Descriptive Analysis of the Individual Migratory Pathways According to Environmental Typologies

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This study tests the influence of environmental changes on migration in Burkina Faso. It describes individual migratory pathways in the 1960–1999 period in Burkina Faso, using environmental typologies of origins and destinations based on rainfall variations and land degradation. The study links data from a national longitudinal (retrospective) survey with fine resolution rainfall data and land degradation data. Results suggest that environmental factors influence, but in different ways, both the probability to out-migrate and the selection of a destination once the migration decision has been made. Migration seems to be more influenced by a slow-acting process such as land degradation than by episodic events such as droughts.

KEY WORDS: migration, land degradation, desertification, Burkina Faso, environmental refugees, drought.

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INTRODUCTION

The meagre literature dealing with the effects of the environment on migration is divided between the minimalist view, for which changes in the natural environment is just a contextual variable that may influence human movements, and the maximalist view, for which environmental degradation is causing large migrations (Suhrke, 1994). Migrations could be caused by environmental change through changes in structural economic conditions (e.g., a reduction of average income), risk effects (by increasing the instability of income) or social effects (by positive or negative environmental externalities) (Bilsborrow, 1991). Migration may be viewed as being just one coping strategy among others (Bates, 2002; Findley, 1992; Suhrke, 1994).

Some authors have put forward the concept of ''environmental refugees'' (Bates, 2002; Hugo, 1996; Kibreab, 1994; NewScientist, 1989; Ramlogan, 1996). The 1951 United Nations Convention on the Status of Refugees and Stateless Persons specified that, to be a refugee, ''the person has to be outside his or her country of origin for reason of persecution based on his or her race, religion, nationality, membership of particular social group or political opinion.'' (Refugee Convention, UNTS No. 2545). In the Convention, internal migrations were not included. The notion of ''forced migration'', as opposed to voluntary movements, helped authors to make the distinction between environmental refugees and environmental migrants. Hugo (1996) and Bates (2002) identified a continuum with forced migration of environmental refugees on one end of the spectrum, voluntary movement by migrants on the other end, and environmental migrations at the centre. Many migratory flows are not easy to classify in one of these categories. As mentioned by Bates (2002, p. 467), as an example: ''Refugee flows usually contain anticipatory refugees. These people recognise that their local situation will eventually deteriorate and have the ability to relocate before they are forced to do so.''

The problem of using the term ''environmental migration'' comes from the various causes of environmental change. The concept encompasses, on one hand, natural disasters (volcanic eruption, floods, earthquake, etc.) producing an unintentional migration and, on the other hand, the gradual deterioration of environmental conditions caused by factors endogenous to the local population and which contributes to migration decisions. Bates (2002, p. 473) distinguished between the two forms: ''disaster and expropriation refugees have limited control over whether environmental changes will produce migration. In contrast, environmental emigrants determine how they respond to environmental change.'' An appropriate response is facilitated by the fact that the impact of land degradation is gradual (Suhrke, 1994).

A large part of the literature on environmental refugees or migrants aims at quantifying their number. Hugo (1996) reported that a million environmental refugees were pushed by the drought of 1968–1973 in Burkina Faso alone. Myers (1997) wrote that, worldwide, there are about 25 million environmental refugees, mainly located in Sub-Saharan Africa and claimed that this figure can be doubled by 2010. He added that 135 million people were already threatened by severe desertification and thus would migrate in the near future. All these estimates must be taken with caution however because the concept is vague, and the literature suffers from a lack of detailed case studies which would have measured precisely the size of flows.

In Burkina Faso, the 1974–1975 National Migration Survey attempted, among other things, to study the impact of the early 1970s drought on migration (Coulibaly, Gregory, & Piché, 1980). Among the people who migrated between 1969 and 1975, less than 10% declared that they experienced a lack of water or food. Among the non-migrants, only 12% declared that they did experience a drought in their village in 1975. Few estimated that the drought pushed people to leave. However these survey results should be taken with caution given inherent biases in the replies to a question on the motives of migration (men generally respond that they migrate to earn more money or because crop yields are too low, and women that they migrate for family reasons). Motives declared by respondents could be different from the underlying factors influencing their migration. Some motives announced by migrants could be an indirect consequence of droughts, such as the reduction in savings or a decline in crop yields. In the current study, rainfall data were used to define drought conditions, independently of the motives of migration declared by migrants or of external classifications. Using an accurate definition of rainfall variability, a previous study in Burkina Faso showed indeed that migration is associated with rainfall anomalies within the season and drought frequency in provinces at the origin (Henry, Boyle, & Lambin, 2003).

During the famine following the 1972–1973 drought in northern Nigeria, Mortimore (1989) showed that the number of villages reporting out-migration jumped from 26 to 43% and a further 51% reported empty houses whose owners were still expected to return. Using data from a longitudinal panel study conducted in 1982 and 1989 in Mali, Findley (1992, 1994) demonstrated that the level of migration did not rise during the drought of 1983–1985. However, there was a dramatic increase in the migration of women and children and a shift to short-cycle circulation during the severe drought. De Bruijn and Van Dijk (2003) studied the rural-rural migration of pastoral Fulbe families in three districts in Mali. They observed an individualised pattern of migration, motivated by economic and ecological factors. Since the onset of the droughts, many families and many young men left their village in the studied districts.

Concerning land degradation, Thapa and Bilsborrow (1995) indicated that in Nepal, some settlers sold their allotted land to purchase better quality land elsewhere (Kansakar, 1985). Ezra and Kiros (2001) used a household survey carried out in the drought-prone and ecologically degraded rural areas of Ethiopia to study rural out-migration over the 1984–1994 period. A multi-level analysis was performed by introducing, among other variables, the community's vulnerability to food crisis in the regression model. The results showed that this variable contributes significantly to out-migration to assist relatives. Migration for marriage was considerably lower during the famine year than in any other period. However, the environmental variable used in this study was very simple and based on an assessment by local institutions, which is probably different from the assessment by migrants of their environmental hardship. Moreover, the vulnerability assessment cannot be assumed to be equally applicable to all regions in Ethiopia.

