Drought and Human Migration in Rural Ethiopia

---------------------------SUBMISSION FOR PAA 2011-------------------------

Clark Gray[1] and Valerie Mueller[2]

[1] Duke University

[2] International Food Policy Research Institute

Abstract: Significant discussion has focused on the possibility that climate change will displace large numbers of migrants in the developing world, but few multivariate studies have addressed this issue. We use a unique longitudinal dataset from the Ethiopian highlands to investigate the effects of multiple measures of drought on the labor and marriage-related mobility of men and women over a ten-year period. The results indicate that men's labor migration increases with drought and that land-poor households are most vulnerable. However, marriage-related moves by women decrease with drought, suggesting a hybrid narrative of environmentally-induced migration that recognizes multiple dimensions of adaptation to environmental change.

Keywords: migration, drought, climate refugee, event history model, Africa, Ethiopia.

Introduction

For agricultural and other natural resource-dependent households in the developing world, drought is an important negative shock that can undermine livelihoods and well-being despite the use of various coping strategies. In semi-arid countries of Sub-Saharan Africa, droughts are frequent and their effects are magnified by deep rural poverty, limited government capacity and exposure to additional political, economic and health shocks (Dercon et al. 2005; Kazianga & Udry 2006). Historical, qualitative and anecdotal accounts indicate that migration and population mobility have been a common response to drought, as falling agricultural and animal production pushes households and individuals to seek new opportunities elsewhere (Hugo 1996; Laczko & Aghazarm 2009). A growing concern is that climate change will magnify this process through increased rainfall variability, displacing millions of "climate refugees" (Myers 1997; Warner et al. 2009). These predictions have been widely cited but also criticized for relying on sparse documentation (e.g., Black et al. 2008), creating significant doubt as to the likely scope of the problem.

Fortunately, a small number of quantitative studies have recently provided new insight into these issues. These studies have combined large-scale household surveys, environmental data sources and multivariate methods to convincingly address the consequences of drought and other environmental factors for human migration (e.g., Massey et al. 2007; Gray 2009). These studies confirm the importance of drought for migration, but also indicate that household responses to drought are considerably more complex than is commonly assumed. Rural households have access to many strategies other than migration with which to respond to drought (Roncoli et al. 2001), and in some cases drought can actually reduce migration (Henry et al. 2004; Gray & Bilsborrow 2010).

We contribute to this literature by investigating the consequences of drought for population mobility in the rural Ethiopian highlands. This region is of particular interest given its endemic poverty, high population pressure on land resources and exposure to recurrent droughts (World Bank 2005). To address this issue we draw on a unique longitudinal household survey, the Ethiopian Rural Household Survey (ERHS), which has repeatedly interviewed 1500 rural households since 1994 (Dercon & Hoddinott 2009). We use data from the 1999, 2004 and 2009 rounds of the ERHS to construct mobility histories for 3,121 individuals, and then use discrete-time event history models to examine the effects of drought on mobility while controlling for baseline characteristics. This period encompasses two severe droughts, in 2002 and 2008. Expanding on previous studies, we build multiple measures of drought using survey and satellite data sources and also test for nonlinear effects, multiple temporal lags and interactions with other characteristics. To examine the gender dimensions of this process and the potential for multiple mobility strategies, we consider both labor-related and marriage-related moves and conduct the analysis separately for men and women.

Together, the results provide robust evidence that drought increases labor migration by men in Ethiopia but reduces marriage-related moves by women. Below, we interpret these results in the light of the Ethiopian cultural context and the ongoing debate about climate refugees. We conclude that this case provides support for an alternative narrative of environmentally-induced migration that recognizes the significant flexibility of rural households in their response to environmental change and variation.

Household Responses to Environmental Shocks and Drought

In the rural developing world, many households are reliant on natural resources for their livelihoods, including soil, water, plant and animal resources. Smallholder agriculturalists, such as those of highland Ethiopia, are particularly reliant on the timing and quantity of rainfall. Rainfall and other environmental factors tend to vary over time and space at a variety of scales in a manner not fully predictable by households, thereby potentially exposing them to environmental shocks such as drought which can undermine household well-being.

Fortunately, traditional resource use systems such as the grain and enset-centered agricultural systems of highland Ethiopia have been adapted over their long histories to repeated environmental shocks, and households can typically access a variety of strategies to both prepare for shocks (risk management strategies) and to respond to shocks (risk coping strategies) (Dercon 2002). Risk management strategies include asset accumulation, diversification of income sources, participation in risk-sharing networks, and adoption of low-risk activities. Risk coping strategies include sales of assets, intensifying livelihood activities or adopting new ones, use of formal and informal credit, reducing non-essential expenditures, reducing caloric intake, and drawing on social networks and public programs for assistance. Thus in highland Ethiopia, rural households prepare for drought by accumulating livestock, planting drought-resistant crops, and participating in traditional risk-sharing networks (Meze-Hausken 2000; Little et al. 2006; Dercon et al. 2008). They can also respond to drought by selling livestock, drawing on assistance from networks, delaying marriage, and accessing publically available food aid and food-for-work programs (Webb 1993; Ezra 2001; Caeyers & Dercon 2008).

Unfortunately, several problems commonly limit the utility of these strategies. Assets such as livestock are "lumpy" and cannot be subdivided, thus households may be reluctant to sell. Risk management strategies such as risk-sharing networks may have barriers to entry that exclude the most vulnerable. Additionally, when a common shock such as a drought affects a large area, the utility of risk-sharing networks is reduced and the value of assets may decline. Public assistance programs are often poorly targeted and late to arrive (Clay et al. 1999; Caeyers & Dercon 2008). Due to these limitations and to deep-seated poverty, many rural households are not able to fully insure against shocks such as drought and thus suffer significant reductions in well-being (Dercon

2002; Kazianga & Udry 2006). Gender and age biases can also magnify the effects of the shock for particular individuals within a household (Quisumbing 2003).

Drought and Migration

Given the limitations of these strategies for dealing with environmental shocks, an additional strategy that can be adopted by households or individuals is migration or local-scale mobility. In the rural developing world, the migration of an individual is often primarily a household-level decision, aimed at generating migrant remittances and reducing total consumption in the origin household (Stark & Bloom 1985). Migration allows diversification of income sources across space and often across sectors of the economy (Rosensweig & Stark 1989), and can help overcome capital market imperfections such as lack of insurance (Taylor & Martin 2001).

Nonetheless, migration as a coping strategy potentially suffers from many of the limitations described above: lack of access to capital or migrant networks can restrict participation (Curran & Rivero-Fuentes 2003; Vanwey 2005), and employment opportunities in nearby destination areas may also decline following a large-scale shock. Drought can also increase the costs of migration by making farm labor more valuable in the origin area, thus reducing the attractiveness of labor migration. Drought could also hinder marriage-related migration by reducing the availability of suitable marriage partners, inflating marriage costs such as dowries, and reducing access to the resources needed to finance a wedding (Rao 1993; Anderson 2003). For these reasons, drought could potentially reduce rather than increase both labor and marriage-related migration.

Previous Studies

Despite the theoretical potential of migration as a coping strategy, the high level of interest in “environmental refugees”, and abundant anecdotal evidence of environmentally-induced migration (Hugo 1996; Warner 2010), as of yet few multivariate studies have attempted to evaluate environmental influences on human migration. Scarcities of data on migration and environmental conditions in the developing world, as well as institutional barriers between environmental studies and the social sciences, have contributed to this lacuna. Fortunately, a small number of recent studies have successfully used survey and environmental datasets and multivariate methods to investigate these effects. This approach allows controls for a variety of other factors which have been shown to influence migration, including age, gender, education, access to resources and migrant networks (Massey & Espinosa 1997; White & Lindstrom 2005).

