Natural Disasters and Population Mobility in Bangladesh

Clark Gray[a1] and Valerie Mueller[b]

[a] Department of Geography, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599

[b] International Food Policy Research Institute, Washington, DC 20006

[1] Corresponding author:
UNC Department of Geography
Saunders Hall, Campus Box 3220
Chapel Hill, NC 27599
(919) 962-3876
cgray@email.unc.edu
http://geography.unc.edu/people/faculty-1/clark-gray

Classification: Social Sciences, Sustainability Science

This paper has been published as:

Gray, C., and V. Mueller. (2012). Natural disasters and population mobility in Bangladesh. Proceedings of the National Academy of Sciences. doi: 10.1073/pnas.1115944109 http://www.pnas.org/content/early/2012/03/28/1115944109.abstract

ABSTRACT

The consequences of environmental change for human migration have gained increasing attention in the context of global climate change and recent large-scale natural disasters, but as yet relatively few large-scale and quantitative studies have addressed this issue. We investigate the consequences of climate-related natural disasters for population mobility in rural Bangladesh, a region particularly vulnerable to environmental change, using longitudinal survey data from 1,700 households spanning a 15-year period. Multivariate event history models are used to estimate the effects of flooding and crop failures on local population mobility and long-distance migration while controlling for a large set of potential confounders at various scales. The results indicate that flooding has modest effects on mobility that are most visible at moderate intensities and for women and the poor. However, crop failures unrelated to flooding have strong effects on mobility, particularly for households that are not directly affected but live in severely affected areas. Together the results highlight both the importance and the complexity of environmental influences on human migration: Natural disasters can increase population mobility, but these effects vary across scales, types of events, and subpopulations.

Keywords: human migration, climate, environmental migrant, event history model

\body

INTRODUCTION

Recent decades have witnessed a significant increase in the population affected by climate-related natural disasters such as floods, droughts and coastal storms[*]. These increases reflect increasing populations and persistent poverty in vulnerable areas of the developing world and are consistent with human-induced climate change (1). Among the many social and economic consequences of these events, population mobility and migration are frequently noted to serve as important coping strategies for affected households and individuals (2, 3, 4). This fact and the increasing frequency of these events have contributed to a concern that the world is experiencing a rising tide of environmentally-induced population displacement (5, 6), with poor and rural households the most affected (7). These issues have drawn the attention of the United Nations and the Intergovernmental Panel on Climate Change (8, 9), among others, and motivated

[*] EMDAT. The OFDA/CRED international disaster database. Université Catholique de Louvain, Brussels, Belgium. www.emdat.net

a discussion about whether individuals displaced across international borders deserve legal protections (10).

As of yet, however, this high level of concern is not supported by existing scientific evidence, as relatively few studies have attempted to estimate the contribution of environmental factors to human migration, particularly in the developing world (11-14). These efforts have been limited by a lack of high-quality data on migration, as well as by institutional barriers between the environmental and social sciences. Existing quantitative studies of natural disasters in the developing world have investigated the migratory consequences of drought in Mexico, Burkina Faso, Ethiopia and Nigeria (13, 15-18), and of earthquakes in El Salvador (19). Together, these studies suggest that exposure to natural hazards does increase migration as expected, but the effects are often most pronounced on short-distance and temporary forms of mobility (16, 17). Additionally, a counterintuitive reverse effect is also possible in which adverse environmental conditions limit participation in costly forms of migration (16-17, 19).

Our study focuses on the consequences of flooding and crop failure in Bangladesh, a low-lying deltaic country that is universally recognized to be highly vulnerable to natural disasters and climate change (20). During the study period, Bangladesh experienced two severe floods (in 1998 and 2004) and a series of other flooding, drought and cyclone disasters (21). These events create significant hardship for many affected households (22-25) and commonly result in short-term population displacement (22, 26-28). It is often assumed that these processes eventually result in significant long-term population relocation (29, 30), but this hypothesis has its skeptics (31, 32) and to our knowledge has not been tested by any previous large-scale quantitative study.

To investigate this issue, we use data from the Chronic Poverty and Long Term Impact Study in Bangladesh, collected by the International Food Policy Research Institute (IFPRI) (33). This unique longitudinal dataset spans the 1994-2010 period and includes 1,680 households in 102 rural communities from 14 districts across Bangladesh (see Methods). The study districts include some that were severely affected by natural disasters during the period and others that were less affected (SI Appendix, S1). The study households are, overall, highly dependent on rice-centered agriculture and quite poor, with 37% reporting in 2006 that their food consumption was insufficient over the past month, suggesting that they are vulnerable to climate-related disasters. We used these data sources to construct a longitudinal dataset on 4,646 individuals at risk for population mobility (Methods). The unit of analysis is the person-year, and the dataset contains baseline and time-varying variables at individual, household, and areal scales. Consistent with previous studies of population and the environment (34, 35), our primary measures of out-migration and exposure to natural disasters are derived from the reports of remaining household members. We also replicate the main results using measures of disasters derived from satellite data on rainfall.

To analyze these data, we use a multivariate approach that links the timing of residential moves by individuals with their level and timing of exposure to flooding and crop failure at household and areal scales, all while controlling for a large number of potential confounders. Specifically, we estimate discrete-time event history models of local population mobility and long-distance migration in which measures of exposure to natural disasters are included as independent variables. Other social and economic factors are included as controls, and fixed effects account for differences between locations and for the changing national context.

Relative to previous studies, this approach has multiple advantages. First, the data allow us to compare the effects of multiple natural disasters instead of focusing on a single event. This is of particular importance in Bangladesh where rural households regularly cope with flooding and are irregularly exposed to other disasters such as drought (22). Second, the use of household and individual-level data permits us to examine the effects of disasters at both household and contextual scales, as well as to compare the vulnerability of different subpopulations. This allows to test predictions that exposure to covariate risks will be more disruptive than exposure to idiosyncratic risks (34), and that vulnerable individuals will be more likely to be displaced by natural disasters (3). Finally, the use of data from migrant rosters gives us access to detailed information on the timing and destination of population movements that has not been accessible to most previous studies. These details allow for confirmation of the short-distance moves attributable to climate events identified by previous studies (12, 16-17).

Definition of key variables

The dependent variable is population mobility, defined at the individual level as a change of permanent residence away from the origin household and from any new local households formed by the original household members after the baseline survey. This dichotomous measure of mobility is additionally decomposed into (a) residential moves within the district of origin ("local mobility"), and (b) moves outside the district of origin ("long-distance mobility"). Long-distance moves, which are consistent with traditional definitions of migration, were often to urban areas (81% of moves) and rarely to international destinations (13% of moves). Annual rates of mobility for at-risk individuals (see Methods) were 6.4% for overall mobility, 3.8% for local mobility, and 2.5% for long-distance mobility.

The key independent variables are exposure to flooding and non-flooding-related crop failure at household and areal scales. Household exposure to flooding was defined as experiencing any flood-related damage to property or income in either year *t* or *t-1*, encompassing the 1-2 year period prior to migration. Crop failure was defined as any non-flood-related damage to crops during the same period, and was driven primarily by rainfall deficits (SI Appendix, S2). In the mean person-year, 5.6% of potential migrants were exposed to flooding and 4.7% were exposed to crop failure (SI Appendix, S3). These measures were derived from household retrospective reports of the timing and severity of exposure to negative events during the study period. Flooding and non-flooding-related crop failure were the most frequent and damaging climate-related events reported by households, and among the most damaging negative events overall (36). Household-level economic damages per event averaged 23% of annual household expenditure for flooding and 16% for crop failure. To additionally capture larger-scale exposure to these events, we derive the annual proportion of sample households exposed in each subdistrict. Subdistricts (i.e., *upazilas* or *thanas*) are territorial units nested within districts that are roughly equivalent to US counties. These subdistrict-level measures are similar to those used by previous studies, which have largely focused on larger-scale effects (e.g., 13).

