How changing environmental factors interact with individual factors to influence migration behavior in environmentally precarious communities

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Abstract

Subsistence farmers in Sahelian Africa are highly vulnerable to the environmental effects associated with climate change. In response to climate variability and subsequently agricultural insecurity, permanent or temporary out-migration can provide an effective mitigation strategy. While climate-migration literature among rural farming communities is growing, questions remain about which climate processes drive individual- or family-level migration decisions. To this end, we examine individual- and community-level responses using detailed migration histories of 3,150 individuals in two villages in Mali. We focus our attention on features of each potential migrant – including the migration histories of each individual. We leverage fine-scale climate data to produce indices of precipitation, temperature, and drought. The migration data are adequately detailed to enable analysis of how within season climate variability, e.g. heatwaves and drought, influence individual out-migration decisions.

Introduction

Warming and drying represent the most direct impacts of climate change on families and communities, most significantly those reliant on rainfed agriculture to meet their food and nutrition needs (IPCC 2013, Brown et al. 2015). Subsistence communities in rural Sahelian Africa, where rainfall is inconsistent and temperatures reach extremely high levels, face notable agricultural, health and livelihood challenges associated with climate change (Grace et al. 2015, Davenport et al. 2017). In these contexts, and for these communities, seasonal rainfall is vital for producing the required food needed to meet the family's nutritional and caloric needs. If the rains are inadequate then household food production is constrained, putting the health and security of families at risk.

Out-migration is an increasingly common coping strategy for livelihood diversification in subsistence communities. In this, community members leave their resource-constrained community to search for other income earning opportunities, or to reduce the needs of the community. Though it is intuitive that out-migration is linked to the environmental conditions of a community, empirical results suggest that this linkage is highly variable (Grace et al. 2018, for example). Additionally, how communities who already rely on seasonal short-term migration adapt to extreme weather events is not understood. More broadly, migration theorists suggest that the livelihoods diversification framework in its common usage is flawed and overly simplistic (Carr 2005, Gidwani and Sivaramakrishnan 2003).

Data limitations are a major challenge in undertaking quantitative migration studies in developing world settings, particularly amongst subsistence populations where short-term (circular) migration strategies are routine. Environmental characteristics must be of an appropriate spatial and temporal scale to correspond to the migration patterns of interest. In other words, small, but important, changes in rainfall or temperature can be difficult to detect if the data are aggregated over time (monthly or seasonal averages) or if broad spatial averages are used. Similarly, migration data must be available for a suitably long period and provide information on destination to provide confidence in one's analysis of the features motivating migration. These data requirements likely explain the paucity of scientific investigations of migration behaviors in communities where circular migration is an institution (Grace et al. 2018, Castles 2010).

In this paper, we investigate out-migration in rural Mali, one of the poorest and most climatically sensitive areas in the world. We aim to investigate the individual out-migration experience as it relates to temperature and rainfall variability in two relatively homogenous villages using detailed migration histories covering 1980-2008, a period of 29 years. This period contains one of the most extreme droughts in the history of modern Sahelian Africa (the drought of 1984), as well as periods of less severe water shortages and heat waves, and periods of adequate and relatively consistent rainfall and temperate summers. In an effort to advance scientific understanding of the complexities of migration, we focus our attention on a variety of different features of each potential migrant – including the migration histories of each individual. These data also contain information on the destinations of the migrations. We use fine-scale site-specific rainfall and temperature datasets to construct indices of rainfall, temperature and soil moisture stresses (see Grace et al. 2018, Mueller et al. 2014, Vincente-Serrano et al. 2010) as separate but related drivers of out-migration. For example, we can identify periods of extreme heat and dryness versus periods of extreme heat and rain and investigate if these different environmental conditions influence the risk of out-migration. Given that in the communities under study nearly every adolescent or young adult out-migrates (including many of the unmarried girls and women), we can explore the characteristics of migrants at the time of each out-migration as well as the characteristics of each migration. We can also consider the characteristics around the individuals who stay in place rather than leave the villages.

Study Site

The study population is in the Bwa ethnic region of Southeast Mali, about 450 kilometers from Bamako, close to the Burkina Faso border. The population relies on family-based agricultural production (mostly food crops) grown during the relatively short rainy season (June-September). Reproductive behavior has not yet changed and fertility remains high, at about eight children per woman and nine children per man (Hertrich et al. 2012b). Migration is common, but mainly within Mali or to neighboring countries. There is no culture of migration to Europe. Schooling was developed in the 1990s but is still limited, with around half of children attending primary school by the end of the 2000s. The area is very homogeneous, with little socio-economic and cultural variation between villages and families. The cultural and economic homogeneity of this population facilitates an investigation of migration as a response to climatic variability over time.