At least five previous studies using quantitative approaches have investigated the consequences of drought and rainfall for migration. In an early study using descriptive approaches, Findley (1994) showed that that total migration did not increase during a drought in Mali, but did shift towards short-cycle migration and moves by women and children. More recent studies have used multivariate methods. Munshi (2003) found that international migration from southwestern Mexico to the United States decreased with rainfall, which he attributed to increased origin-area opportunities in rainfed agriculture. Henry et al. (2004) revealed that drought in Burkina Faso increased rural-rural migration by men but reduced their international migration as well as the rural-urban migration of women. Badiani and Safir (2008) showed that, in six villages in rural India, temporary migration decreased with rainfall for agricultural households and increased with rainfall for wage laboring households. Finally, Gray and Bilsborrow (2010) found that droughts in Ecuador increased local and international migration but decreased internal migration, perhaps due to the relative poverty of most internal migrants. Together these studies are largely consistent with the idea that when rainfall increases agricultural opportunities in the origin area, migration decreases from agricultural households. Nonetheless the Burkina Faso and Ecuador cases provide interesting counterexamples where drought decreased migration, perhaps reflecting the lack of capital to invest in costly migrations.

Multivariate studies have also investigated the migratory response to large-scale natural disasters. Halliday (2006) showed that a large earthquake in El Salvador had negative effects on international migration, likely because international migrants returned to work in damaged areas. Gray et al. (2009) found that the Indian Ocean tsunami in Indonesia led to high rates of displacement, but that potentially vulnerable households were not disproportionately affected. In the very different context of the United States, several studies have also examined migration after Hurricane Katrina, revealing that poor and African-American households were disproportionately vulnerable to flood damage and long-term displacement (e.g., Stringfield 2009). These studies suggest that environmental shocks have complex effects on migration that are not fully consistent with the "environmental refugees" narrative: adverse environmental conditions often increase migration by vulnerable populations, but not always.

Ethiopia is of particular interest in the study of environmentally-induced migration because of its deep poverty and long history of environmental, economic and political shocks. Our research builds on three previous studies which have examined migration in Ethiopia in context of war, famine and shifting rights to land. Berhanu and White (2000) used retrospective migration data for the period 1960-1989 to show that rural-urban migration by women increased during periods of armed conflict but was not affected by periods of famine. Ezra and Kiros (2001) used a similar approach to show that rural out-migration from 1984-1994 was higher from communities that were perceived to be more vulnerable to shocks. Finally, de Brauw and Mueller (2010) used the ERHS data described below to show that rural out-migration increased with secure land tenure in an environment of changing land rights.

The Contribution of Our Study

Our study contributes to these literatures by drawing on a unique panel dataset that includes 1500 households from a large geographic area over a ten-year period. Building on the richness of this dataset, we contribute three important innovations to the study of environmentally-induced migration.

First, we consider marriage-related mobility separately from labor migration. As noted above, the processes underlying these two types of moves are likely to be quite different, but often they have been conflated or marriage-related moves have been ignored. Second, we examine these processes separately for men and women, which is important because marital arrangements (Fafchamps & Quisumbing 2005a) and labor participation rates differ significantly between men and women in Ethiopia (Quisumbing & Yohannes 2005). By doing so, we contribute to a growing number of quantitative studies which consider how gendered social structures influence the process of migration (Davis & Winters 2001; Curran & Rivero-Fuentes 2003).

Our third core innovation relates to the measurement of drought, which previous studies have measured primarily via annual rainfall totals from weather stations (e.g., Munshi 2003). This approach ignores the timing of rainfall, which is equally important from an agronomic perspective, as well as the detailed environmental knowledge held by rural households (Meze-Hausken 2004). Instead, we draw on household self-reports of drought, satellite measures of daily rainfall, and a model predicting self-reported drought in order to build three measures of drought and to test the robustness of our findings. This study thus adds to a small number of previous studies of migration which have drawn on both survey and spatial measures of environmental conditions (Gray 2009; Gray & Bilsborrow 2010).

The Ethiopian Rural Household Survey

Data collection

We use data from the Ethiopia Rural Household Survey (ERHS), a unique survey which has collected panel data from approximately 1500 households from 15 rural communities over a fifteen-year period. The communities were selected as a judgment sample intended to be representative of the rural highlands (Figure 1), and comparisons with the census indicate that the communities are similar to the rural highlands as whole (Dercon & Hoddinott 2009). [FIGURE 1 HERE] Data collection in the full set of fifteen communities began in 1994 and additional rounds were conducted in 1995, 1999, 2004 and 2009 by the International Food Policy Research Institute, Oxford University, and Addis Ababa University. Within the study communities, households were sampled through a stratified random sample, and then linked across rounds based on residence of the male head or, in his absence, the majority of household members. Attrition of the panel has been low at 1-2% of households per year (Dercon & Hoddinott 2009).

Data collection in each round included the implementation of a structured questionnaire in each sample household. This questionnaire collected information on demographic composition, assets, expenditures, agricultural activities, and other individual and household characteristics, and it retains many common elements across rounds. Previous studies using this dataset have investigated the consequences of shocks for household well-being (e.g., Dercon et al. 2005), participation in traditional risk-sharing networks (e.g., Dercon et al. 2008), and the impacts of development policies (e.g., Quisumbing 2003; Caeyers & Dercon 2008), among other topics. Our analysis, described below, draws on the 1999, 2004 and 2009 rounds and specifically on household histories of migrant departure and exposure to shocks collected in 2004 and 2009.

Study Areas

From an agroecological perspective, the study communities are characterized by rugged topography, temperate to subtropical climates with seasonal rainfall, and a dependence on smallholder agriculture as the primary livelihood strategy. The communities range in elevation from 1200 m to 2900 m and in mean annual rainfall from 470 mm to 1300 mm. Rainfall is highly seasonal, falling mostly during a summer *kiremt* season, the primary agricultural season, but in many areas also during a shorter spring *belg* season. Interannual variation in rainfall is also high, with droughts occurring in 1999, 2003, 2005 and 2008, as well as earlier and with disastrous consequences in the mid-1980's (EMDAT 2010). Government food aid and food-for-work programs have been put in place, but are not able to fully relieve the effects of drought (Clay et al. 1999; Caeyers & Dercon 2008).

Rural households are primarily dependent on smallholder agriculture, which is focused on the cultivation of grains in dryer areas (teff, barley, wheat, maize and sorghum) and on perennials in wetter areas (enset, coffee and khat) using animal traction or hoe plowing. Livestock are an important form of wealth, but the median household owned only the equivalent of two cattle in 2004. Following the nationalization of land in the 1970's, land legally belongs to the state but in practice is often held semi-privately (Deininger et al. 2008). The population pressure on land is significant and the median household cultivated only 1 ha in 2004.