Statistical models

To estimate the effects of natural disasters on population mobility, we estimate discrete-time event history models, which are appropriate for the person-year data structure and naturally accommodate data censoring due to mobility and the survey design (37). For each of several model specifications described below, we first estimate a logit model of mobility with the following form:

$$\log\left(\frac{\pi_{it}}{1-\pi_{it}}\right) = \alpha_t + \alpha_a + \beta X_{it}$$

where π_{it} is the odds of population mobility for individual *i* in year *t*, α_t is the baseline hazard of mobility in year *t*, α_a is the baseline hazard of mobility in subdistrict *a*, X_{it} is a vector of independent variables for individual *i* in year *t*, and β is a vector of parameters for the effects of the independent variables. The independent variables include measures of exposure to natural disasters and control variables as described below.

We subsequently extend this into a multinomial model of both local and long-distance mobility:

$$\log\left(\frac{\pi_{rit}}{\pi_{sit}}\right) = \alpha_{rt} + \alpha_{ra} + \beta_r X_{it}$$

where π_{rit} is the odds of mobility of type r for individual i in year t, π_{sit} is the odds of no mobility, and the other terms are made specific to the type of mobility.

We estimate these models using four primary and four supplementary specifications of exposure to natural disasters. Consistent with previous studies which have focused on larger scales, Specification A includes only subdistrict-level measures of exposure to flooding and crop failure. Specification B retains the subdistrict-level measures of exposure and adds household-level measures. This approach allows larger-scale effects of disasters, such as damaged infrastructure, increased prices and disrupted labor markets (38), to affect potential migrants differently from damage to their household, which most frequently included loss of assets and income.

Specification C retains the household-level measures and permits a nonlinear effect of subdistrict-level exposure. We distinguish between subdistrict-years in which greater than 20% of households were exposed ("severe"), versus years in which 5-20% were exposed ("moderate"), and years in which less than 5% were exposed ("low"), with the latter serving as the reference category. This specification asks whether individuals respond differently to moderate and severe levels of disaster-related disruption at the subdistrict level. Moderate flooding occurred in 11% of subdistrict-years, severe flooding in 9% of subdistrict-years, moderate crop failure in 20% of subdistrict-years, and severe crop failure in 6% of subdistrict-years. To examine the vulnerability of different subpopulations to these effects, we also re-estimate the Specification C logit model for (a) men and women separately, and (b) for individuals in the poorest, intermediate and richest terciles of household per capita expenditure[†].

Specification D extends Specification C by allowing the effects of household and subdistrict-level measures to interact. Specifically, the effects of household-level flooding and crop failure are allowed to differ between years with low, moderate and severe events at the

[†] Household expenditure was measured at baseline and inflated to 2005 prices.

subdistrict level, creating six categories of exposure for both flooding and crop failure. Finally, to test the robustness of these results, we estimate the model with four supplementary specifications. Specification E uses an alternative measure of disaster exposure based on economic damages, Specification F allows the effects of disaster exposure to differ between year *t* and *t*-1, Specification G includes a separate model for each baseline survey (Methods), and Specification H integrates satellite data on rainfall through an instrumental variables approach.

To account for the array of non-environmental factors which have been shown to influence population mobility (39), the models also include a large number of control variables as well fixed effects for the subdistrict and year. The 21 control variables include various demographic characteristics of the individual and household, baseline measures of household wealth and village infrastructure, and time-varying measures of migrant networks (SI Appendix, S4). Exposure to livestock deaths and health shocks are also included as control variables, and the specification is allowed to vary per flooding and crop failure as described above. The inclusion of fixed effects for the subdistrict and year additionally accounts for any baseline differences between subdistricts as well as changes in the national context over time. Subdistricts were selected as the unit to measure aggregrate exposure and to include fixed effects as a scale that is highly relevant to the daily lives of the respondents and at which we have sufficient data to estimate these terms. Finally, to account for the original sampling design (Methods), we also adjust all standard errors for clustering (40) at the level of the village, a spatial unit nested within subdistricts.

RESULTS

Table 1 presents the results of the logit and multinomial models for Specifications A-C. Model coefficients (β) have been exponentiated to create odds ratios (e^{β}), which can be interpreted as the multiplicative effect of a one unit increase in the independent variable on the odds of that form of mobility, and are accompanied by the results of cluster-adjusted significance tests. Coefficients for the control variables and fixed effects are included in the model but not displayed (SI Appendix, S5).

Specification A, including only the subdistrict-level measures, reveals that, contrary to expectations, the effects of flooding on overall, local and long-distance mobility are non-significant and near zero. In contrast, the effects of crop failure are positive and highly significant. A 1% increase in the proportion of households experiencing crop failure lead to a 3.5% increase in the odds of overall population mobility (p <.001), a 3.8% increase in the odds of local mobility (p <.001), and a 2.9% increase in the odds of long-distance mobility (p =.007).

Specification B adds the household-level measures and reveals that the effects of flooding remain largely non-significant. Household exposure to flooding had a positive and marginally significant effect on long-distance mobility (p =.085), but the joint effects of both flood measures on long-distance mobility remain non-significant (p =.165). Exposure to crop failure at the household level, however, had large *negative* effects on mobility. Relative to households that were not exposed, household-level exposure to crop failure reduced the odds of overall population mobility by 38% (p <.001), of local mobility by 33% (p =.018), and of long-distance mobility by 47% (p <.001). Subdistrict-level exposure to crop failure continued to have significant positive effects per Specification A.

Specification C additionally permits a nonlinear effect of subdistrict-level exposure, and reveals important nonlinear effects on mobility. Compared to years with low flooding, moderate flooding increased the odds of local mobility by 57% (p =.001), and marginally decreased the odds of long-distance mobility by 28% (p =.066). These effects cancel out to produce non-significant effects of flooding on overall mobility. The effects of crop failure are consistent with the linear specification, with large positive effects from severe crop failure on mobility and mixed effects from moderate crop failure. Thus under severe crop failure, the odds of overall mobility are 138% higher (p <.001), the odds of local mobility are 197% higher (p <.001), and the odds of long-distance mobility are 82% higher (p =.006). Additionally, under moderate crop failure the odds of local mobility are 45% higher (p =.004).

Re-estimating Specification C for various subpopulations reveals important differences in the effects of both flooding and crop failure at the subdistrict level but not at the household level (Table 2, S5). Subdistrict-level flooding has a nonlinear effect on the overall mobility of women and the poor that is consistent with the effects on local mobility in Table 1. Relative to non-flood years, the odds of overall mobility in moderate flood years are 59% higher for the poor (p =.020) and 36% higher for women (p =.021) but not significantly different for men and higher-expenditure households. The subdistrict-level effects of severe crop failure are also stronger for women relative to men, with the odds of women's overall mobility increasing 178% (p <.001) versus only 91% for men (*p* =.001). No clear pattern is evident, however, in the effects of crop failure across terciles of household expenditure.