In sum, the few previous studies on the impact of land degradation on migration suggest a slight and geographically limited influence. There is some empirical evidence on the influence of drought on migration but the migratory response does not take a unique form. However, these empirical evidences are limited by a lack of appropriate data. Either these studies were confined to a small geographical or ethnical area, or the definition of the environmental variable(s) was very simple. Often, only one drought event was studied, therefore missing the cumulative aspect of the influence of environmental conditions on migration.

The aim of this study was to test the impact of the natural environment on migration in Burkina Faso. It describes the individual migratory pathways in the 1960–1999 period, in Burkina Faso, based on an environmental typology of origins and destinations. This typology includes environmental conditions related both to rainfall variations and land degradation. The study tested two hypotheses. The first one concerns the conditions at the origin (push factors): individuals who lived in an area with unfavourable environmental conditions were quicker to quit their residence than individuals who lived in an area with favourable environmental conditions (hypothesis 1). This hypothesis was tested by using "the survivor function" methodology (as explained below). The second hypothesis concerns the conditions at the destination (pull factors): migrants choose proportionally more often areas with favourable environmental conditions than areas with unfavourable environmental conditions for their destination (hypothesis 2). This hypothesis was tested by using the ''conditional probability'' methodology (as explained below). Each of these two hypotheses was tested first for environmental conditions defined according to climatic variables, and second according to land degradation data.

STUDY AREA

Burkina Faso has a gradient of environmental conditions, from the Sahelian environment in the North where rainfall is sparse and irregular, and soils are poor, to the southwestern region where rainfall is higher and more regular, and where soil conditions are much more favourable for agriculture. The population distribution does not match environmental suitability for agriculture: the centre-north plateau is densely populated while the southwestern region has a lower density of settlements. Some authors (Gray, 1999; Mathieu, 1998; Tallet, 1993) argue that a large migratory movement is taking place from the former area to the latter, mostly to cultivate cash crops (cotton). Migrants were also encouraged by a national resettlement programme, the 'Aménagement des Vallées des Voltas' (AVV) developed in 1974, to occupy the valleys of the Volta rivers which had been freed from onchorcercosis (Cordell, Gregory, & Piché, 1996; Ouédraogo, 1986). This ''river blindness'' disease has been prevalent in the savannah regions of Burkina Faso, Benin, Ivory Coast, Ghana, Niger and Togo, and has been largely eradicated.

Since 1960, Burkina Faso experienced two severe droughts during 1968–1973, and 1983 to 1985 (Hulme, 2001; Nicholson, 2001). Droughts in the Sahelian region allegedly amplified large-scale migratory flows from the dry zone to the coastal areas (Makinwa-Adebusoye, 1995). The decrease in soil productivity is also generally assumed to be a determinant of migration. Farmers from the Mossi ethnic group for example, experiencing severe land degradation due partly to inappropriate agricultural practices, are widely believed to migrate to search for more fertile land (Mathieu, 1993).

However, the reality of land degradation in Burkina Faso remains contested. On the basis of an assessment by regional experts (the GLASOD map, in Oldeman, Hakkeling, & Sombroeck, 1990), a large part of the country was considered to be degraded, mostly in the centre-north plateau. Recently, Niemeijer and Mazzucato (2002) suggested that neither agricultural soil productivity, calculated as the total energetic value per hectare produced by all major food crops, nor soil chemical fertility had significantly declined over the last few decades in Burkina Faso. Only a loss of organic matter was found for lowland soils. Nevertheless, empirical data on land degradation are sparse and it is difficult to identify consistent processes of land-cover change from time series of data. For example, in the landscape of vegetation-fixed dune systems in northern Burkina Faso, Lindqvist and Tengberg (1993) used aerial photographs and satellite images to reveal severe land degradation, which occurred mostly during the late 1960s. More recently, these areas experienced a recovery of vegetation with a change in species composition (Rasmussen, Fog, & Madsen, 2001).

In terms of population, Burkina Faso counted 10,312,609 inhabitants, with 51.8% of female and 47.9% of children younger than 15 (according to the population census survey of 1996, INSD, 1998). In 1996, Burkina Faso counted 45 provinces and 351 departments where about 30,000 inhabitants lived (Figure 1). Provinces around Ouagadougou, the capital, are densely populated (more than 50 inhabitants per km^2) and the country experienced large disparities in population density. Burkina Faso has always been characterised by important migratory dynamics (Cordell et al., 1996). Results from the census of 1985 (INSD, 1990) showed that 4% of the population migrated during the preceding year. International migrations, principally to the Côte d'Ivoire, mostly involved young men hoping to gain a maximum of money in a short period of time (Cordell et al., 1996). According to the 1996 population census survey, Burkina Faso has an increasingly negative migratory balance, compared to the previous population census survey in 1985 (INSD, 2000). Internal migrations were principally directed to a rural destination (78% of migrants in 1985). Flows to urban areas were concentrated toward the two largest cities, Ouagadougou and Bobo-Dioulasso.

DATA

Reliable national scale data on demographic, socio-economic and biophysical factors, collected for consistent geographical units and over similar periods of time, are rarely available in Africa; Burkina Faso is an exception. This study was based on a large longitudinal and national-scale demographic survey coupled with the most current rainfall and land degradation data.