From a cultural perspective, the study communities are diverse and retain many traditional practices, as described by the survey data and a series of ethnographies conducted in the 1990's (Bevan & Pankhurst 1996). More than ten ethnicities are represented in the sample as well as large numbers of Orthodox Christians, Catholics, Protestants and Muslims. Marriage practices differ significantly between ethnicities, but most commonly marriages are arranged by parents and both households provide gifts. The couple then moves to the husband's parents' household and later establishes an independent household drawing on land and livestock from the husband's family (Ezra 2003; Fafchamps & Quisumbing 2005b). Polygamous marriages and/or divorce are accepted in some contexts. Men are the primary agricultural laborers but women also participate in many agricultural tasks in addition to providing the majority of labor for home production. Agricultural work is also regularly shared through traditional labor-sharing and oxen-sharing practices, but agricultural wage labor also occurs. The burden of risks such as illness is also shared through traditional burial societies, saving associations, religious societies and kin networks (Dercon et al. 2008).

From a development perspective, the study communities are characterized by severe poverty, lack of infrastructure, and low levels of migration. In both 2004 and 2009, 35-40% of households reported that their food consumption had been insufficient in the previous month. Most homes are constructed of wood or mud with thatched roofs and dirt floors with a single sleeping area, and most communities do not have access to electricity, piped water or paved roads.

Additionally, most household heads have no formal education and very few participate in non-agricultural wage labor. Significant long-distance rural-rural migration occurred during armed conflicts in the 1970's and as part of state-led resettlement schemes during the droughts of the 1980's. However subsequent governments placed significant restrictions on rural-urban migration, and current rates of migration and urbanization are low (Berhanu & White 2000; World Bank 2005).

Analysis

Person-year dataset

To investigate the effects of drought on mobility, we used the survey data described above to build a longitudinal dataset on individuals at risk of migration. In the ERHS questionnaires, rosters collect information on both current household residents and previous household residents who have either departed or died, including on the timing and destination of departures. Using existing identifiers and a supplementary within-household age-sex match, we linked roster data on individuals resident in 1999 to roster data from the 2004 and 2009 surveys. We excluded one community (Sirbana Goditi), where individual identifiers were inconsistent across rounds. Individuals who were present in 1999 and were reported to have departed the origin household in 2004 or 2009 were considered to be migrants[1]. This definition encompasses many shorter-distance moves (e.g., within the community) than those traditionally considered to represent migration[2], but for the sake of consistency we refer to all moves as migration. Consistent with previous studies (Berhanu & White 2000; Ezra & Kiros 2001), migration occurred overwhelmingly among individuals aged 15-39 during the study period who were not the head of household or spouse of the head in 1999, and this population was defined to be at risk of migration.

---

[1] This definition excludes as migrants individuals who departed and then returned prior to the subsequent survey round as data their movements was not collected. However only 5% of migrants who departed prior to 2004 had returned by 2009, suggesting that the number of return migrants missed by this definition is low.

[2] Approximately 40% moves occurred to a destination "in or near the community". We also conducted analyses stratified by the distance of move and the results are similar to those presented here.

Individuals not at risk of migration were excluded from the analysis, as were those died in the interval, departed the household before age 15, or were lost to follow-up after 1999 (see *Attrition*). A small additional number were excluded who had missing data on the timing of migration. Following these exclusions, the dataset contains 1,667 adult men and 1,454 adult women at risk of migration, of whom 702 men and 711 women became migrants. This individual-level dataset was then converted into a person-year dataset in which each case is a year in the life of a person at risk for migration. Individuals enter the dataset in 1999 or when they turn fifteen years old, and leave the dataset when they migrate, turn forty years old, or are censored at data collection in 2009. Men contribute 9,268 person-years to the dataset and women contribute 7,435 person-years.

In addition to the dichotomous measure of migration defined above, migration was decomposed into a multinomial outcome based on stated motivation. Migration that was reported to have been motivated by employment was considered to be labor migration, migration associated with marriage was considered to be marriage migration, and other reasons for migration were combined into a category for other migration, which primarily included moves for schooling and to live with other family members. This decision was motivated by the observation that marriage-related moves accounted for a large proportion of moves, particularly among women (Table 1), and a desire to contribute to the small literature that has compared labor and marriage migration (Fan & Li 2002). [TABLE 1 HERE] Among the population at risk, men made 226 labor-related moves, 266 marriage-related moves, and 210 other moves. Women in turn made 108, 439 and 164 moves of these types respectively. Descriptive analyses reveal that labor-related moves by both men and women were primarily directed towards cities and towns outside of the district of origin, whereas marriage-related moves were directed primarily to rural destinations within the district of origin.

Predictors

The dataset contains time-varying and time-invariant predictors at individual, household and community levels (Table 2). [TABLE 2 HERE] To examine the influences of drought on migration, we constructed three measures of drought using the household survey data and satellite data on rainfall. Our primary measure of drought, drawing on the household survey, is the proportion of households in the community that reported exposure to a drought in the previous year (t-1), which we will refer to as reported drought. This measure draws on households' detailed knowledge of local environmental conditions and uses the proportion reporting drought as a measure of intensity. These values are multiplied by ten to produce a score that ranges from zero to ten; thus the mean value of 1.41 can be interpreted as 14.1% of households reporting a drought. These values peak in 2003 and 2008, with considerable variation in intensity across communities, which is consistent with other reports of drought intensity (EMDAT 2010) and with the dispersed locations and varying climates of the fourteen study communities. Given that most rain falls in the latter part of the Ethiopian year and migration can occur at any time of year, we select the previous year's rainfall (i.e., a one year lag) as the primary specification, but as described below we also relax this assumption to allow multiple temporal lags as well as nonlinear effects.

To confirm the robustness of the effects of reported drought, we also test the effects of two additional community-level measures of drought incorporating direct measures of rainfall. As complete data was not available for weather stations near the study communities, we instead draw on satellite measures of rainfall from NASA's Prediction of Worldwide Energy Resources (POWER) dataset, which provides global daily precipitation values at 1 degree resolution from 1997-2009[3] (White et al. 2008). These data were linked to the study communities using Global Positioning System points collected in the field. Three pairs of nearby communities were located in the same cells and thus received identical values. We summed rainfall values for July-October[4], the primary agricultural season, and then transformed these annual totals into a normalized index ranging from zero to ten that increases with drought[5], which we refer to as the rainfall deficit. The mean value of this measure is 5.06, and can be interpreted as representing rainfall at 94% of the community median. This measure is positively correlated with reported drought at $r = 0.29$ with $p < 0.001$.

---

[3] At the time of preparation, rainfall data were not yet available for September and October of 2009. We interpolated July-October rainfall for 2009 by dividing the July and August rainfall by its mean proportion of the July-October total.

[4] The Ethiopian calendar, used by the study communities and the ERHS questionnaire, is distinct from the Gregorian calendar and begins in early September. We consider the July-October rains to occur in the earlier year as most rain falls in July and August.

[5] Rainfall deficit = $(2- (rain_{tc}/median\_rain_c))*10-5$ where $rain_{tc}$ is the July-October rainfall in community c in year t, and $median\_rain_c$ is the median July-October rainfall in community c.

Finally, we also develop a third measure to address the potential limitations of both reported drought, which could reflect perception biases, and the rainfall deficit, which ignores the timing of rainfall within the rainy season. We created a household-year dataset and used logistic regression to predict household's reports of drought as a function of community fixed effects and monthly rainfall totals for the previous two years, allowing for a lag in the perception of drought. This approach uses the cross-community relationship between rainfall and reported drought together with community-specific measures of rainfall to predict the level of reported drought in each community-year. We refer to this value as predicted drought. It has a similar interpretation to reported drought and is highly correlated with it at $r = 0.86$ and $p < 0.001$.