Specification D additionally allows interactions between the household and subdistrict-level measures, creating six categories of flooding and crop failure. To highlight the effects of crop failure, we derive predicted probabilities of the three forms of mobility across the six categories of crop failure using mean values of the other predictors and present them in Table 3. (The effects of flooding are shown in S6.) Consistent with the results of Specification C, this analysis reveals that households that *did not* experience crop failure in subdistricts that experienced *severe* crop failure were the most likely to send household members. Ten percent of at-risk individuals moved under these circumstances, relative to 4.5% in the no crop-failure condition. Similarly, 2.8 times as many individuals made local moves under these circumstances, and 1.7 times as many individuals made long-distance moves.

Finally, the supplementary specifications reveal that our core results are robust to (a) the use of an alternative measure of disaster exposure based on economic damages, (b) allowing the effects of disaster exposure to differ between year *t* and *t*-1, (c) accounting for differences in the timing and location of the baseline surveys, and (d) accounting for the potential endogeneity of household-level exposure to disasters (SI Appendix, S6). We also show that our survey-based measures of disaster exposure have strong but nonlinear relationships with external measures of rainfall (SI Appendix, S7).

DISCUSSION

The analysis reveals that exposure to natural disasters has strong effects on population mobility in rural Bangladesh as expected. However the complexity of the effects belies a simple narrative of increasing mobility with disaster exposure. Flooding, which has received the most attention as a potential driver of migration in Bangladesh (29, 30), appears to only have modest effects on long-term population mobility. Relative to non-flood conditions, moderate flooding has positive effects on local mobility and moves by women and the poor, consistent with a disaster coping strategy, but these effects are not evident following severe floods. Household-level effects were also largely non-significant. These results likely reflect (a) the temporary nature of most flood-related displacement (26-28), (b) the partial success of local responses and government assistance following severe floods (23, 24), and (c) an inhibitory effect of severe flooding on mobility due to damaged infrastructure and the need for reconstruction (19).

In contrast, crop failure, which has received less attention in the Bangladeshi context, consistently has significant effect on mobility, but these effects vary starkly across scales. At the subdistrict scale, crop failure has large positive effects, suggesting that mobility serves as an important coping response to the local economic contractions that accompany large-scale crop failure (41). This effect is consistent with (a) the effects of drought on mobility observed in agricultural areas of Africa (16-18), (b) the lower priority that crop failure has received in terms of domestic and international aid distribution (22, 25), and (c) the general difficulties that rural communities experience in insuring against aggregate risks (42). Of particular interest, this effect appears to be strongest for women, who make the majority of marriage-related moves and also have options for urban employment in the garment industry. Because access to land in rural Bangladesh is controlled primarily by men (43), women may have greater facility to move in times of crisis because they do not fear losing access to land.

At the household level, however, a negative effect of crop failure is observed across types of mobility and subpopulations. Combined with the subdistrict-level effect, the net effect in most cases is that these households do not experience significantly higher mobility during moderate or severe crop failure events. This result suggests that a negative income shock from crop failure prevents these households from investing in population mobility, which often entails significant costs, even under adverse circumstances. This pattern is counterintuitive, but similar patterns have also been observed for droughts in Burkina Faso, Ethiopia, Nigeria and El Salvador (16-19).

These results have important implications for the study of environmentally-induced migration and for disaster relief efforts in Bangladesh and elsewhere. Academic and policy-oriented discussions of environmentally-induced migration commonly assume that adverse environmental conditions universally result in permanent and long-distance displacement, particularly among vulnerable populations (2, 8). However, accumulating evidence from this and other studies indicates that environmentally-induced population displacements are often temporary, short-distance and of a smaller magnitude than expected, and that the poor are not necessarily disproportionately affected (11-19). Future discussions should acknowledge the significant adaptability of rural households, as well as the significant economic, social and legal barriers that often lie in the way of migration. Policy makers interested in assisting climate-induced migrants should be aware that migration is almost always multi-causal and that typically only a small proportion of displaced individuals will have the means or motivation to cross a national boundary.

Regarding Bangladesh specifically, these results are consistent with previous studies in suggesting that drought and crop failure deserve greater attention from the disaster relief community (22, 25). Large-scale floods are high-visibility events that deservedly attract significant assistance and concern about Bangladesh's future in a warmer, wetter and more variable climate (20). However, multiple lines of evidence suggest that droughts and crop failure events can be equally or more damaging, though they are often invisible to the outside world (22, 25). The increasing use of satellite imagery and rapid household surveys to identify vulnerable populations is a promising way forward to address this need (44).

METHODS

Our baseline data were originally collected by IFPRI from three separate household samples using overlapping questionnaires (33). The first baseline survey was conducted in 1994 with 350 households in 7 rural communities, the second in 1996 with 957 households in 47 rural communities, and the third in 2003 with 473 households in 48 rural communities. The household and village samples were not selected to be strictly representative of rural Bangladesh, but the sample is large and encompasses diverse areas that span much of the country (SI Appendix, SI Appendix, S1). In 2006, as part of the Chronic Poverty and Long Term Impact Study, the samples were linked through a joint follow-up survey that targeted all baseline households as well as local split-off households containing one or more original household members. Information on departed household members was collected through a migrant roster, which measured the timing of moves with a scale of one year and the destination of moves at the scale of the district (an administrative division that includes multiple subdistricts). An additional follow-up of the second and third baseline surveys was conducted in 2010 using the same approach. Only 6.5% of baseline individuals at risk for mobility were lost to follow-up between rounds, representing an annual rate of attrition of less than 1%, and this process does not appear to have been affected by flooding or crop failure (SI Appendix, S8).

These data sources were used to create a longitudinal dataset containing baseline and time-varying variables at individual, household, village and subdistrict scales. The unit of analysis is the person-year, with a total sample size of 32,229 person-years. Data on the destination of moves is missing for 35 of 4,646 individuals, leaving 32,056 person-years for analyses of this outcome. Consistent with observed rates of mobility and with previous studies (11-12, 14, 16-17), individuals aged 15-39 in year *t* who were not heads of household of spouses of the head at baseline were considered to be at risk of mobility and were included in the analysis. Individuals enter the dataset at baseline or when they turn 15 years old, and leave the dataset when they move, turn 40 years old, and are censored at the final data collection. Due to differences in the timing of baseline and follow-up surveys, not all individuals are observed for the same set of years. This feature is naturally accounted for through the use of the event history model described above. The robustness of the core results to additional differences between the baseline surveys in established in S8.

ACKNOWLEDGEMENTS

We thank the International Food Policy Research Institute for providing access to the data, and Wahid Quabili for assistance with data preparation. Agnes Quisumbing and Michael Emch provided helpful comments on a previous draft. While preparing this manuscript Clark Gray was supported by a grant from the National Institutes of Health (R00HD061752).