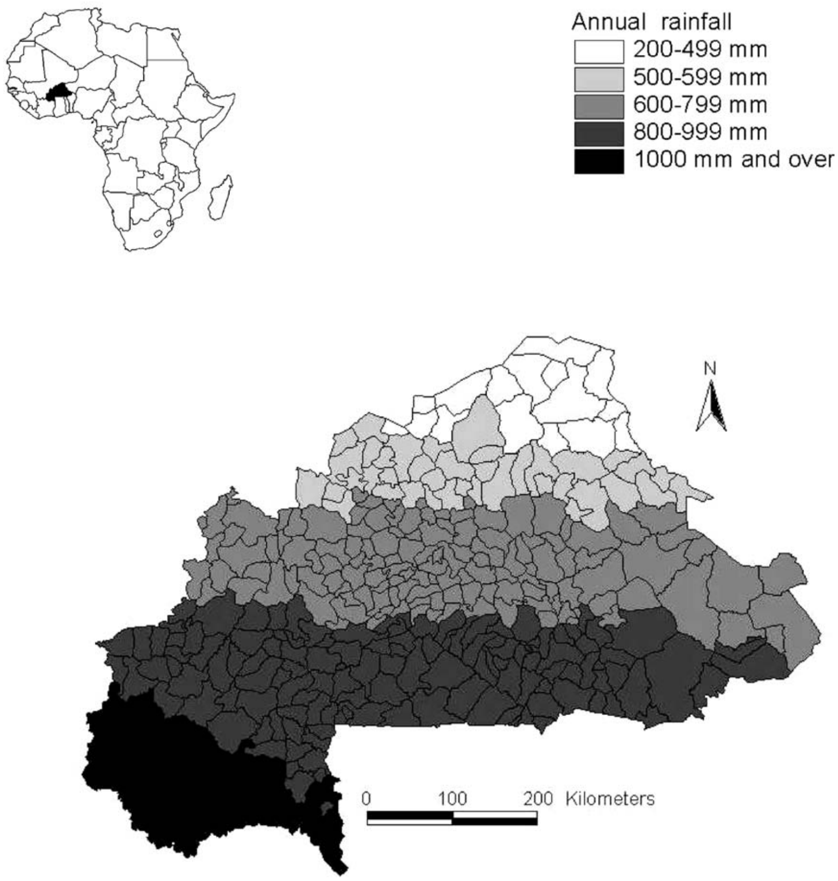

FIGURE 1. Map of Burkina Faso showing mean annual rainfall at the department level, 1960–1998.

Demographic Data

Migration data come from a large survey conducted by the Unité d'Enseignement et de Recherche en Démographie (UERD, Burkina Faso), the Centre d'Études et de Recherches sur la Population pour le Développement (CERPOD, Mali) and the Université de Montréal (UdeM, Canada) during the first semester of 2000 (Poirier et al., 2001). Households (3570) were sampled in eight strata: five rural regions (the Sahel, the East, the West, the Southwest and the Centre) and three cities (Ouagadougou, Bobo-Dioulasso and

Banforah). These strata were chosen according to geographic, climatic and ethnic criteria and by respecting the provincial division. From these households, each individual between 25 and 64 years old, and one individual in every two for the age bracket of 15–24 years old were interviewed. The reason to proceed in this way is to take into account the relatively large weight of the youngest age group in the Burkinabé population (15–24), as well as their highly censored biography. A total of 9612 biographies were collected by retrospective survey, including the emigrants of the households for whom information is limited. This information was given by the other household members.

The household questionnaire included questions on the characteristics of household members (sex, age, place of birth, ethnic group, education, economic activity, etc.), characteristics of household emigrants (sex, age, date of departure, destination, activity, instruction, etc.), housing and household's economic situation (type of parcel, occupation status of the household, etc.), household's environment (water, cesspool, etc.) and household expenses for cooking fuel (in urban areas only). The biographic questionnaire covered family origins and childhood (sex, age, place of birth, etc.), residential mobility (date and place of installation, status of residence, land access, purpose of migration, etc.), economic activities (instruction level, activity status, etc.), matrimonial history (union, celebration, husband, etc.), birth history (number of children, child-death, contraception, etc).

The present study was based on the questions related to residential mobility. Each residence of more than 3 months since the 6th birthday of the individual was registered. For this study, the definition of a migration was restricted to an inter-departmental change of residence of more than one year. Population movements of less than one year were not analysed to minimise the bias related to the memory of the individuals. Actually, we assume that it is easier to remember long lasting compared to temporary movements. Note that migrations of more than one year concerns 94% of all recorded movements.

The migration age was also limited from 20 to 40 years old, to exclude movements of children following their parents. After the age of 40, the study was constrained by the small number of cases, as migration is less frequent after this age. Migrations with the aim of studying were excluded because these movements are unlikely to be influenced by environmental conditions. Finally, this study was restricted to migrations by men since almost all women are married by the age of 20 and therefore follow their husband.

Rainfall Data

Rainfall data were extracted from the global monthly precipitation data set provided by the Climatic Research Unit based on New, Hulme and Jones (2000). These data were extrapolated from a network of rainfall stations at a 0.5° latitude/longitude resolution. Rainfall data were aggregated at the department level. The analysis was limited to the period from 1960 to 1998 given the large number of missing data prior to 1960. These data are very consistent with other rainfall databases such as the rainfall data provided by the Global Historical Climatology Network and those provided by the *Direction nationale de la Météorologie au Burkina Faso*.