In addition to these measures of drought, we also include several control variables at individual and household levels in order to capture their previously described effects on migration (White & Lindstrom 2005). Time-invariant controls, measured in 1999, include whether the individual was a child of the household head, gender of the household head, whether the head was an ethnic minority, whether a parent of the head was important to village social life, whether the head had formal schooling, size of the household, the number of migrants sent by the household between 1994 and 1999, agricultural land area, and the number of livestock owned by the household. These variables measure access to resources, economic and social status, and social networks in and outside of the community. Time-varying controls include age of the individual and whether the individual had children. The latter serves as a time-varying measure of marital status as a marital history was not collected. Finally, in a supplementary specification we also include measures of exposure to four additional agricultural shocks constructed in the same way as reported drought: exposure to flooding, problems with agricultural or animal pests, problems with access to agricultural inputs (including high prices), and problems selling agricultural products (including low prices). These were most common agricultural shocks experienced by households other than drought, and we include them to test for potential confounding of the effects of drought.

Event history models

To test the effects of drought on migration, we estimate a series of discrete-time event history models (Allison 1984). These models are appropriate to examine exposure over time to a single risk (dichotomous model) or to a mutually exclusive set of risks (multinomial model). The multinomial model includes one equation for each multinomial outcome beyond the reference category, in this case migration for labor, marriage and other reasons as defined above. To account for baseline differences in migration across communities, we include community fixed effects. To account for changes in the national context and for artifacts arising from the timing of the surveys, we also include year fixed effects[7]. In the multinomial model the log odds of experiencing a migration event of type *r* relative to no migration (event *s*) are given by

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

where π_{rit} is the odds of migration for reason *r* for individual *i* in year *t*, π_{sit} is the odds of no migration, α_{rt} is the baseline hazard of migration for reason *r* in year *t*, α_{rc} is the baseline hazard of migration for reason *r* in community *c*, X_{it} is a vector of predictor variables for individual *i* in year *t*, β_r is a vector of parameters for the effects of the independent variables on migration for reason *r*, and the reasons, *r*, are labor, marriage and other. In the dichotomous version of this model, all forms of migration are considered jointly.

All models include corrections for clustering at the level of the community to account for the non-independence of households in the same community and the use of community-level predictors (Angeles et al. 2005). For presentation, we exponentiate the coefficients of this model to produce odds ratios, which can be interpreted as the multiplicative effects of a unit increase in the predictor on the odds of the outcome relative to the reference outcome (i.e., no migration). Due to the inclusion of fixed effects for the community and year, these coefficients can interpreted as comparing two individuals who are exposed to the same baseline community context as well as the same national context that changes over time.

For each of seven specifications, we estimate both a dichotomous and a multinomial model for men and then separately for women. Model 1 presents the preferred specification including reported drought and the set of controls. Model 2 adds the additional measures of agricultural shocks. To test for nonlinear effects, Model 3 collapses the continuous measure of reported drought into dichotomous indicators for moderate and severe drought. Moderate drought was defined as 10-50% of households reporting drought, and severe drought was defined as greater than 50% of households reporting drought. Models 4-6 incorporate three different measures of

[7] The year fixed effects likely absorb some effects of droughts to the extent they were a nationwide phenomenon. Thus the drought effect is identified by exploiting between-community and between-year differences.

drought (reported drought, rainfall deficit, and predicted drought) and permit effects of drought from year *t* as well as from year *t*-1; additional lags beyond *t*-1 were consistently non-significant. Finally, Model 7 allows interactions between reported drought and the control variables.

Attrition

A common problem in studies using panel data is attrition or loss to follow-up. In our case, migration of individuals does not represent a loss to follow-up as departures are reported by remaining household members. However, attrition did occur in the form of the departure of entire households, individual migration that was not reported, and miscoding of individual identifiers across rounds. Among individuals in the 1999 data who were at risk of migration, 16% could not be linked to data from the 2004 and/or the 2009 rounds and were thus lost to follow-up. Among those lost to follow-up, 49% were part of whole households lost to follow-up, likely to due to migration of the entire household.

To examine whether loss to follow-up is likely to bias our estimates of the effects of drought, we estimated logit models of individual and household-level attrition as influenced by baseline characteristics, community fixed effects, and (for individual attrition) the number of droughts reported by the household during the study period[8] (results available upon request). Household attrition (i.e., the loss of an entire household) increased with education of the head and decreased with household size, consistent with the out-migration of small, well-educated households, but was not influenced by other baseline characteristics. Individual attrition (i.e., the loss of an individual from a remaining household) was lower for children of the head and higher from larger households, consistent with both migration and miscoding of individual identifiers, but was not influenced by other baseline characteristics. Individual attrition was also not influenced by the total number of droughts reported by the household for the 2000-2008 period, suggesting that our estimates of the effects of drought are not likely to be biased by attrition.

Results

The results of the preferred specification (Model 1), including odds ratios and significance tests, are presented in Table 3. [TABLE 3 HERE] Below we discuss the results for the control variables before moving on to discuss the effects of drought and interactions with drought.

---

[8] Given that the exact timing of attrition is unknown, we introduce this alternative household-level measure of drought to allow within-community variation in exposure to drought.

Control variables

Overall, effects of the control variables are consistent with previous studies from Ethiopia and, more broadly, with previous studies of internal migration in the developing world. Men's mobility increased after age 20, and for marriage migration peaked after age 30. Women's migration peaked at ages 25-29, consistent with their earlier age at marriage. For both men and women, mobility was lower for children of the head and individuals with children, reflecting the influence of ties to other household members, and increased with household size, reflecting competition for household resources. Social ties to the community, as measured by social importance of the head's parents, reduced migration as expected, specifically marriage migration by men and labor migration by women. Migrant networks, measured by the number of migrants prior to 1999, increased non-labor-related moves by women but did not affect other moves, consistent with previous studies showing that migration networks are particularly important for women (Davis and Winters 2001; Curran & Rivero-Fuentes 2003).

Additionally, members of ethnic minorities were more likely to participate in labor migration, potentially reflecting ethnic discrimination in rural areas or higher levels of entrepreneurialism by ethnic minorities (Mengistae 2001). Finally, wealth in the form of land and livestock had mixed effects on migration: land decreased labor migration, likely reflecting a reduced need for additional income, but increased "other" migration, perhaps due to increased opportunities for schooling in destination areas. Ownership of livestock similarly decreased labor migration by women but increased marriage migration by men, likely due to increased access to the resources needed to form a new household.

The effects of drought

The effects of drought in the preferred specification (Model 1) are repeated in Table 4, [TABLE 4 HERE] which also presents the results of multiple alternative specifications (Models 2-6). In Model 1, reported drought significantly increases overall migration and labor migration by men but does not affect other forms of migration by men. With a one unit increase in reported drought (equivalent to a 10% increase in the proportion of households reporting drought), the odds of overall migration by men increased by 11% and the odds of labor migration increased by 17%. This result is consistent with the expectation that drought will reduce livelihood opportunities in the origin area and thus promote labor migration, which as described above primarily targets cities and towns outside of the origin district. The finding that drought does not significantly influence men's marriage-related and other non-labor-related moves suggests that, for men, labor migration is the primary mobility response to drought.