REFERENCES

1. Patt A et al. (2010) Estimating least-developed countries' vulnerability to climate-related extreme events over the next 50 years. *Proc Natl Acad Sci USA* 107 (4) 1333-1337.
2. Laczko F, Aghazarm C (2009) *Migration, Environment and Climate Change: Assessing the evidence*. (International Organization for Migration)
3. Wisner B, Blaikie P, Cannon T, Davis I (2004) *At Risk: Natural Hazards, People's Vulnerability and Disasters* (Routledge)
4. Hunter L (2005) Migration and environmental hazards. *Popul Environ* 26: 273-302
5. Hugo G (1996) Environmental concerns and international migration. *Int Migr Rev* 30:105-131

6. Myers N (2002) Environmental refugees: A growing phenomenon of the 21st century. *Philos Trans R Soc Lond B Biol Sci* 357: 609-613.
7. McSweeney K, Coomes O (2011) Climate-related disaster opens a window of opportunity for rural poor in northeastern Honduras. *Proc Natl Acad Sci USA* 108: 5203-5208.
8. Warner K (2010) Global environmental change and migration: Governance challenges. *Glob Environ Change* 20: 402–413.
9. Wilbanks T et al. (2007) *in Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* eds Parry M, Canziani O, Palutikof J, van der Linden P, Hanson C (Cambridge University Press, Cambridge, UK) pp 357-390.
10. White G (2011) *Climate Change and Migration: Security and Borders in a Warming World* (Oxford University Press, Oxford)
11. Gray C (2009). Environment, land and rural out-migration in the southern Ecuadorian Andes. *World Dev* 37: 457–468.
12. Massey D, Axinn W, Ghimire D (2010) Environmental change and out-migration: Evidence from Nepal. *Popul Environ* 32: 109-136.
13. Feng S, Krueger A, Oppenheimer M (2010) Linkages among climate change, crop yields and Mexico–US cross-border migration. *Proc Natl Acad Sci USA* 107: 14257-14262.
14. Gray C (2011) Soil quality and human migration in Kenya and Uganda. *Global Environ Change* 21: 421–430.
15. Munshi K (2003) Networks in the modern economy: Mexican migrants in the U.S. Labor Market. *Q J Econ* 118: 549-599.
16. Henry S, Schoumaker B, Beauchemin C (2004) The impact of rainfall on the first out-migration: A multi-level event-history analysis in Burkina Faso. *Popul Environ* 25: 423-460.
17. Gray C, Mueller V (In press) Drought and population mobility in rural Ethiopia. *World Dev*
18. Dillon A, Mueller V, Salau S (In press) Migratory responses to agricultural risk in northern Nigeria. *Am J Agr Econ*
19. Halliday T (2006) Migration, risk, and liquidity constraints in El Salvador. *Econ Dev Cult Change* 54: 893–925.
20. Yu W, Alam M, Hassan A (2010) *Climate Change Risks and Food Security in Bangladesh* (Earthscan, Oxford)

21. Mirza M (2011) Climate change, flooding in South Asia and implications. *Regional Environmental Change* 11: 95-107.
22. Paul B (1998) Coping mechanisms practised by drought victims (1994/5) in North Bengal, Bangladesh. *Appl Geogr* 18: 355-373.
23. Del Ninno, C (2001) *The 1998 Floods in Bangladesh: Disaster Impacts, Household Coping Strategies, and Response* (International Food Policy Research Institute, Washington DC)
24. Khandker S (2007) Coping with flood: Role of institutions in Bangladesh. *Agric Econ* 36:169–180.
25. Shahid S, Behrawan H (2008) Drought risk assessment in the western part of Bangladesh. *Natural Hazards* 46: 391-413.
26. Paul S, Routray J (2010) Flood proneness and coping strategies: The experiences of two villages in Bangladesh. *Disasters* 34: 489–508.
27. Ali A (2007) September 2004 flood event in southwestern Bangladesh: A study of its nature, causes, and human perception and adjustments to a new hazard. *Natural Hazards* 40: 89-111.
28. Findlay A, Geddes A (2011) *in Migration and Climate Change*, eds Piguet E, Pécoud A, Guchteneire P (Cambridge University Press, Cambridge), pp 138-159.
29. IOM (2010) *Assessing the Evidence: Environment, Climate Change and Migration in Bangladesh* (International Organization for Migration)
30. Black R, Kniveton D, Schmidt-Verker K (2011) Migration and climate change: towards an integrated assessment of sensitivity. *Environ Plan A* 43: 431-450.
31. Lein H (2000) Hazards and "forced" migration in Bangladesh. *Nor Geogr Tidsskr* 54: 122-127.
32. Paul, B (2005) Evidence against disaster-induced migration: the 2004 tornado in north-central Bangladesh. *Disasters* 29:370–385.
33. Hassan M, Quabili W, Zobair M, Baulch B, Quisumbing A (2011) Sampling and survey design of the Bangladesh long-term impact study. *J Dev Effect* 3: 281-296.
34. Dercon S, Krishnan P (2000) Vulnerability, seasonality and poverty in Ethiopia. *J Dev Stud* 36:25-53.
35. AxinnW, Pearce L (2006) *Mixed Method Data Collection Strategies* (Cambridge University Press)

36. Quisumbing, A (2011) *in Why Poverty Persists: Poverty Dynamics In Asia And Africa*, ed Baulch B (Edward Elgar Publishing, Cheltenham, UK) pp 29-64.
37. Allison P (1984) *Event History Analysis*. (Sage Publications, Thousand Oaks)
38. Mueller V, Quisumbing A (In press) How resilient are labor markets to natural disasters? The case of the 1998 Bangladesh flood. *J Dev Stud*.
39. White M, Lindstrom D (2006) in *Handbook of Population*, eds Poston D, Micklin M (Kluwer Academic Publishers, New York) pp 311-346.
40. Huber P (1981) *Robust Statistics* (Wiley, New York)
41. Dercon S (2004) Growth and shocks: Evidence from rural Ethiopia. *J Dev Econ* 74:309-329.
42. Dercon S (2002) Income risk, coping strategies, and safety nets. *World Bank Res Obs* 17:141-166
43. Quisumbing A, Maluccio J (2003) Resources at marriage and intrahousehold allocation: Evidence from Bangladesh, Ethiopia, Indonesia, and South Africa. *Oxf Bull Econ Stat* 65: 283-327.
44. Brown M (2008) *Famine Early Warning Systems and Remote Sensing Data* (Springer).

TABLE LEGENDS

Table 1. Odds ratios and significance tests from the event history analysis of population mobility. Models also include control variables and indicators for the subdistrict and year.

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

[1] The reference category for subdistrict-level nonlinear shocks is <5% exposed.

Table 2. Odds ratios and significance tests from logit models of population mobility stratified by subpopulation.

Models also include control variables and indicators for the subdistrict and year. The reference category for subdistrict-level shocks is <5% exposed.

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

Table 3. Predicted probabilities of population mobility under various conditions of crop failure.