Land Degradation Data

Land degradation was measured by remote sensing at the department-level. The net annual increase in biomass, or net primary production (NPP), is a measure of the productivity of an ecosystem (Nicholson, Tucker, & Ba, 1998). The normalised difference vegetation index (NDVI) measured by remote sensing was used as a proxy of NPP. In the northern parts of the Sahel, NPP is largely determined by rainfall, whereas in the central and southern parts of the zone the influence of soil fertility also becomes significant. The NDVI is not an adequate indicator of land degradation per se since it is sensitive to interannual rainfall variability. The rain use efficiency (RUE), calculated as the ratio between net primary production and precipitation (as in Prince, De Colstoun, & Kravitz, 1998), is a more useful indicator of land degradation because it normalizes NPP by rainfall. Land degradation is associated with a reduction in RUE over several years. However, RUE is not sensitive to species composition. Changes in forage species composition and therefore grazing quality associated with degradation are not measured by RUE. According to Prince et al. (1998), there was no dramatic downward trend in RUE between 1982 and 1990 in the Sahel. On the contrary, there was a small but significantly upward trend in RUE. However, this observation at the regional scale is entirely compatible with observations of serious land degradation at the local scale.

To calculate RUE, the NDVI time series from the Pathfinder NOAA AVHRR satellite data were used as a proxy to net primary production. NDVI data are available at the resolution of 8 × 8 km, from 1982 to 1995. Three years (1989, 1991 and 1994) were excluded because of late equator crossing time of the NOAA satellite (for more details, see Gutman, 1999) or atmospheric contamination from the Mount Pinatubo eruption.

METHODOLOGY

Individual migration pathways composed of one or more migrations were extracted from the longitudinal demographic survey data. Each residence was associated with time-independent variables related to individual attributes and time-dependent variables related to the residence at destination. Rainfall and land degradation data were linked to the database, with the department as a common spatial unit and the year as the common time unit. To describe migratory pathways, two environmental typologies of origins and destinations were used: a climatic and a land degradation typology. The favourable or unfavourable character of each department was defined, as explained below, for each year for the ''climatic'' definition, and for the entire period for the ''land degradation'' definition.

Methodology to Define the Favourable or Unfavourable Climatic Character

The definition of the favourable or unfavourable climatic character was based on three rainfall variables. The first variable is the mean annual precipitation during the 1960–1998 period, with only one value per department for the entire period. This variable represents the agro-climatic zones in Burkina Faso: the Sahelian region (with an annual rainfall lower than 600 mm per year), the Sudanian region (between 600 and 800 mm per year) and the guineo-congolian/Sudanian region (higher than 800 mm per year). The second variable represents the inter-annual variability in rainfall. It is measured by the ratio between the annual rainfall of the year under consideration and the 1960–1998 annual mean rainfall. Departments were clustered in three groups: current annual rainfall lower than 50%, between 50 and 80%, or higher than 80% of the 1960–1998 mean annual rainfall.[1] The third variable is an intra-seasonal variability index which accounts for rainfall variation during the vegetative period. It is measured as the number of months during the growing season for which precipitation was lower than 50% of the 1960–1998 mean rainfall for the corresponding months, for the same area.

For each agro-climatic zone, specific thresholds were fixed on the two latter variables to define the favourable or unfavourable climatic character (Table 1). We assumed that the impact on livelihood strategies of a lower-than-usual rainfall is likely to be more dramatic in the northern drier than in the southern wetter part of the country. A residence was considered as being in an unfavourable department based on the climatic conditions for the years before the residence change took place. Specifically, the department at year *t* was considered to be in unfavourable climatic conditions if the

TABLE 1

Thresholds to define the Favourable (+) or Unfavourable (–) Climatic Character, for Each Year

		C		
A	B	< 50%	50–80%	80% et +
<600 mm	0	–	–	+
	1 et +	–	–	–
600-800 mm	0–1	–	–	+
	2 et +	–	–	–
800 mm et +	0–1	–	+	+
	2 et +	–	–	+

A = the mean annual precipitation during the 1960–1998 period.
B = the number of months during the growing season for which precipitation was lower than 50% of the 1960–1998 monthly mean for the same area.
C = the ratio between the annual rainfall of the considered year and the 1960–1998 annual mean rainfall.

department was in unfavourable climatic conditions during 2 out of the 3 years before the date of residence change. We assumed that it is not possible to survive more than 2 or 3 years on the cereal stocks accumulated during the good years because of the limited surplus production and the low food storage and conservation capacity. Thus, the definition of the favourable or unfavourable climatic character was different for every year, for each department. Depending on the year, from 0 to 42% of the departments were defined as enduring unfavourable climatic conditions according to the index composed by the three variables.

Methodology to Define the Favourable or Unfavourable Land Degradation Character

Unlike rainfall variations, land degradation is a slow-acting process. Only areas with a downward trend in rain-use efficiency, over the period 1982–1995, were considered as being degraded. A statistically significant negative slope of the regression of RUE against time was used to define degraded areas. The absolute value of the RUE for each year does not provide a useful land degradation metrics as it is influenced by location-specific factors. Land degradation is best revealed by the interannual trend in RUE in a given location. Because the scale of this study is limited to the departmental level, a department was considered to be in unfavourable land degradation conditions if a significant proportion (fixed as >50%) of its area was degraded. The main difference with the definition of the unfavourable or favourable environmental character of departments based on land degradation rather than rainfall is that a department is or is not in unfavourable land degradation conditions during the entire study period rather than for every individual year. 4.8% of the departments were defined as enduring unfavourable land degradation conditions.