Interestingly, however, the results for women are quite different. Women's overall migration and labor migration were not significantly affected by drought, but their odds of marriage migration decreased by 8% for each unit increase in reported drought. This result is consistent with the ethnographic finding, reported above, that households delay marriage in drought years, and also with the significant expenses associated with marriage. Given overlap in their household duties, women's marriage might also be delayed to substitute for the labor of male migrants who depart following a drought. That this effect is significant for women's marriage migration but not men's can be explained by the fact that, as mentioned above, their marriage migration commonly occurs at different times: women first move to the home of their father-in-law with large expenses by both households, and the couple later forms an independent household. In contrast to the effect for men, the effect of reported drought on women's labor migration was positive but non-significant, though this finding is not consistent across alternative measures of drought as described below.

Model 2 expands the predictors to include measures of four additional agricultural shocks: flooding, pest problems, problems accessing agricultural inputs, and problems selling agricultural outputs. For the most part, these shocks have weak and non-significant effects on migration. Pest problems weakly decreased labor migration and output problems weakly decreased marriage migration. However, input problems had a large positive effect on women's labor and marriage migrations. This may reflect a strategy to lower consumption when input costs are high by sending female migrants, but retain potential male migrants whose value as wage laborers might also be high during these periods. Critically, the inclusion of these shocks does not noticeably change the effects of drought on migration. Drought effects on men's migration become slightly less important and effects on women's migration become slightly more so, but the changes are very small. This result suggests that the effects of drought on migration cannot be accounted by other weather shocks or by correlated shocks to input and output markets.

Model 3 collapses reported drought into dichotomous measures of moderate and severe drought in order to test for nonlinear effects on migration. For men, the nonlinear specification is less significant by the joint test than the linear specification, though the results nonetheless suggest that most of the drought effects for men are accounted for by extreme drought. For women, the nonlinear fit is jointly more significant than the linear fit and becomes significant for overall migration. Women's overall migration and marriage migration were lowest under moderate drought, with non-significant negative effects from severe drought. This pattern suggests that household's precautionary reduction of female marriage migration during adverse years may not be sustainable during severe drought, when female labor migration and reducing consumption appear to take priority.

Model 4 again expands the original specification, this time by allowing effects of reported drought from year *t* as well as year *t*-1. This specification thus captures short-term migratory responses to drought as it is occurring (year *t*) as well medium-term responses to drought in the previous year (year *t*-1). The joint chi-squared tests show that this specification is a somewhat better fit than the original one. In the year of the drought (year *t*), men's overall migration again increases with drought, but due to increased marriage migration and other migration instead of labor migration. These forms of migration thus appear to serve as immediate responses to drought, with men perhaps moving to live with their wife's families or with other family members. Labor migration to more distant destinations is likely to be a more costly strategy that takes longer to mobilize. For women, marriage migration is reduced during the year of the drought as for the year after, and the negative effect on their overall migration also becomes significant.

Models 5 and 6 alter Model 4 by replacing reported drought with two additional measures of drought, rainfall deficit and predicted drought as defined above. The year *t* and year *t*-1 specification is retained to capture potential lags in how deficits in rainfall are perceived as drought. Overall, the effects of these two measures of drought are similar to reported drought, but there are a few notable differences. For men, the positive effect of drought in year *t*-1 on labor migration is robust across specifications, though the weaker year *t* effects do vary. For women, there remains a negative effect of drought on marriage migration, but for both rainfall deficit and predicted drought this effect is significant only in year *t* and not in year *t*-1. This may reflect mental "backdating" of droughts to include earlier dry periods that are picked up by reported drought but not by direct measures of rainfall. An additional notable difference for women is that the positive effects of past-year drought on labor migration become significant and similar to the effects for men. This difference may reflect a gendered perception of drought severity in which negative consequences for women are not given as much weight.

Overall, the results presented in Table 4 indicate that the effects of drought on migration are robust to alternative specifications. The positive effect of drought on men's labor migration is highly significant and consistent across models. A significant negative effect of drought on women's marriage migration is also evident in all models. Differences across models using alternative measures of drought suggest the importance of additional research on drought perception beyond the scope of this study (such as Meze-Hausken 2004).

Interactions with drought

To investigate whether drought affects the migration of some groups disproportionately, we also tested for interactions between reported drought and the control variables in the dichotomous model using the preferred specification (Table 5). [TABLE 5 HERE] Jointly, interactions were highly significant for both men and women. For men, increasing land area reduced the positive effects of drought but other interactions were not significant. For landless households the odds ratio of the effect of reported drought is 1.16, a positive effect, but for households with 2 ha of land (at the 80^{th} percentile of land ownership) the odds ratio is 0.94, a small negative effect. Land-poor households have fewer resources with which to cope with drought and fewer opportunities for on-farm diversification, and likely for these reasons more often send migrants following a drought year. By indicating that poor households are vulnerable to climate-induced displacement, this result is consistent with many previous discussions of "climate refugees" (Myers 1997). However, the story for women is quite different.

For women, drought has no effect on migration for the reference category but several characteristics significantly alter this relationship. The effect of drought is positive for women ages 30-49 and those in female-headed households, and also marginally so in households where the head has schooling. In contrast, the effect of drought is negative for women in households where the head's parents were socially important and marginally negative for women with children. These results indicate that older, childless women in households with a female or educated head and with few social ties to the community are most vulnerable to drought-induced migration. Overall, these individuals are similar to those who tend to migrate in non-drought contexts (Davis & Winters 2001; Curran & Rivero-Fuentes 2003), suggesting that drought simply displaces those with the highest underlying propensity for migration. Only the higher drought-induced mobility of women in female-headed households supports the theory of the most vulnerable being displaced by drought.

Conclusions

Our results provide robust evidence that drought has important consequences for rural out-migration in highland Ethiopia. After controlling for baseline characteristics as well as fixed effects and testing various specifications, it becomes clear that men's labor migration increases with drought and women's marriage migration decreases, with a difference in magnitude of roughly 2:1. Men from land-poor households are most vulnerable to this effect, presumably due to a lower ability to cope. This result supports the common observation that migration serves as a key coping strategy following drought. This finding is also consistent with a common narrative concerning "climate refugees" in which the vulnerable populations are viewed as most likely to be displaced (Myers 1997).

However the findings for women provide an important counter-example to this narrative. Following drought, households respond by reducing women's marriage-related mobility, consistent with ethnographic accounts but contrary to the common assumption that adverse environmental conditions will increase migration. This likely represents an effort to conserve resources by delaying marriages, which entail significant expenses for the households of both the spouse and groom. Susceptibility to drought among women is predicted by traditional predictors of migration rather than measures of vulnerability such as land poverty. This result reinforces the importance of considering gender dimensions of migration, and of considering forms of mobility other than labor migration.

Together these results contribute to a pattern that emerges from the small number of previous demographic studies of environmentally-induced migration: Adverse environmental conditions often, but not always, increase migration. Instead, consistent with migration theory, migration remains selective with important barriers to participation, and adverse conditions can actually reduce migration by undermining the necessary resources. The generality of this alternative narrative of environmentally-induced migration is now supported by several quantitative studies (e.g., Henry et al. 2004; Halliday 2006; Massey et al. 2007; Gray 2009), and should give policy-makers pause before they accept the common narrative of inevitable large-scale displacement occurring under future climate change (e.g., Myers 1997; Warner et al. 2009). Regarding Ethiopia specifically, a warmer climate with more variable rainfall would likely accelerate the effects described here, but current models project higher rainfall for highland Ethiopia under future climate change (De Wit & Stankiewicz 2006).

