
Number of female buffaloes household has	1391	0	8	1.35	1.25
Number of sheep and goats household has	1391	0	24	1.98	1.46
Number of pigs household has	1391	0	8	0.35	0.06
Neighborhood Development					
Minutes on foot to nearest school	151	0	30	6.55	9.17
Minutes on foot to nearest healthcare	151	0	90	18.06	20.48
Minutes on foot to nearest bus service	151	0	75	14.91	12.31
Distance by bus to Narayanghat	151	0	195	51.74	80.49
Minutes on foot to nearest market	151	0	120	16.41	12.13
Minutes on foot to nearest bank	151	0	150	35.83	58.22
Minutes on foot to nearest place of employment	151	0	180	22.95	20.58
Minutes on foot to nearest police station	151	2	240	38.93	64.32

TABLE 4

Descriptive Statistics for the Dependent and Independent Variables

	Count	Min	Max	SD	Mean
OUTCOME VARIABLES					
Migration to within Chitwan locations	1,748				
Migration to other districts	1,335				
Migration to other countries	357				
ENVIRONMENTAL VARIABLES					
Increase in time to collect fodder compared to 3 years ago	1383	0	1	0.20	0.04
Did not collect fodder in both years	1383	0	1	0.46	0.30
Increase in time to collect firewood compared to 3 years ago	1386	0	1	0.29	0.09
Did not collect firewood in both years	1386	0	1	0.44	0.26
Perception of decrease in crop production compared to 3 years ago	1391	0	1	0.50	0.50
Does not farm	1391	0	1	0.37	0.17
Water less clear compared to 3 years ago	1391	0	1	0.42	0.23
Neighborhood population density	151	0.89	1338.93	120.41	36.97
CONTROLS					
Physical Capital					
Owns farmland	1391	0	1	0.40	0.80
Standardized Index of household amenities	1391	-1.18	1.80	1	0
Standardized index of goods owned	1391	-1.22	4.74	1	0
Standardized index of livestock owned	1391	-1.04	10.12	1	0
Neighborhood Development					
Standardized index of neighborhood development	151	-2	5	1	0
Human Capital					
Education	295635	0	16	4.21	3.56
Salary job	295635	0	1	0.24	0.06
Age	295635	15	69	13.37	38.65
Age squared	295635	225	4761	1088.35	1672.80
Social Capital					
House member migrated within Chitwan	295635	0	1	0.25	0.07
House member migrated to other districts	295635	0	1	0.30	0.10
House member an international migrant	295635	0	1	0.31	0.11
House member migrated to other districts or other countries	295635	0	1	0.40	0.20
Level of Violence					
Violence from Maoist insurgency	295635	0	1	0.49	0.41
Demographic Variables					
Female	295635	0	1	0.49	0.57
Married	295635	0	1	0.34	0.87
Number of household members	295635	1	26	3.43	6.68
Ethnicity					
Hindu upper caste	295635	0	1	0.50	0.47
Hindu lower caste	295635	0	1	0.30	0.10
Hill Tibetoburmese	295635	0	1	0.35	0.14
Newar and other	295635	0	1	0.25	0.07
Terai Tibetoburmese	295635	0	1	0.41	0.22

TABLE 5

Multinomial Logistic Regression Output for Predicting the Competing Risks of Taking A Trip to Three Competing Locations in month t + 1