Data

Population data: Our data are based on a longitudinal project, SLAM (Suivi Longitudinal au Mali[1], Hertrich, 1996), implemented in the late eighties (1987-89) and updated every five years, the latest being 2009–2010. We use an exhaustive life history survey carried out in two villages (1,750 inhabitants in 2009), which recorded the matrimonial, reproductive, migratory and

[1] http://slam.site.ined.fr/

religious histories of men and women of all ages. Migration histories were recorded from birth until the last round of the survey (Lesclingand 2004; Hertrich and Lesclingand, 2012a). Any migration lasting longer than three months was recorded. The fine temporal scale allows for the inclusion of short-term, seasonal and circular moves, which are common in Western Africa (Hulme 2001). Information regarding destination and reason for out-migration are also included, as well as various data on the context of migration and family involvement. During each round of the survey, the biographies previously recorded were updated, and those of new residents, i.e. immigrants and the children born since the last visit, were recorded. For emigrants, the information was obtained from relatives, up to the first marriage for women, and up to the current survey visit for men.

Our analysis focuses on the individuals interviewed as residents during at least one of the SLAM visits, between 1988 and 2010 (about 3,150 individuals). The use of these longitudinal data limits the bias inherent to retrospective surveys; indeed the only emigrants not included in our analysis are those who left before 1988 (first survey) and have not returned to the village since that date. An under-estimation of emigration potentially arises in the period before 1988 and may result in a bias of trends that complicate comparisons of emigrations before and after this period. However, two data-quality analyses suggest that these limitations do not prevent an analysis of emigration using the data. First, a large majority of male emigrations[2] are temporary, meaning that the emigrations before the first survey (1988) that did not end before the last round of the survey (twenty years into the future (2009-10)), represent a minority. We assume these extended absences make up less than 10% of emigrations[3]. Second, a detailed study examining emigrants through genealogical data (Hertrich and Lesclingand, 2012b) provides evidence that the bias does not significantly affect the trends in emigration during adolescence and the beginning of adulthood, the ages with the highest concentration of migrations.

Environmental Data

Rainfall data: We use the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) dataset (Funk et al. 2014a), which was recently developed by USGS scientists in collaboration with Climate Hazards Group at University of California at Santa Barbara. The CHIRPS dataset combines a high-resolution (0.05°) climatology (Funk et al. 2012; Funk et al. 2015) with time-varying station data and observations from geostationary weather satellites. USAID supported research projects use CHIRPS for monitoring and forecasting rainfall across Africa (Funk et al. 2014b).

Temperature data: We use the maximum temperature dataset developed by the Terrestrial Hydrology Research Group at Princeton University (Sheffield et al. 2006). These temperatures are available at 0.5-degree spatial resolution and daily temporal scale, which facilitate the analysis of within-season variability. Given the relative homogeneity of temperatures over sub-Saharan Africa, the spatial resolution is adequate to represent local conditions. These data have

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[2] The situation is different for women who move when they get married to join their husband's families. The survey does not follow women's emigration after they get married, making it difficult to rigorously compare men's and women's migration into adulthood.

[3] Among male emigrations registered since 1988 (and controlling for the time of observation), about 60% of emigrations last less than 1 year, 80% are completed within 4 years, and 16% last at least 8 years.

been used extensively in West Africa (Odoulami et al. 2017; Wang et al. 2017; Ahmed et al. 2017; McNally et al. 2017), and are deemed representative of historic conditions.

Soil moisture data: We use the Standardized Precipitation-Evapotranspiration Index (SPEI) dataset (Vincente-Serrano et al. 2010) to develop an index of drought. We interpret the SPEI as a measure of drought because it is a representation of the climatic water balance, thus water availability, in a region. The SPEI is available online at 0.5-degree spatial resolution, with time scales ranging from one to 48 months. The time scale represents a moving window over which the climatic water balance (SPEI) is computed. For this application, we utilize the 12-month SPEI data product, consistent with previous analyses (e.g., Mueller et al. 2014, Paulo et al. 2012, Hernandez & Uddameri 2014).