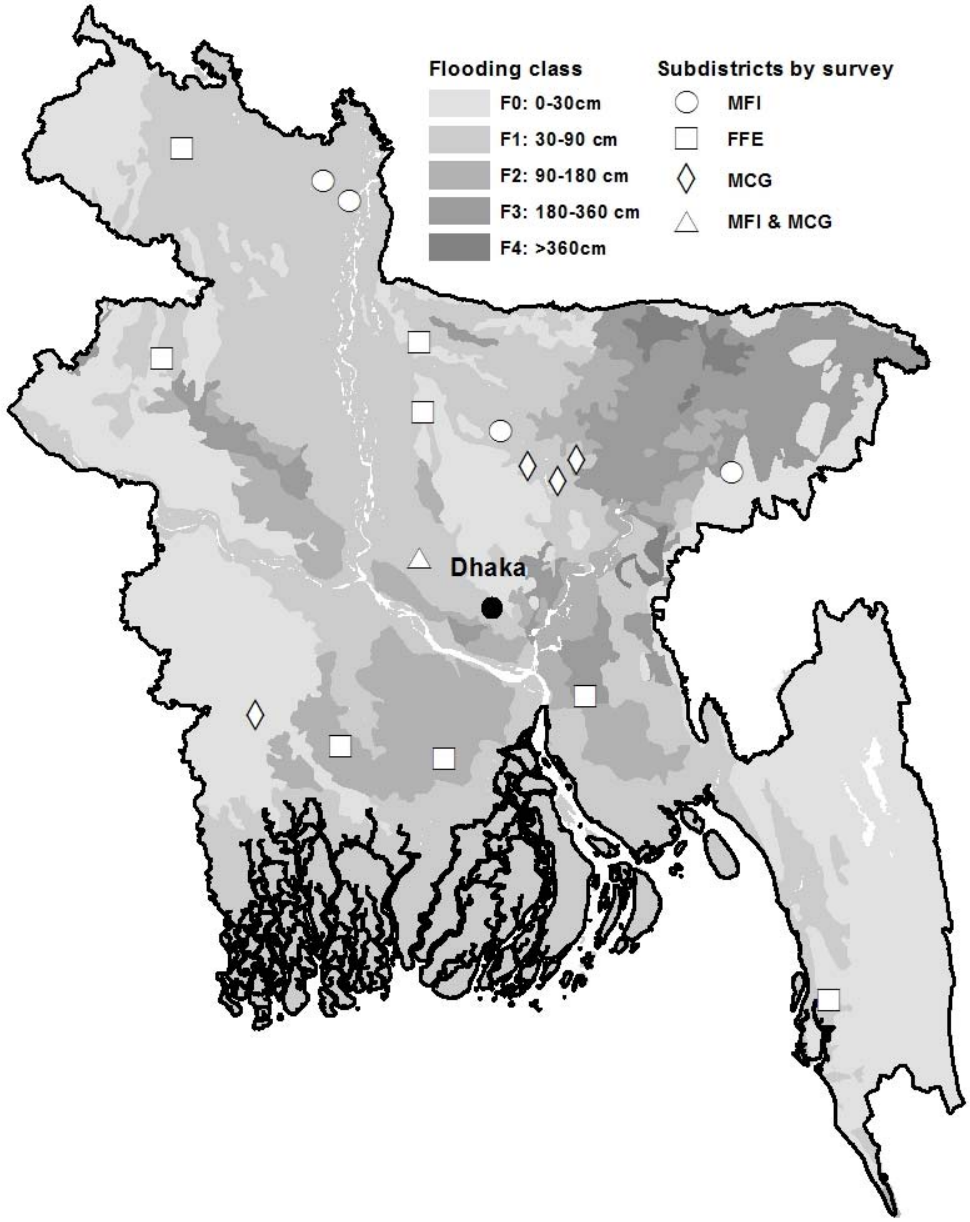
Results are derived from Specification D of the event history model (see text). Stars indicate the significance of contrasts with the no-crop-failure condition: + $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Exposure to natural disasters	Logit		Multinomial			
	All mobility		In district		Out of district	
A. Subdistrict exposure						
Flooding: Percent exposed in subdistrict (%)	1.00		1.00		0.99	
Crop failure: Percent exposed in subdistrict (%)	1.04	***	1.04	***	1.03	**
B. Household and subdistrict exposure						
Flooding: Household exposed (0/1)	1.08		0.93		1.31	+
Percent exposed in subdistrict (%)	1.00		1.00		0.99	
Crop failure: Household exposed (0/1)	0.62	***	0.67	*	0.53	***
Percent exposed in subdistrict (%)	1.04	***	1.04	***	1.04	***
C. Household and nonlinear subdistrict exposure[1]						
Flooding: Household exposed (0/1)	1.08		0.93		1.29	
5-20% exposed in subdistrict (0/1)	1.08		1.57	***	0.72	+
>20% exposed in subdistrict (0/1)	0.93		1.12		0.73	
Crop failure: Household exposed (0/1)	0.64	***	0.69	*	0.54	***
5-20% exposed in subdistrict (0/1)	1.19	+	1.45	**	0.96	
>20% exposed in subdistrict (0/1)	2.38	***	2.97	***	1.82	**
$N_{person\text{-}years}$	32,229		32,056			

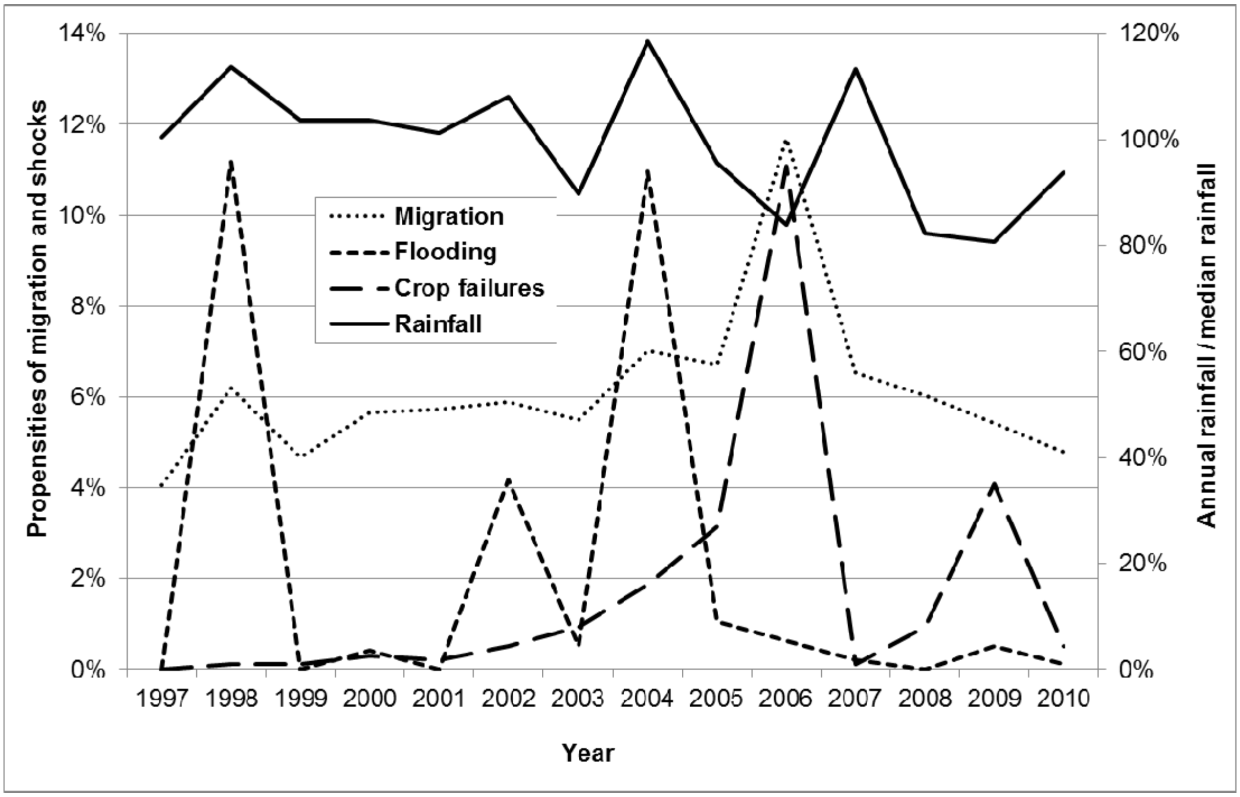
Exposure to natural disasters	Gender				Expenditures per capita					
	Men		Women		Low		Medium		High	
Flooding: Household exposed (0/1)	0.99		1.11		0.86		0.97		1.30	
5-20% exposed in subdistrict (0/1)	0.89		1.36	*	1.59	*	0.94		1.04	
>20% exposed in subdistrict (0/1)	0.91		0.99		0.90		0.91		1.04	
Crop failure: Household exposed (0/1)	0.63	**	0.68	*	0.55	*	0.79		0.52	**
5-20% exposed in subdistrict (0/1)	1.13		1.31	*	1.32	+	1.25		1.04	
>20% exposed in subdistrict (0/1)	1.91	***	2.78	***	2.42	**	2.36	**	2.53	***
$N_{person\text{-}years}$	20,748		11,481		9,449		11,232		11,548	

Exposure to crop failure		All moves		Within-district moves		Out-of-district moves		Person-years exposed
Subdistrict level	Household level							
<5% crop failure	No crop failure	4.5%	ref	1.8%	ref	1.8%	ref	23,817
	Crop failure	3.2%	+	1.3%		1.0%		290
5-20% crop failure	No crop failure	5.3%	+	2.6%	**	1.7%		6,027
	Crop failure	3.4%		1.7%		1.0%	+	889
>20% crop failure	No crop failure	10.0%	***	5.0%	***	3.2%	**	864
	Crop failure	6.6%		3.7%	*	1.7%		343

S1. Map of the study subdistricts, with the normal depth of annual flooding from Yu et al. (2010).