	Within Chitwan		To Other Districts		To Other Countries	
INDEPENDENT VARIABLES IN MONTH t	**B**	**SE**	**B**	**SE**	**B**	**SE**
Environmental Variables						
Increase in time to collect fodder compared to 3 years ago	**0.221****	(0.107)	**0.294****	(0.124)	**-1.359*****	(0.456)
Did not collect fodder in both years	**0.251*****	(0.072)	0.145	(0.089)	-0.186	(0.174)
Increase in time to collect firewood compared to 3 years ago	**0.348*****	(0.074)	0.023	(0.096)	0.276	(0.177)
Did not collect firewood in both years	-0.030	(0.070)	0.041	(0.075)	0.201	(0.142)
Perception of decrease in crop production compared to 3 years ago	**0.168*****	(0.055)	0.076	(0.063)	-0.153	(0.116)
Does not farm	**0.243****	(0.119)	**0.267***	(0.146)	0.234	(0.316)
Water less clear compared to 3 years ago	0.046	(0.058)	0.037	(0.068)	0.087	(0.132)
Neighborhood population density	**0.002*****	(0.000)	-0.000	(0.001)	**0.0015*****	(0.0005)
CONTROLS						
Physical Capital						
Owns farm land	**-0.172***	(0.103)	**-0.255****	(0.129)	0.488	(0.298)
Standardized Index of household amenities	**-0.108*****	(0.036)	**-0.098****	(0.040)	**-0.196****	(0.080)
Standardized index of goods owned	0.008	(0.031)	**0.080****	(0.034)	**0.126***	(0.070)
Standardized index of livestock owned	-0.033	(0.030)	**0.077*****	(0.030)	-0.042	(0.072)
Neighborhood Development						
Distance from essential facilities	**0.178*****	(0.028)	0.051	(0.037)	-0.000	(0.072)
Human Capital						
Education	**0.050*****	(0.008)	**0.094*****	(0.009)	**0.049*****	(0.018)
Salary job	**0.546*****	(0.087)	**0.397*****	(0.098)	0.086	(0.172)
Age	**-0.173*****	(0.013)	**-0.197*****	(0.015)	**-0.145*****	(0.031)
Age squared	**0.002*****	(0.000)	**0.002*****	(0.000)	**0.001*****	(0.000)
Social Capital						
House member migrated within Chitwan	**0.353*****	(0.086)	0.016	(0.127)	0.025	(0.291)
House member migrated to other districts	0.061	(0.084)	**0.873*****	(0.074)	**0.349***	(0.196)
House member an international migrant	**-0.169****	(0.086)	**0.163***	(0.095)	**1.502*****	(0.137)
Level of Violence						
Violence from Maoist insurgency	**-0.886*****	(0.065)	**-1.439*****	(0.090)	**-1.853*****	(0.204)
Demographic Variables						
Female	0.012	(0.055)	0.007	(0.063)	**-1.881*****	(0.148)
Married	**0.499*****	(0.076)	**0.541*****	(0.084)	**0.559*****	(0.165)
Number of household members	**-0.018***	(0.010)	**-0.049*****	(0.012)	**-0.120*****	(0.027)
Ethnicity						
Hindu upper caste	**0.165****	(0.079)	**0.385*****	(0.101)	**0.783*****	(0.223)
Hindu lower caste	0.116	(0.098)	**0.419*****	(0.126)	**1.125*****	(0.238)
Hill Tibetoburmese	**0.427*****	(0.087)	**0.602*****	(0.112)	**0.804*****	(0.242)
Newar and other	0.045	(0.128)	**0.494*****	(0.137)	0.246	(0.331)
Terai Tibetoburmese	_	_	_	_	_	_
Constant	**-2.109*****	(0.251)	**-2.176*****	(0.295)	**-3.702*****	(0.614)
No. of person months			295635			

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

TABLE 6

Multinomial Logistic Regression Output for Predicting the Competing Risks of Taking A Trip to Two Competing Locations for Males and Females in month t + 1