The Use of the Survivor Function to Compare the Individual life Histories

The survivor function was used to describe the speed of the departure from a residence (the outmigration), according to the environmental context of this residence. This study compared survivor functions for migrants who settled in areas with favourable and unfavourable environmental conditions. The idea of the survivor function is to follow a population of individuals all beginning a certain migration episode with origin residence j at the same point in time (the episode's starting time), which, for this study, is the arrival in the first residence after the age of 20.[2] As time goes on, emigrations occur (i.e. individuals leave the given origin residence). The survivor function gives the probability of staying in the residence beyond a time t. As the number of years t since the arrival in the first residence increases, the probability of staying decreases and thus the probability of migrating increases. Also known as the product-limit estimator, the Kaplan–Meier (KM) estimator is the most widely used method for estimating survivor functions (Allisson, 1995). A probability is calculated by dividing the number of non-migrants (or stayers) by the population at risk which is composed by all individuals of 20 and over in the origin area. Biographies were not complete for individuals which were not yet 40 years old at the time of the survey as these individuals could still migrate after the end of the survey. Such observations are referred to as right censored cases. The KM method was used to include the information on a censored person up to the time of censorship, rather than simply ignoring all the information on a censored person (Kleinbaum, 1996). A KM survival probability at event time $t_{(j)}$ is the probability of surviving past the previous event time $t_{(j-1)}$, multiplied by the conditional probability of surviving past time $t_{(j)}$, given survival to at least time $t_{(j)}$. This method was used to test the first hypothesis of the study — i.e., that the individuals who lived in an area with unfavourable environmental conditions were quicker to leave their residence than individuals who lived in an area with favourable environmental conditions. In this section, no distinction was made between destinations.

The Use of Conditional Probabilities to Describe Individual Pathways

The life histories of individuals were analysed by the use of the non-Markovian portion of the LIFEHIST software (created by Rajulton, 1991). This creates multiple-decrement life tables with the assumption that previous experiences of events affect subsequent transitions. The individuals are followed from an initial state. Four states were defined: (i) residence in a rural area with unfavourable environmental conditions, (ii) residence in a rural area with favourable environmental conditions, (iii) residence in an urban area and (iv) residence in a foreign country. The conditional probability to migrate from one state to another was calculated to predict the occurrence of a migration event, considering previous migrations. The algorithm preserves the different sequences of events already integrated when estimating the probability of experiencing a succeeding event. Note that LIFEHIST weights the conditional probabilities to consider the sampling scheme of the survey. LIFEHIST takes into account right censoring for the probability calculation, by removing the censored individuals from the population at risk of migrating. By reducing the denominator of the probability calculation, the probability is greater than the probability calculation without taking into account the right censoring. This increase reflects the fact that the censored individuals could still migrate after the end of the survey. LIFEHIST computes the number of persons at risk and the probabilities to migrate from one state to another but does not provide the exact number of migrants who experienced a specific migration. The difference between a probability and actual figures depends on the number of censored cases. This number can be estimated by applying to the population at risk of migrating from one state to another the probability of going through this migration. In this study, however, figures cannot be extrapolated to the national scale since the sampling scheme of the survey was not designed to represent environmental disparities. The behaviour of the few interviewed individuals can not be assumed to be representative of their environmental group but they are assumed to be representative of their stratum, as defined in the survey.

The initial state was the first residence with the mentioned characteristics — unfavourable or favourable — after the age of 20. Firstly, the initial state was a rural area with unfavourable environmental conditions. Secondly, the initial state was set to be a rural area with favourable environmental conditions. This method was used to test the second hypothesis of the study — i.e., that migrants choose proportionally more often areas with favourable environmental conditions than areas with unfavourable environmental conditions for their destination. Note that the LIFEHIST software does not offer a significance test of differences between groups.

The two methods — the survivor function and the analysis of migratory pathways — do not study the same migrations. The survivor function only analyses the first migrations, all origins being confounded, whereas the analysis of migratory pathways also deals with second or third migrations, depending on the characteristics of the residence. For example (Figure 2), in the analysis of the survivor function, the first studied residence of this individual is the number 2, the first one after the age of 20. This residence is located in an area with favourable conditions. With the analysis of migratory pathways from an area with unfavourable conditions, the first studied residence of this individual is the number 3. It is the first residence, after the age of 20 with the characteristic of unfavourable conditions. For this individual, this migration is the second one after the age of 20. In this latter approach, no restriction on the order of migration was chosen, to increase the number of studied individuals and thus the possibility to study more than one migratory step.

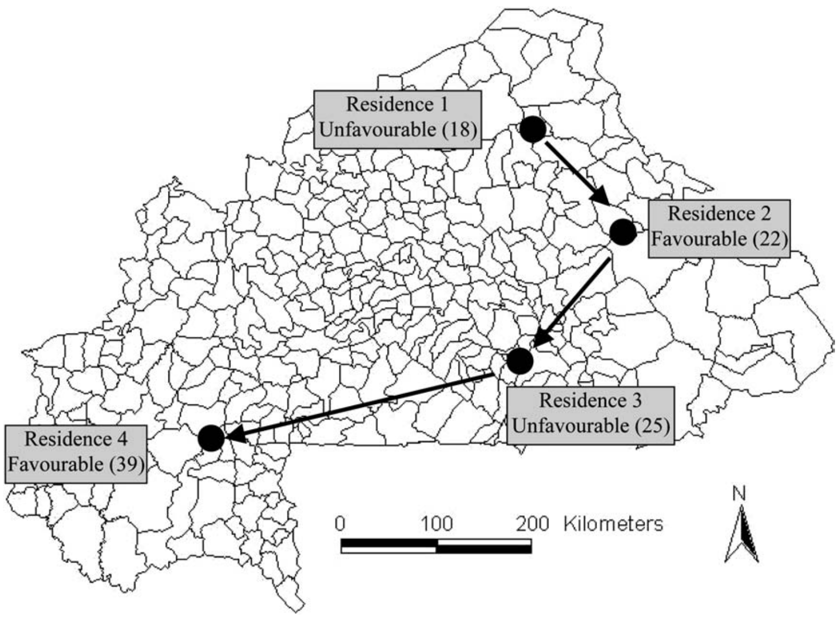

FIGURE 2. An example of a migratory pathway. Legend: Environmental characteristic of the residence (Age at the arrival in the residence).