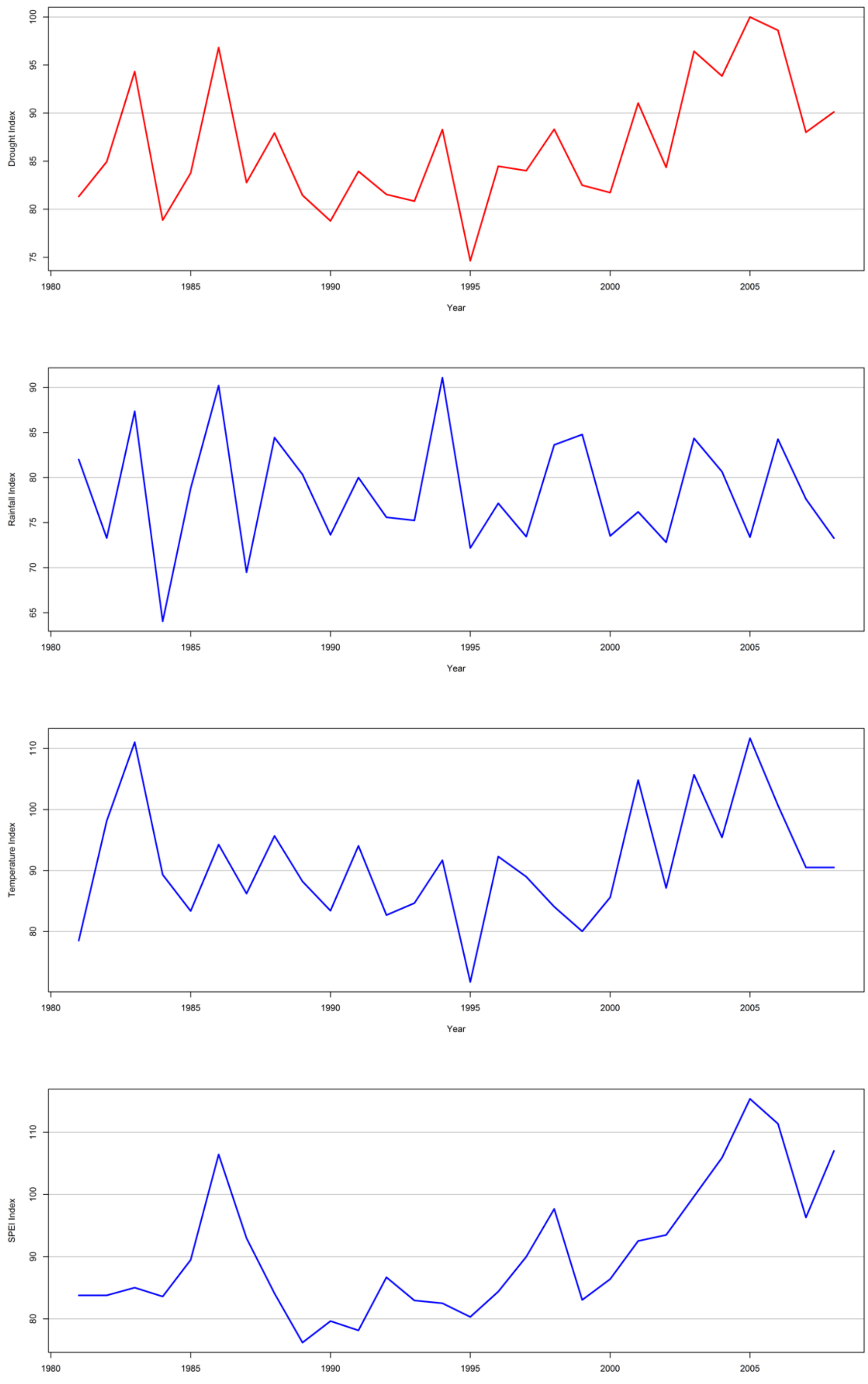
Measures and Methods

We first develop a series of environmental index variables designed to capture conditions correlated to either a failed agricultural season or climate stressors that might create a perception of the possibility of a failed agricultural season. These indices are developed using the fine-scale temperature and rainfall datasets listed above and are then matched to out-migration experiences using different temporal lags (how long after the climatic event are people "pushed" to out-migrate?). The indices will reflect within season variability as well as the potential for the previous year(s) to influence an individual's or household's perception of the current year's years condition's. In this way we can explore the potential for individuals to be pushed to out-migrate because of a sequence of poor quality years or because of a single poor year, for example.

As part of this, we will also explore the combined impact of poor rainfall, hot conditions and low soil moisture, for example. To demonstrate, in Figure 1 a composite indicator that averages SPEI indices with rainfall and temperature indices can be used as a measure of drought.

We use these index measures as independent variables in a series of different types of regression models. Additional independent variables are used to control for an individual's age, the time of the out-migration event, the history of out-migrations (e.g., to compare the changes in out-migration duration or destination), and the destination of the outmigration. Dependent variables will reflect the risk of an individual out-migrating (using event-history analysis and statistical analyses for recurrent events). We will also investigate the characteristics of individuals who have left the village and those who stay under certain conditions.

Figure 1: Example of different indices capturing different dimensions of climatic context over time in Malian study site



Anticipated Results

Preliminary results have highlighted the complexity in responses to climatic events when using a rainfall measure designed to capture within season variability as well as year to year variability. Low rainfall years do not necessarily correlate to increased out-migration but may correlate with more people staying in their communities (see Grace et al. 2018). The research, however, has not yet incorporated other measures of climatic variability like temperature and soil moisture. The highly detailed migration data combined with the highly detailed climate data that capture a range of different climatic conditions, allows us to better investigate the aspects of the environmental context that contribute to changing migration behaviors.

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