	FEMALES				MALES			
	Within Chitwan		To Other Districts or Other Countries		Within Chitwan		To Other Districts or Other Countries	
INDEPENDENT VARIABLES IN MONTH t	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
Environmental Variables								
Increase in time to collect fodder compared to 3 years ago	**0.244***	(0.138)	-0.007	(0.175)	0.238	(0.173)	0.150	(0.163)
Did not collect fodder in both years	**0.332*****	(0.098)	-0.079	(0.121)	0.131	(0.109)	**0.203***	(0.106)
Increase in time to collect firewood compared to 3 years ago	**0.362*****	(0.095)	-0.128	(0.131)	**0.328*****	(0.118)	**0.215***	(0.112)
Did not collect firewood in both years	**-0.201****	(0.096)	-0.074	(0.098)	**0.197***	(0.104)	**0.197****	(0.091)
Perception of decrease in crop production compared to 3 years ago	**0.173****	(0.074)	-0.101	(0.081)	0.123	(0.083)	0.097	(0.076)
Does not farm	0.205	(0.163)	0.094	(0.185)	**0.298***	(0.177)	0.318	(0.196)
Water less clear compared to 3 years ago	0.058	(0.077)	0.074	(0.086)	0.042	(0.091)	0.053	(0.085)
Neighborhood population density	**0.002*****	(0.000)	0.001	(0.001)	**0.002*****	(0.000)	0.001	(0.000)
CONTROLS								
Physical Capital								
Owns farm land	-0.166	(0.140)	**-0.386****	(0.163)	-0.157	(0.154)	0.071	(0.177)
Standardized Index of household amenities	-0.068	(0.048)	0.028	(0.051)	**-0.150*****	(0.055)	**-0.279*****	(0.050)
Standardized index of goods owned	0.058	(0.042)	**0.087****	(0.044)	-0.055	(0.049)	**0.101****	(0.043)
Standardized index of livestock owned	0.052	(0.039)	**0.078***	(0.041)	**-0.119****	(0.049)	**0.064***	(0.038)
Neighborhood Development								
Distance from essential facilities	**0.173*****	(0.038)	0.005	(0.052)	**0.189*****	(0.041)	0.049	(0.043)
Human Capital								
Education	**0.082*****	(0.012)	**0.092*****	(0.013)	0.008	(0.012)	**0.087*****	(0.012)
Salary job	**0.823*****	(0.187)	**0.488****	(0.221)	**0.519*****	(0.100)	**0.382*****	(0.096)
Age	**-0.237*****	(0.018)	**-0.272*****	(0.020)	**-0.077*****	(0.021)	**-0.137*****	(0.020)
Age squared	**0.003*****	(0.000)	**0.003*****	(0.000)	**0.001****	(0.000)	**0.001*****	(0.000)
Social Capital								
House member migrated within Chitwan	0.158	(0.115)	-0.219	(0.166)	**0.636*****	(0.132)	0.218	(0.163)
House member migrated to other districts or other countries	-0.050	(0.082)	**0.559*****	(0.083)	-0.156	(0.112)	**0.774*****	(0.082)
Level of Violence								
Violence from Maoist insurgency	**-0.795*****	(0.087)	**-1.276*****	(0.109)	**-0.990*****	(0.098)	**-1.817*****	(0.128)
Demographic Variables								
Married	**0.899*****	(0.101)	**1.141*****	(0.116)	-0.074	(0.123)	**0.197***	(0.108)
Number of household members	**-0.028****	(0.013)	**-0.058*****	(0.016)	-0.009	(0.016)	**-0.064*****	(0.016)
Ethnicity								
Hindu upper caste	**0.183***	(0.109)	**0.445*****	(0.138)	0.143	(0.116)	**0.473*****	(0.123)
Hindu lower caste	**0.372*****	(0.133)	**0.552*****	(0.167)	-0.227	(0.149)	**0.512*****	(0.146)
Hill Tibetoburmese	**0.564*****	(0.119)	**0.443*****	(0.156)	0.169	(0.130)	**0.691*****	(0.134)
Newar and other	0.168	(0.174)	**0.856*****	(0.175)	-0.067	(0.190)	0.044	(0.192)
Terai Tibetoburmese	_	_	_	_	_	_	_	_
Constant	**-1.540*****	(0.344)	**-1.169*****	(0.389)	**-3.076*****	(0.380)	**-2.731*****	(0.378)
No. of person months	169959				125676			

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