RESULTS

Survivor Function Related to the Origin Conditions (Test of Hypothesis 1)

The first hypothesis concerns the conditions at the origin (push factors): individuals who lived in an area with unfavourable environmental conditions were quicker to quit their residence than individuals who lived in an area with favourable environmental conditions. Fifty percent of individuals migrated after 7 years in their residence, whatever the environmental characteristics of origins.[3] Surprisingly, the proportion of the population that did not migrate at all after 15 years at their residence was 35% in departments with unfavourable climatic conditions and only 23% in departments with better environmental conditions (Figure 3). Differences between these two groups are significant (Log-rank test) but not during the first years (Wilcoxon test). Note that the number of studied individuals varied as a function of the origin (143 from an area with unfavourable climatic conditions and 528 from an area with favourable climatic conditions). Thus, less people migrate out of areas

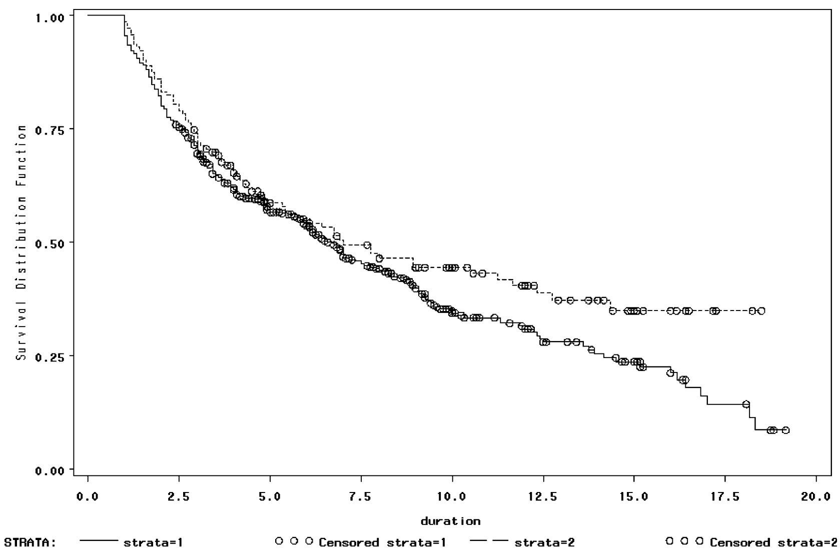

FIGURE 3. Survivor distributions from areas with unfavourable climatic conditions (dotted line) and favourable climatic conditions (continuous line).

with unfavourable climatic conditions during the 20 years spent at their residence compared to what is observed for areas with favourable climatic conditions.

Thirty one percent of the population who lived in a department with unfavourable land degradation conditions did not yet migrate after 20 years in their residence, while they were only 11% in this case among those who lived in areas with better environmental conditions (Figure 4). Thus, the observation on the low outmigration rate from areas with unfavourable land degradation conditions is similar to the one concerning areas with unfavourable climatic conditions.

These results do not support the first hypothesis of the study. Actually, contrary to what was expected, people from areas with unfavourable land degradation and climatic conditions migrate less out of their first residence than individuals from areas with favourable conditions. Rather than encouraging migration, unfavourable environmental conditions in combination with other non-environmental factors may limit people's ability to invest in migration.

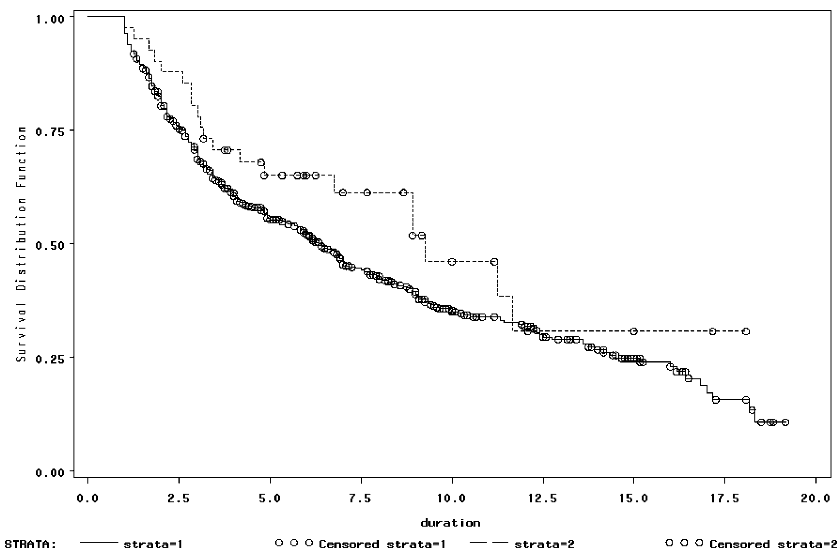

FIGURE 4. Survivor distributions from areas with unfavourable land degradation conditions (dotted line) and favourable land degradation conditions (continuous line).

Migratory Pathways from Areas with Unfavourable Climatic Conditions (Test of Hypothesis 2)

The second hypothesis concerns the conditions at the destination (pull factors): migrants choose proportionally more often areas with favourable environmental conditions than areas with unfavourable environmental conditions for their destination. 1287 men — out of 6815 studied men — lived in rural areas with unfavourable climatic conditions after the age of 20 (Figure 5). From this residence, 1%[4] of the sampled population was likely to migrate to another rural area with unfavourable climatic conditions, 4% to a rural area with favourable climatic conditions, 5% to an urban area, and 47% to a foreign country. 43% of the studied individuals (1287) were likely to stay in their first residence between the age of 20 and 40. 37% of those who had migrated once to a rural area with favourable climatic conditions were likely to experience a second migration to another rural area with favourable climatic conditions before their fortieth birthday, 7% of them to a rural area with unfavourable climatic conditions and 2% to an urban area. Those who had chosen an urban or foreign destination in their first migration were likely to move almost exclusively in their second migration back to a rural area, more often with unfavourable climatic conditions (50%) than with favourable climatic conditions (20%). This is likely to represent largely a return migration to the origin. One percent was likely to move to an urban area in their second migration if their destination in their first migration was a foreign country, and to a foreign country if their destination was an urban area. Twenty nine percent were likely to remain settled in a foreign country until their 40th birthday after their first migration. Note that, according to the climatic criteria used, the same area could be unfavourable at the year of departure and become favourable at the year of return.