This study also has important implications for research methods in the field of environmentally-induced migration. Publications in this field are characterized by a very high ratio of review and theoretical papers to empirical analyses, with the former often arguing that there is no generalizable methodology for testing environmental influences on migration (e.g., Laczko & Aghazarm 2009). We disagree and hope that other investigators will take note of the approach described here and apply it in new contexts, improving our ability to generalize. We use data from an unique long-term panel survey with specific questions about environmental shocks and supplement with additional geospatial data, but important progress can also be made using shorter-duration panel surveys (e.g., Halliday 2006) and specially designed retrospective surveys of migration (e.g., Henry et al. 2004). In many contexts, however, new data collection will be required, and we hope that these concerns will inform a new generation of longitudinal surveys that increasingly take environmental factors into account.

References

Allison, P. (1984). Event History Analysis. Thousand Oaks, CA: Sage Publications.

Anderson, S. (2003). Why dowry payments declined with modernization in Europe but are rising in India. Journal of Political Economy 111(2): 269-310.

Angeles, G., D. Guilkey, & T. Mroz. (2005). The impact of community-level variables on individual-level outcomes: Theoretical results and applications. Sociological Methods and Research 34(1): 76-121.

Badiani, R. & A. Safir. (2008). Coping with aggregate shocks: Temporary migration and other labor responses to climatic shocks in rural India. Presentation to the European Society for Population Economics, Seville, June 11-13.

Berhanu, B., & M. White. (2000). War, famine, and female migration in Ethiopia, 1960–1989. Economic Development and Cultural Change 49: 91–113.

Bevan, P. & A. Pankhurst. (1996). Ethiopian village studies. Centre for the Study of African Economies. www.csae.ox.ac.uk/evstudies/main.html

Black, R., D. Kniveton, R. Skeldon, D. Coppard, A. Murata, & K. Schmidt-Verkerk. (2008). Demographics and climate change: Future trends and their policy implications for migration. Working Paper T-27. Development Research Centre on Migration, Globalisation and Poverty

Caeyers, B., & S. Dercon. (2008). Political connections and social networks in targeted transfer programmes: Evidence from rural Ethiopia. Center for the Study of African Economies Working Paper 2008-33.

Clay, D., D. Molla, & D. Habtewold. (1999). Food aid targeting in Ethiopia:: A study of who needs it and who gets it. Food Policy 24(4): 391-409.

Curran, S., & E. Rivero-Fuentes. (2003). Engendering migrant networks: The case of Mexican migration. Demography 40(2): 289-307.

Davis, B. & P. Winters (2001). "Gender, Networks, and Mexico-US Migration," Journal of Development Studies 38(2): 1-26.

De Brauw, A., & V. Mueller. (2010). Do limitations in land rights transferability influence low mobility rates in Ethiopia? Centre for the Study of African Economies Conference, March 21-23, Oxford.

Deininger, K., D. Ali, S. Holden, & J. Zevenbergen. (2008). Rural land certification in Ethiopia: Process, initial impact, and implications for Other African Countries. World Development 36(10): 1786–1812.

Dercon, S. (2002). Income risk, coping strategies, and safety nets. The World Bank Research Observer 17(2): 141-166.

Dercon, S., & J. Hoddinott. (2009). The Ethiopian Rural Household Surveys 1989-2004: Introduction. International Food Policy Research Institute.

Dercon S., J. Hoddinott, P. Krishnan, & T. Woldehanna (2008). Collective Action and vulnerability: Burial societies in rural Ethiopia. CAPRi Working Paper No. 83.

Dercon, S., J. Hoddinott, & T. Woldehanna. (2005). Shocks and consumption in 15 Ethiopian Villages, 1999–2004. Journal of African Economies 14(4): 559–585.

De Wit, M., & J. Stankiewicz. (2006). Changes in surface water supply across Africa with predicted climate change. Science 311(5769): 1917-1921.

EMDAT. (2010). The OFDA/CRED international disaster database [www.emdat.net]. Université Catholique de Louvain, Brussels, Belgium.

Ezra, M. (2001). Demographic responses to environmental stress in the drought- and famine-prone areas of northern Ethiopia. International Journal of Population Geography 7: 259-279.

Ezra, M. (2003). Factors Associated with Marriage and Family Formation Processes in Southern Ethiopia. Journal of Comparative Family Studies 34(4): 509-530.

Ezra, M., & G. Kiros. (2001). Rural out-migration in the drought prone areas of Ethiopia: A multilevel analysis. International Migration Review 35(3): 749-771.

Fafchamps, M., & A. Quisumbing. (2005a). Assets at marriage in rural Ethiopia. Journal of Development Economics 77(1): 1-25.

Fafchamps, M., & A. Quisumbing. (2005b). Marriage, bequest and assortive matching in rural Ethiopia. Economic Development and Cultural Change 53: 347–380.

Fan, C., & L. Li. (2002). Marriage and migration in transitional China: A field study of Gaozhou, western Guangdong. Environment and Planning A 34: 619-638.

Findley, S. (1994). Does drought increase migration? A study of migration from rural Mali during the 1983-1985 drought. International Migration Review 28(3), 539-553.

Gray, C. (2009). Environment, land and rural out-migration in the southern Ecuadorian Andes. World Development 37(2): 457–468.

Gray, C. & R. Bilsborrow. (2010). Environmental influences on out-migration in rural Ecuador. Paper presented to the Population Association of America, Dallas, April 15-17.

Gray, C., E. Frankenberg, T. Gillepsie, C. Sumantri & D. Thomas. (2009). Tsunami-induced displacement in Sumatra, Indonesia. Paper presented to the International Union for the Scientific Study of Population. Marrakech, September 27-October 2.

Halliday, T. (2006). Migration, risk, and liquidity constraints in El Salvador. Economic Development and Cultural Change 54:893–925.

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. Population and Environment 25(5): 423-460.

Hugo, G. (1996). Environmental concerns and international migration. International Migration Review 30(1):105-131.

Kazianga, H., & C. Udry (2006). Consumption smoothing? Livestock, insurance, and drought in rural Burkina Faso. Journal of Development Economics 79(2): 413-446.

Laczko, F. and C. Aghazarm. (2009). Migration, environment and climate change: Assessing the evidence. International Organization for Migration.

Little, P., M. Stoneb, T. Moguesc, A. Castrod, & W. Negatue. (2006.) 'Moving in place': Drought and poverty dynamics in South Wollo, Ethiopia. Journal of Development Studies 42(2): 200-225.

Massey, D., Axinn, W., & Ghimire, D. (2007). Environmental change and out-migration: Evidence from Nepal. Population Studies Center Research Report No. 07-615, University of Michigan.

Massey, D., & K. Espinosa. (1997). What's driving Mexico-U.S. migration? A theoretical, empirical, and policy review. American Journal of Sociology 102(4): 939-999.

Mengistae, T. (2001). Indigenous ethnicity and manufacturing success in Africa: Some evidence from Ethiopia. World Bank Policy Research Working Paper 2534.

Meze-Hausken, E. (2000). Migration caused by climate change: How vulnerable are people in dryland areas? A case-study in northern Ethiopia. Mitigation and Adaptation Strategies for Global Change 5: 379–406.

Meze-Hausken, E. (2004). Contrasting climate variability and meteorological drought with perceived drought and climate change in northern Ethiopia. Climate Research 27: 19–31.

Munshi, K. (2003). Networks in the modern economy: Mexican migrants in the U.S. Labor Market. Quarterly Journal of Economics 118(2): 549-599.