S2. Annual rates of migration, flooding, and crop failure with the ratio of annual rainfall to median rainfall.



S3. Annual rates of migration under various environmental conditions.

Type of move	Overall	Flooding exposure				Crop loss exposure				Number of moves
		<5%	5-20%	>20%	F-test	<5%	5-20%	>20%	F-test	
All moves	6.4%	6.0%	10.8%	6.8%	**17.2***	5.8%	7.1%	15.6%	**61.8***	2,070
Within-district moves	3.8%	3.6%	6.5%	4.2%	**12.5***	3.5%	4.3%	7.9%	**18.8***	1,227
Out-of-district moves	2.5%	2.4%	4.2%	2.6%	**6.2**	2.2%	2.7%	7.6%	**48.7***	808
Person-years of exposure	32,229	26,572	2,036	3,621		24,106	6,916	1,207		
Subdistrict-years of exposure	193	154	22	17		143	39	11		

Note: Values are annual rates of migration for at-risk individuals, and exposure is measured by the annual proportion of households exposed in the subdistrict (see text). Data on the destination of moves are missing for 173 migrants. F-tests are for the independence of migration rates and environmental conditions, corrected for clustering at the level of the community.

S4. Predictors used in the event history analysis.

Predictor	Unit	Time-varying?	Person-year mean	Standard deviation
Individual controls				
Female	1/0	No	0.36	0.48
Age 15-16	1/0	Reference	0.17	0.38
Age 17-19	1/0	Yes	0.22	0.42
Age 20-24	1/0	Yes	0.26	0.44
Age 25-29	1/0	Yes	0.17	0.38
Age 30-39	1/0	Yes	0.17	0.38
Child of head	1/0	No	0.76	0.43
Less than primary education	1/0	Reference	0.36	0.48
Primary education	1/0	No	0.31	0.46
Secondary education	1/0	No	0.32	0.47
Has a child	1/0	Yes	0.21	0.41
Household controls				
Household size	#	No	7.18	2.96
Proportion of minors	%	No	34.04	18.28
Head is female	1/0	No	0.05	0.22
Head is non-Muslim	1/0	No	0.07	0.25
Head without primary education	1/0	Reference	0.62	0.48
Head has primary education	1/0	No	0.18	0.39
Head has secondary education	1/0	No	0.19	0.39
Ln(expenditures per capita)	Tk	No	6.82	0.46
Ln(land area+1)	ha	No	3.86	1.52
Land with irrigation	1/0	No	0.42	0.49
Village and subdistrict controls				
Rich community	1/0	No	0.19	0.39
Intermediate community	1/0	Reference	0.56	0.50
Poor community	1/0	No	0.25	0.43
Jute-producing community	1/0	No	0.78	0.42
Community has a road	1/0	Yes	0.93	0.26
Community has a school	1/0	Yes	0.70	0.46
Subdistrict propensity of local moves	%	Yes	3.40	2.38
Subdistrict propensity of out-migration	%	Yes	2.92	2.64
Shocks[1]				
Flood exposure: in household	1/0	Yes	0.06	0.23
Percent exposed in subdistrict	%	Yes	4.73	10.02
5-20% exposed in subdistrict	1/0	Yes	0.06	0.24
>20% exposed in subdistrict	1/0	Yes	0.11	0.32
Crop loss: in household	1/0	Yes	0.05	0.21
Percent exposed in subdistrict	%	Yes	3.76	5.94
5-20% exposed in subdistrict	1/0	Yes	0.21	0.41
>20% exposed in subdistrict	1/0	Yes	0.04	0.19
Livestock death: in household	1/0	Yes	0.06	0.23
Percent exposed in subdistrict	%	Yes	4.81	4.89
5-20% exposed in subdistrict	1/0	Yes	0.38	0.48
>20% exposed in subdistrict	1/0	Yes	0.01	0.09
Health shock: in household	1/0	Yes	0.15	0.36
Percent exposed in subdistrict	%	Yes	12.29	9.74
5-20% exposed in subdistrict	1/0	Yes	0.57	0.49
>20% exposed in subdistrict	1/0	Yes	0.20	0.40

[1] The reference category for the subdistrict-level shock categories is <5% exposed.

S5. Full results of Specifications A-C, including odds ratios and significance tests.