Migration from a department with favourable climatic conditions as origin was mainly directed to foreign destinations (52%) (Figure 5). When these migrations were aimed at a rural destination in the country, it was almost exclusively to a rural area with favourable climatic conditions (8%). In the second step of migration, rural areas with favourable climatic conditions were always preferred, all origins confounded.

In summary, this analysis showed that a large proportion of the population living in an area with unfavourable climatic conditions was likely to move between the age of 20 and 40. Among those that migrated, a foreign country was the most frequent destination in the first migration. Note that Côte d'Ivoire, the most frequent destination for Burkinabé

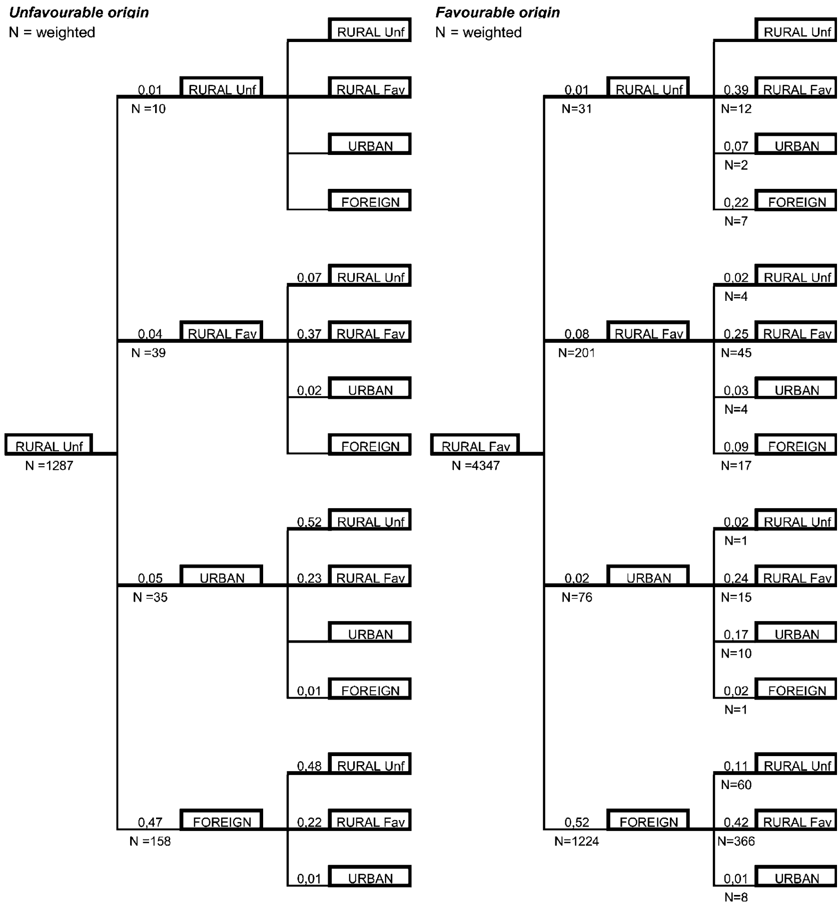

FIGURE 5. Pathways from areas with unfavourable (left) or favourable (right) climatic conditions.

migrants, benefits from favourable environmental conditions compared to all departments of Burkina Faso. Burkinabé migrants are not likely pulled by rainfall conditions in Côte d'Ivoire but are rather attracted by job opportunities in plantations of cafe and cacao. Most of the international migrants came back in Burkina before their fortieth birthday, in their second migration. The Burkinabé living abroad indeed maintain ties with villages of origin and with family networks (Cordell et al., 1996). The most frequent destinations of these return migrants are their village of origin. These migrations are thus unlikely to be linked to environmental conditions.

The second hypothesis (migrants choose proportionally more often areas with climatically favourable environmental conditions than areas with unfavourable climatic conditions as their destination) is confirmed. Whether it concerns the first or second migration, and whether migrants originated from departments with favourable or unfavourable climatic conditions, departments with favourable climatic conditions were a much more frequent destination chosen by individuals than departments with unfavourable climatic conditions.

Migratory Pathways from Areas with Unfavourable Land Degradation Conditions (Test of Hypothesis 2)

Origins which were unfavourable in terms of land degradation rather than climatic conditions were much often associated with migration. Actually, 82% of individuals living in a rural area with unfavourable land degradation conditions were likely to outmigrate, compared to 57% for areas with unfavourable climatic conditions. A foreign country was the destination of 73% of the migrants originating from a department with unfavourable land degradation conditions (Figure 6). 5% of all migrants (478) were likely to move to a rural area with favourable land degradation conditions, 3% to a rural area with unfavourable land degradation conditions and 1% to an urban area.