Myers, N. (1997). Environmental refugees. Population and Environment 19(2): 167-182

Quisumbing, A. (2003). Food aid and child nutrition in rural Ethiopia. World Development 31(7): 1309-1324.

Quisumbing, A. & Y. Yohannes (2005). How fair is workfare? Gender, public works, and employment in rural Ethiopia. World Bank Policy Research Working Paper No. 3492.

Rao, V. (1993). The rising price of husbands: A hedonic analysis of dowry increases in rural India. Journal of Political Economy 101(3): 666-677.

Roncoli, C., K. Ingram, & P. Kirshen. (2001). The costs and risks of coping with drought: livelihood impacts and farmers' responses in Burkina Faso. Climate Research 19: 119-132.

Rosenzweig, M., & O. Stark (1989). Consumption smoothing, migration, and marriage: Evidence from rural India. Journal of Political Economy 97(4): 905-926.

Stark, O., & D. Bloom. (1985). The new economics of labor migration. American Economic Review 75(2): 173-178.

Stringfield, J. (2009). Higher ground: an exploratory analysis of characteristics affecting returning populations after Hurricane Katrina. Population & Environment 31(1-3): 43-63.

Taylor, J., & P. Martin (2001). Human capital: Migration and rural population change. In Handbook for Agricultural Economics, ed. G. Rausser and B. Gardner. Elsevier Science, New York.

VanWey, L. (2005). Land ownership as a determinant of international and internal migration in Mexico and internal migration in Thailand. International Migration Review 39(1): 141-172.

Warner, K. (2010). Global environmental change and migration: Governance challenges. Global Environmental Change 20: 402–413.

Warner, K., C. Ehrhart, A. de Sherbinin, S. Adamo, & T. Chai-Onn. (2009). In search of shelter: Mapping the effects of climate change on human migration and displacement. www.ciesin.columbia.edu/documents/clim-migr-report-june09_final.pdf

Webb, P. (1993). Coping with drought and food insecurity in Ethiopia. Disasters 17(1): 33-47.

World Bank. (2005). Well-being and poverty in Ethiopia: The role of agriculture and agency. Report No. 29468-ET.

White J., G. Hoogenboom, P. Stackhouse, & J. Hoell. (2008). Evaluation of NASA satellite- and assimilation model-derived long-term daily temperature data over the continental US. Agricultural and Forest Meteorology 148(10): 1574-1584.

White, M., & Lindstrom, D. (2005). Internal migration. In D. Poston, and M. Micklin (Eds.), Handbook of Population. New York: Kluwer Academic Publishers.

Figure 1. Map of the study communities.

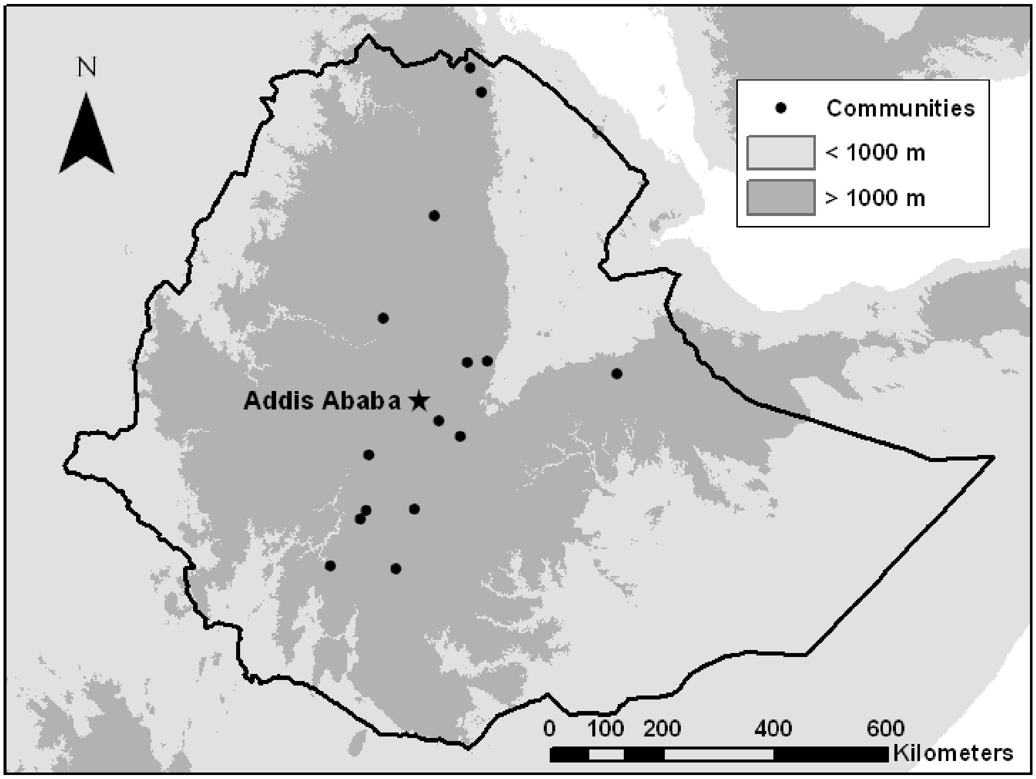

Table 1. Annual migration rates for men and women under varying levels of drought.

Gender	Type of move	Proportion reporting drought[1] Overall	<10%	10-50%	>50%	Chi-squared test[2]	Number of moves
Men	All	7.6%	7.2%	7.9%	9.5%		702
	Labor	2.5%	2.1%	2.5%	4.9%	+	226
	Marriage	2.8%	3.0%	2.8%	2.2%		266
	Other	2.2%	2.2%	2.5%	2.5%		210
Women	All	9.6%	9.9%	8.3%	10.4%		711
	Labor	1.5%	1.6%	1.1%	1.7%		108
	Marriage	5.9%	6.1%	5.3%	6.0%		439
	Other	2.2%	2.3%	1.9%	2.7%		164

[1] Proportion of households in the community reporting drought in the previous year.

[2] Chi-squared test of independence adjusted for community-level clustering; + p<.10, * p<.05

Table 2. Predictors for the regression analysis with person-year means.

Predictor	Unit	Level	Time-varying?	Mean	
				Men	Women
Controls					
Age 15-19	0/1	Individual	Yes	0.46	0.51
Age 20-24	0/1	Individual	Reference	0.31	0.27
Age 25-29	0/1	Individual	Yes	0.15	0.12
Age 30-49	0/1	Individual	Yes	0.09	0.10
Child of head	0/1	Individual	No	0.88	0.82
Has children	0/1	Individual	Yes	0.06	0.12
Female head	0/1	Household	No	0.26	0.26
Ethnic minority	0/1	Household	No	0.13	0.11
Parent socially important	0/1	Household	No	0.72	0.71
Head has schooling	0/1	Household	No	0.30	0.31
Household size	#	Household	No	7.40	7.41
Previous migrants	#	Household	No	0.42	0.41
Ln(land area+1)	ha	Household	No	3.56	3.27
Livestock units	#	Household	No	0.75	0.72
Shocks					
Reported drought *t* -1	0/1	Community	Yes	1.41	1.44
Reported drought *t*	0/1	Community	Yes	1.40	1.43
Moderate drought *t* -1	0/1	Community	Yes	0.25	0.26
Severe drought *t* -1	0/1	Community	Yes	0.07	0.08
Rainfall deficit *t* -1	0/1	Community	Yes	5.06	5.07
Rainfall deficit *t*	0/1	Community	Yes	5.75	5.72
Predicted drought *t* -1	0/1	Community	Yes	1.41	1.45
Predicted drought *t*	0/1	Community	Yes	1.44	1.48
Flooding *t* -1	0/1	Community	Yes	0.37	0.38
Pest problems *t* -1	0/1	Community	Yes	1.01	0.98
Input problems *t* -1	0/1	Community	Yes	1.26	1.31
Output problems *t* -1	0/1	Community	Yes	0.53	0.54

Table 3. Results from the event history analysis of out-migration (**Model 1**), including odds ratios and significance tests.