Predictor	**Specification A**			**Specification B**			**Specification C**							
		Multinomial			**Multinomial**			**Multinomial**		**Logit by subpopulation**				
	Logit	In district	Out of district	**Logit**	In district	Out of district	**Logit**	In district	Out of district	Men	Women	Low PCE	Medium PCE	High PCE
Individual controls														
Female	2.99 ***	6.42 ***	1.01	2.98 ***	6.41 ***	1.00	2.98 ***	6.40 ***	1.00	-	-	3.93 ***	3.50 ***	2.19 ***
Age 17-19	1.63 ***	1.52 ***	1.98 ***	1.63 ***	1.52 ***	1.98 ***	1.63 ***	1.54 ***	1.98 ***	1.61 ***	1.83 ***	1.73 ***	1.65 ***	1.66 ***
Age 20-24	1.82 ***	1.61 ***	2.37 ***	1.83 ***	1.61 ***	2.38 ***	1.83 ***	1.62 ***	2.39 ***	1.91 ***	2.20 ***	1.95 ***	1.92 ***	1.92 ***
Age 25-29	1.70 ***	1.17	2.81 ***	1.70 ***	1.17	2.84 ***	1.70 ***	1.18	2.86 ***	2.04 ***	1.72 **	1.87 **	1.79 ***	1.67 ***
Age 30-39	1.42 *	1.08	2.05 ***	1.44 **	1.08	2.08 ***	1.43 *	1.07	2.09 ***	1.91 ***	0.83	1.18	1.22	1.72 **
Child of head	1.26 **	1.21 +	1.23 +	1.26 **	1.21 +	1.24 +	1.26 **	1.22 +	1.24 +	0.48 ***	2.18 ***	1.25	1.63 **	1.03
Primary education	0.67 ***	0.55 ***	0.94	0.67 ***	0.55 ***	0.94	0.67 ***	0.54 ***	0.94	0.77 *	0.59 ***	0.60 ***	0.68 **	0.66 ***
Secondary education	0.56 ***	0.39 ***	0.94	0.56 ***	0.39 ***	0.93	0.56 ***	0.39 ***	0.94	0.84	0.36 ***	0.54 **	0.53 ***	0.58 ***
Has a child	0.24 ***	0.18 ***	0.36 ***	0.24 ***	0.18 ***	0.36 ***	0.24 ***	0.18 ***	0.36 ***	0.40 ***	0.20 ***	0.20 ***	0.23 ***	0.30 ***
Household controls														
Household size	0.99	1.00	0.97 +	0.99	1.00	0.97 +	0.99	1.00	0.97 +	1.01	0.99	0.98	0.99	0.99
Proportion of minors	1.01 ***	1.01 **	1.01 +	1.01 ***	1.01 **	1.01 *	1.01 ***	1.01 **	1.01 +	1.01 *	1.01 **	1.01 *	1.01 *	1.00 +
Head is female	0.97	0.82	1.25	0.97	0.82	1.26	0.98	0.83	1.25	0.85	1.19	0.83	0.94	1.23
Head is non-Muslim	0.76 *	0.60 *	1.05	0.75 *	0.60 *	1.05	0.75 *	0.59 *	1.03	0.63 *	0.75 *	0.44 *	0.99	0.87
Head has primary education	1.13	1.10	1.13	1.12	1.10	1.11	1.12	1.10	1.11	1.07	1.09	1.22	0.98	1.16
Head has secondary education	1.24 **	1.19 +	1.28 *	1.24 **	1.18	1.26 *	1.24 **	1.20 +	1.26 *	1.15	1.15	1.06	1.32 +	1.24 *
Ln(expenditures per capita)	1.17 *	1.16	1.17 +	1.17 *	1.17 +	1.18 +	1.17 *	1.16 +	1.18 +	1.33 **	1.05	0.94	1.79 +	1.01
Ln(land area+1)	0.98	1.03	0.89 **	0.98	1.04	0.90 **	0.98	1.04	0.90 **	0.93 *	1.03	1.00	1.03	0.97
Land with irrigation	0.97	0.92	1.05	0.97	0.92	1.05	0.97	0.93	1.05	0.98	0.94	0.87	1.01	1.09
Village and subdistrict controls														
Rich community	1.30 **	1.56 **	1.02	1.29 **	1.54 **	1.01	1.29 **	1.54 **	1.01	1.19	1.24	0.99	1.70 ***	1.34
Poor community	1.05	1.00	1.11	1.05	1.00	1.11	1.05	1.00	1.12	1.09	1.06	1.31 *	0.87	1.22
Jute-producing community	0.85 *	0.82 *	0.84	0.85 *	0.82 *	0.83 +	0.84 *	0.81 *	0.83 +	0.80 *	0.90	0.77	0.94	0.81 +
Community has a road	0.80	0.97	0.63 *	0.81	0.97	0.63 *	0.79 +	0.92	0.65 *	0.64 *	0.95	0.61 **	0.79	0.93
Community has a school	0.94	0.81 **	1.16	0.95	0.82 **	1.18	0.95	0.82 **	1.18	0.93	0.97	0.99	0.76 **	0.98
Subdistrict propensity of local moves	0.98	0.98	0.99	0.98	0.98	0.99	0.98 +	0.98	0.99	0.98	0.98	0.98	0.95 *	1.02
Subdistrict propensity of out-migration	1.00	1.00	0.99	1.00	1.00	0.99	1.00	1.01	1.00	1.03	0.97	0.98	1.02	0.98
Shocks														
Flood exposure: in household				1.08	0.93	1.31 +	1.08	0.93	1.29	0.99	1.11	0.86	0.97	1.30
Percent exposed in subdistrict	1.00	1.00	0.99	1.00	1.00	0.99								
5-20% exposed in subdistrict							1.08	1.57 ***	0.72 +	0.89	1.36 *	1.59 *	0.94	1.04
>20% exposed in subdistrict							0.93	1.12	0.73	0.91	0.99	0.90	0.91	1.04
Crop loss: in household				0.62 ***	0.67 *	0.53 ***	0.64 ***	0.69 *	0.54 ***	0.63 **	0.68 *	0.55 *	0.79	0.52 **
Percent exposed in subdistrict	1.04 ***	1.04 ***	1.03 **	1.04 ***	1.04 ***	1.04 ***								
5-20% exposed in subdistrict							1.19 +	1.45 **	0.96	1.13	1.31 *	1.32 +	1.25	1.04
>20% exposed in subdistrict							2.38 ***	2.97 ***	1.82 **	1.91 ***	2.78 ***	2.42 **	2.36 **	2.53 ***
Livestock death: in household				0.99	1.02	0.97	0.96	0.99	0.95	0.91	1.05	1.00	0.94	0.90
Percent exposed in subdistrict	0.98	0.97 +	0.99	0.98	0.97 +	0.99								
5-20% exposed in subdistrict							1.12	1.12	1.08	1.02	1.22 +	1.33 *	1.09	0.98
>20% exposed in subdistrict							1.51	1.27	2.18	2.35 *	1.10	0.88	2.69 +	0.88

Health shock: in household				0.87 *	0.93	0.79 *	0.87 +	0.95	0.79 *	0.79 *	1.00	0.65 ***	0.98	0.96
Percent exposed in subdistrict	1.01 *	1.03 ***	1.00	1.02 *	1.03 ***	1.00								
5-20% exposed in subdistrict							1.15	1.02	1.39 +	1.33	1.02	1.19	0.97	1.10
>20% exposed in subdistrict							1.49 +	1.63 +	1.21	1.55	1.41	1.59	1.13	1.52
Joint tests (χ^2)														
Flooding	0	0	1	1	1	4	2	12 **	7 +	1	6	8 *	0	3
Crop losses	27 ***	18 ***	7 **	55 ***	25 ***	28 ***	50 ***	28 ***	28 ***	23 ***	19 ***	14 **	8 *	24 ***
Year indicators	86 ***	51 ***	40 ***	87 ***	51 ***	40 ***	106 ***	62 ***	60 ***	43 ***	69 ***	53 ***	953 ***	73 ***
Subdistrict indicators	120 ***	92 ***	149 ***	117 ***	91 ***	146 ***	120 ***	118 ***	151 ***	108 ***	92 ***	49 ***	91 ***	50 ***

Models also include indicators for the subdistrict and year.

PCE = per capita expenditure

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

S6. Main results of Specifications D-H, including odds ratios, significance tests, and IV coefficients.

Exposure to natural disasters	Logit		Multinomial				Descriptive values	
	All mobility		In district		Out of district		Mean	SD
D. Subdistrict X household interactions[1]								
Flooding: subdistrict low X household yes	0.83		0.31	*	1.55		0.01	0.08
Subdistrict moderate X household no	1.07		1.56	**	0.72	+	0.06	0.23
Subdistrict moderate X household yes	1.15		1.38		0.93		0.01	0.08
Subdistrict severe X household no	0.90		1.02		0.75		0.07	0.25
Subdistrict severe X household yes	1.03		1.15		0.91		0.04	0.20
Crop failure: subdistrict low X household yes	0.71	+	0.74		0.55		0.01	0.09
Subdistrict moderate X household no	1.19	+	1.46	**	0.95		0.19	0.39
Subdistrict moderate X household yes	0.75		0.97		0.55	+	0.03	0.16
Subdistrict severe X household no	2.39	***	2.96	***	1.84	**	0.03	0.16
Subdistrict severe X household yes	1.53		2.11	*	0.96		0.01	0.10
E. Cost-based measures of exposure[2]								
Ln(household flooding losses +1)	1.04		0.99		1.09	+	0.15	0.64
Ln(subdistrict mean flooding losses+1)	1.01		1.12	+	0.94		0.33	0.62
Ln(household crop losses +1)	0.84	**	0.90		0.73	***	0.11	0.51
Ln(subdistrict mean crop losses+1)	1.49	**	1.67	***	1.39		0.28	0.35
F. Multiple temporal lags								
Flooding: Household exposed in year t	1.26		1.11		1.50	+	0.03	0.16
Household exposed in year t-1	0.92		0.81		1.10		0.03	0.17
Percent exposed in subdistrict in year t	1.00		1.00		0.99		2.33	7.19
Percent exposed in subdistrict in year t-1	1.00		1.01	+	0.99		2.41	7.30
Crop failure: Household exposed in year t	0.67	*	0.84		0.42	***	0.02	0.16
Household exposed in year t-1	0.57	**	0.48	**	0.66		0.02	0.15
Percent exposed in subdistrict in year t	1.03	***	1.03	**	1.03	*	1.97	3.92
Percent exposed in subdistrict in year t-1	1.05	***	1.05	***	1.04	**	1.83	3.73
G. Stratified by baseline survey								
Survey 1 (n = 5,855)								
Flooding: Household exposed	0.95		0.86		1.14		0.06	0.23
Percent exposed in subdistrict	0.99	*	0.99		0.97	**	4.31	10.84
Crop failure: Household exposed	1.04		1.09		0.91		0.05	0.22
Percent exposed in subdistrict	1.02		1.07	***	0.94		2.54	4.29
Survey 2 (n = 21,857)								
Flooding: Household exposed	1.32	*	1.16		1.46	*	0.05	0.22
Percent exposed in subdistrict	1.00		1.00		1.00		4.36	9.44
Crop failure: Household exposed	0.52	***	0.51	*	0.52	**	0.04	0.19
Percent exposed in subdistrict	1.02	+	1.03		1.02		3.50	5.46
Survey 3 (n = 4,517)								
Flooding: Household exposed	0.83		0.68		1.25		0.08	0.28
Percent exposed in subdistrict	0.99		0.99		0.99		7.06	11.25
Crop failure: Household exposed	0.64	+	0.86		0.38	*	0.09	0.28
Percent exposed in subdistrict	1.03	*	1.01		1.05	*	6.61	8.58
H. IV model: Cost-based measures of exposure[2,3]								
Endogenous variables								
Ln(household flooding losses +1)	0.10	+	0.06		0.04		0.15	0.64
Ln(household crop losses +1)	0.34	*	0.21	*	0.14	+	0.11	0.51
Specification tests								
Underidentification (Kleibergen-Paap)	11.2	*	11.4	**	11.4	**	-	-
Overidentification (Hansen)	0.2		0.8		0.1		-	-
Weak identification (Cragg-Donald)	8.5		8.8		8.8		-	-

Models also include control variables and indicators for the subdistrict and year.
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

[1] Reference category is "subdistrict low, household no".

[2] Losses measured in '000 thaka.

[3] Second stage results from three linear instrumental variables models of mobility, presented as untransformed coefficients. Models for overall, within-district and out-of-district mobility were each estimated separately using the two-step generalized method of moments estimator. N = 26,211

S7. First stage results of the instrumental variables model, Specification H.

Exogenous variables	Endogenous variables: Ln(household flooding losses +1)		Ln(household crop losses +1)	
Individual controls				
Female	-0.01		0.00	
Age 17-19	0.00		-0.01	
Age 20-24	0.00		0.01	
Age 25-29	0.01		0.01	
Age 30-39	0.02		0.04	+
Child of head	-0.02		0.01	
Primary education	0.01		0.01	
Secondary education	-0.01		-0.01	
Has a child	-0.01		-0.02	
Household controls				
Household size	0.02	**	0.01	+
Proportion of minors	0.00		0.00	**
Head is female	-0.06		0.02	
Head is non-Muslim	-0.06		-0.05	
Head has primary education	0.00		-0.06	**
Head has secondary education	0.07	*	-0.02	
Ln(expenditures per capita)	0.03		0.03	
Ln(land area+1)	0.01		0.03	***
Land with irrigation	0.05	+	0.00	
Village and subdistrict controls				
Rich community	-0.11	**	-0.06	*
Poor community	0.00		0.00	
Jute-producing community	-0.15	**	-0.07	+
Community has a road	0.06		0.04	+
Community has a school	0.01		0.04	+
Subdistrict propensity of local moves	0.00		0.01	*
Subdistrict propensity of out-migration	0.02	**	0.00	
Instruments				
Annual rainfall/median rainfall, year t	-8.31	**	2.19	+
(Annual rainfall/median rainfall)^2, year t	4.04	**	-1.23	+
Annual rainfall/median rainfall, year t-1	-3.30		2.95	*
(Annual rainfall/median rainfall)^2, year t-1	1.91		-1.34	*
Measures of model fit				
F test of instruments	3.96	**	3.15	*
R-squared	0.031		0.024	

Notes: Models also include indicators for the subdistrict and year. Annual rainfall values were extracted at the subdistrict level from NASA's Prediction of Worldwide Energy Resources dataset (http://power.larc.nasa.gov/), which provides global daily precipitation values at 1 degree resolution from a variety of satellite sources. Because the data are restricted to the period 1997-2009, the sample size is restricted to N = 26,211 person-years.

S8. Determinants of sample attrition with alternative measures of exposure.

Predictor	Logit All attrition		Multinomial logit Household lost		Multinomial logit Individual lost		Logit Individual lost[1]	
Individual-level controls								
Female	1.28	*	1.33	*	1.22		1.22	
Age	0.99		0.94	+	1.06	*	1.06	*
Age squared	1.00		1.00		1.00	*	1.00	*
Child of head	0.57	**	0.50	*	0.60	*	0.61	*
Household-level controls								
Household size	0.88	**	0.77	*	0.92	*	0.93	
Proportion of minors	1.01		1.02	+	1.00		1.00	
Head is female	1.65	+	1.15		2.05	*	2.11	*
Head is non-Muslim	0.71		0.39		0.97		0.92	
Head has primary education	1.31		1.33		1.24		1.19	
Head has secondary education	1.19		0.98		1.46		1.43	
Ln(expenditures per capita)	1.37		2.08		0.84		0.90	
Ln(land area+1)	0.79	**	0.61	**	1.08		1.09	
Land with irrigation	1.02		0.99		1.26		1.29	
Community-level controls								
Rich community	1.01		1.00		1.22		1.19	
Poor community	0.81		1.19		0.59	*	0.58	*
Jute-producing community	0.94		2.10	+	0.47	*	0.52	+
Cumulative village shocks (mean annual percent of households exposed in village)								
Flooding	0.90		0.81		0.99			
Crop losses	0.93		0.97		0.84	+		
Livestock deaths	0.85	*	0.74	+	0.91			
Health shocks	1.08		1.12		1.06			
Cumulative household shocks (number of times household exposed over study period)								
Flooding							0.85	
Crop losses							0.65	*
Livestock deaths							0.93	
Health shocks							1.08	
Joint test of flooding & crop losses	**2.12**		**4.00**				**4.41**	
N (individuals)	6060		6060				5668	
Percent lost to follow up	6.47		3.05		3.42		3.16	

Model also includes indicators for subdistrict and year.

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

[1] Conditional on whole household not being lost

Note: Models also include indicators for the subdistrict. Because these models are cross-sectional rather than longitudinal, alternative measures of exposure were developed to identify disaster effects when subdistrict fixed effects are controlled. For the case of households lost to follow up, exposure is measured by the cumulative proportion of households exposed in the village. For the case of individuals lost to follow up (where household data are available), exposure is measured by the cumulative number of times the household was exposed over the study period.