Predictor	**Men**				**Women**			
	Dichotomous	**Multinomial**			**Dichotomous**	**Multinomial**		
		Labor	**Marriage**	**Other**		**Labor**	**Marriage**	**Other**
Age 15-19	0.42 ***	0.44 ***	0.17 ***	0.70 *	0.36 ***	0.28 ***	0.31 ***	0.58 **
Age 25-29	1.76 ***	1.19	3.38 ***	0.96	1.32 ***	1.57 +	1.49 **	0.80
Age 30-49	2.17 ***	1.76	5.08 ***	0.94	0.66	0.99	0.59	0.72
Child of head	0.43 ***	0.49 ***	0.72	0.24 ***	0.61 ***	0.79	0.83	0.29 ***
Has children	0.26 ***	0.30 ***	0.17 ***	0.30 +	0.18 ***	0.11 ***	0.20 ***	0.17 ***
Female head	1.06	0.91	1.17	1.08	0.95	0.81	1.01	0.97
Ethnic minority	1.04	1.46 ***	0.90	0.80	1.09	2.27 ***	0.80 +	1.31
Parent socially important	0.85	1.05	0.74 **	0.83	0.87	0.61 *	0.92	0.97
Head has schooling	0.98	0.78	1.28 *	0.90	0.87 +	0.63 +	0.86	1.18
Household size	1.06 ***	1.04 +	1.02	1.10 ***	1.05 ***	1.14 ***	1.06 **	0.97
Previous migrants	1.06	1.01	0.96	1.30	1.24 **	0.83	1.25 *	1.58 **
Ln(land area+1)	0.99	0.66 +	0.90	1.59 +	1.00	0.48 **	0.94	1.71 **
Livestock units	1.04 **	1.03	1.10 **	1.00	0.97	0.91 *	0.97	1.01
Reported drought *t*-1	1.11 **	1.17 ***	1.02	1.07	0.99	1.11	0.92 ***	1.10
Joint tests								
Community fixed effects	5.E+03 ***	2.E+06 ***	3.E+05 ***	2.E+05 ***	4.E+05 ***	3.E+04 ***	4.E+05 ***	8.E+04 ***
Year fixed effects	39 ***	191 ***	106 ***	124 ***	226 ***	1417 ***	183 ***	208 ***
$N_{individuals}$	1,667				1,454			

Table 4. Results from the event history analysis of out-migration with alternative specifications of drought.

Predictor	Men				Women			
	Dichotomous	Multinomial			Dichotomous	Multinomial		
		Labor	Marriage	Other		Labor	Marriage	Other
Model 1								
Reported drought t-1	1.11 **	1.17 ***	1.02	1.07	0.99	1.11	0.92 ***	1.10
Joint test of drought	9.5 *	14.0 **	0.1	1.5	0.2	2.3	14.1 **	1.9
Model 2								
Reported drought t-1	1.10 **	1.13 **	0.99	1.09	0.98	1.09	0.90 ***	1.09
Flooding *t*-1	1.08	0.98	0.90	1.01	1.01	0.99	1.07	0.96
Pest problems *t*-1	0.83 +	0.70 *	1.07	0.88	0.96	0.70 +	1.02	0.94
Input problems *t*-1	0.99	1.01	1.08	0.92	1.11 ***	1.27 ***	1.12 ***	1.04
Output problems *t*-1	1.01	0.97	0.89 +	1.20 +	0.92	0.72 +	0.90 *	0.98
Joint test of drought	9.2 *	7.6 *	0.1	2.0	1.7	0.9	15.1 ***	1.4
Model 3								
Moderate drought *t*-1	1.19	1.11	1.27	1.12	0.74 **	1.22	0.63 ***	0.83
Severe drought *t*-1	1.79 *	2.15 **	1.20	1.62	1.02	2.81 +	0.79	1.35
Joint test of drought	5.0 +	8.0 *	0.7	1.5	10.1 *	3.6	17.0 **	6.9 *
Model 4								
Reported drought t-1	1.10 **	1.17 ***	1.01	1.07	1.00	1.11	0.93 **	1.10
Reported drought t	1.05 **	0.96	1.06 +	1.07 +	0.95 *	0.93	0.94 +	1.01
Joint test of drought	19.8 ***	17.1 **	3.2	4.9 +	6.5 *	3.4	36.1 ***	2.6
Model 5								
Rainfall deficit *t*-1	1.17 **	1.27 ***	0.98	1.18 +	1.02	1.33 **	0.94	1.02
Rainfall deficit *t*	1.14 *	1.06	0.99	1.32 **	0.93 *	0.96	0.88 **	1.08
Joint test of drought	7.4 *	30.1 ***	0.1	6.8 *	4.7 +	12.6 *	8.3 *	0.9
Model 6								
Predicted drought *t*-1	1.24 ***	1.38 ***	1.03	1.20 +	1.09 *	1.27 **	0.99	1.21 **
Predicted drought *t*	1.08	1.02	1.16 *	1.08	0.90 ***	0.93	0.89 **	0.97
Joint test of drought	24.8 ***	33.0 ***	8.2 *	3.8	23.0 ***	15.0 **	9.2 *	8.6 *
$N_{individuals}$			1,667				1,454	

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

Models also include other predictors plus community and year fixed effects.

Table 5. Results of the dichotomous event history analysis including interactions with drought (**Model 7**).

Predictor	**Men** **Dichotomous**	**Women** **Dichotomous**
Age 15-19	0.39 ***	0.37 ***
Age 25-29	1.81 ***	1.37 *
Age 30-49	1.92 *	0.57 *
Child of head	0.40 ***	0.52 ***
Has children	0.29 ***	0.26 ***
Female head	1.07	0.79
Ethnic minority	0.90	1.02
Parent socially important	0.84	1.00
Head has schooling	1.00	0.80 *
Household size	1.06 ***	1.06 ***
Previous migrants	1.07	1.24 **
Ln(land area+1)	1.15	1.04
Livestock units	1.06 **	0.96 +
Reported drought *t*-1	1.16 *	0.98
RDX Age 15-19	1.05	0.98
RDX Age 25-29	0.99	0.99
RDX Age 30-49	1.09	1.13 *
RDX Child of head	1.05	1.12
RDX Has children	0.93	0.70 +
RDX Female head	0.99	1.12 *
RDX Ethnic minority	1.08	1.03
RDX Parent socially important	1.01	0.89 **
RDX Head has schooling	0.99	1.06 +
RDX Household size	1.00	0.99
RDX Previous migrants	0.99	1.02
RDX Ln(land area+1)	0.90 **	0.97
RDX Livestock units	0.99	1.01
Joint tests		
Interactions	3820 ***	227 ***
Community fixed effects	1.E+04 ***	1.E+05 ***
Year fixed effects	49 ***	336 ***
$N_{individuals}$	1,667	1,454

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

RDX = Interaction with reported drought