In the case of migrations from areas with favourable land degradation conditions, 18% of migrants were likely to leave to a foreign country, 13% to a rural area with favourable land degradation conditions, 4% to an urban

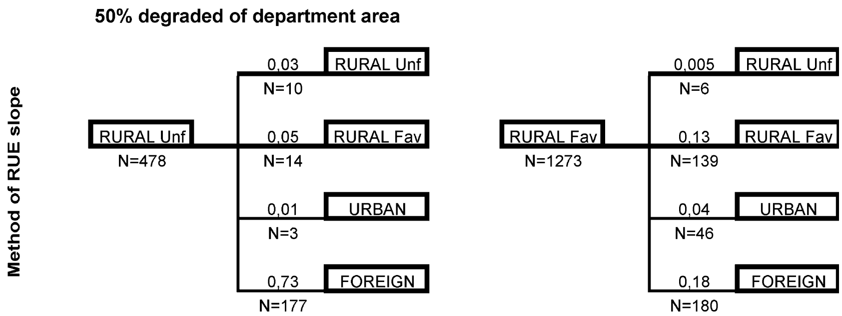

FIGURE 6. Pathways from areas with unfavourable (left) or favourable (right) land degradation conditions.

area and only 0.5% to a rural area with unfavourable land degradation conditions. The probability to migrate to any destination from a department with favourable land degradation conditions reaches only 35.5%, against 82% for those originating from a department with unfavourable land degradation conditions.

In summary, departments with unfavourable land degradation conditions were a less frequent destination than departments with favourable conditions[5]. This was particularly the case when the origin was an area with favourable land degradation conditions. This supports the second hypothesis of this study.

CONCLUSION AND DISCUSSION

Few studies have so far estimated the proportion of migrations that can be directly attributed to environmental conditions. In this study, a descriptive analysis of population movements between regions characterised by different rainfall and land degradation conditions was performed. The survivor function, used to analyse the influence of the conditions at the origin, showed that, from the age of 20, people from areas with unfavourable land degradation and climatic conditions migrate less out of their first residence than individuals from areas with favourable conditions. The destinations chosen by migrants were analysed by using conditional probabilities to describe individual pathways.

People leaving a rural area settle more often in a rural area with favourable environmental conditions than in an area with unfavourable conditions. This finding holds true for origins with favourable or unfavourable environmental conditions, and whether this was defined based on climatic or land degradation data. While the difference between the conditional probabilities to migrate to areas with favourable or unfavourable conditions was not very high, the odds were up to 1 to 10 in favour of areas with favourable environmental conditions. Results concerning the distribution of migrants among destinations were not sensitive to the criteria used to define the unfavourable or favourable climatic character of departments. In this paper, the department at year *t* was considered to be in unfavourable climatic conditions if the department was in unfavourable climatic conditions during 2 out of the 3 years before the date of residence change. Several durations (from 2 to 10 years) were considered and conclusions were similar.

Whether environmental conditions were defined based on rainfall or land degradation affected the proportion of people leaving their residence (not necessarily the first one). A large proportion (82%) of the population living in rural areas affected by land degradation outmigrated before the age of 40. That proportion was smaller (57%) for areas affected by poor climatic conditions. It may thus be assumed that migrations are likely to be more influenced by a slow-acting process such as land degradation than by episodic events such as droughts. Land degradation progressively makes livelihood strategies based on farming unsustainable. By contrast, a number of coping and adaptation strategies have made agropastoralism sustainable in semi-arid regions affected by climatic variability. Other factors are likely to interact however.

Note that, with the analysis of migratory pathways, a much larger proportion of the population residing in areas with unfavourable land degradation conditions outmigrates than it is the case with population residing in areas with favourable land degradation or climatic conditions, or even with unfavourable climatic conditions. These results may seem to contradict the conclusions of the analysis with the survivor function. The main difference between these two methods is the order of the analysed migration. With the survivor function, only the first migration is analysed. The attachment of an individual to his first residence is stronger than to the following residences. Moreover, unfavourable environmental conditions, by reducing or making difficult the production of a surplus (in food or money), limit people's ability to invest in migration by comparison to areas of residence with favourable environmental conditions. Therefore, people from areas with unfavourable land degradation and climatic conditions tend to migrate less out of their *first* residence than individuals from areas with favourable conditions.

However, in the analysis of migratory pathways using conditional probabilities, it could be the second, the third (or over) migration that is analysed. The probability to migrate is known to be increasing with the migration experience. Moreover, when the origin is not the first residence (as it is often the case with the method of migratory pathways by conditional probabilities), the attachment to a location is lower. Individuals who have already migrated would prefer not to stagnate in an area with unfavourable conditions and would prefer to migrate again to an area with favourable conditions.

This study suffers from several limitations. It was based on data from a national longitudinal survey coupled with fine resolution rainfall data and land degradation data derived from time-series of remote sensing data. However, as for any survey data, the sampling scheme could influence conditional probabilities. This study could not take into account the difference in the potential of attraction between areas with favourable or unfavourable environmental conditions because the sampling scheme was not elaborated to take into account environmental disparities. The potential of attraction of areas with favourable conditions is greater than for areas with unfavourable environmental conditions as the former are much larger. Consequently, in this study, the object of the analysis is the individual migration and not the attractivity of places.

The definitions of favourable and unfavourable environmental conditions are based on a rational scientific logic. The decision of the migrants is likely to be based not only on an objective but also on a subjective assessment. Moreover, all other things being equal, even if both their origins and destinations are located in areas with unfavourable environmental conditions, migrants may move to obtain a small ecological gain.

The two descriptive techniques used in this study take censoring into account but the number of censored cases was relatively high for some origins. To consider the bias related to the memory of individuals, the duration of migrations was defined at a minimum of 1 year. However, Shrestha (1989, cited by Bates, 2002) explains that environmental migrants begin with a short-time journey, on reconnaissance. Finally, there is still no standard indicators measuring land degradation. This study used the rain-use efficiency, considered in the literature as a good proxy to provide large-scale estimates but, at a local scale, Diouf and Lambin (2001) showed that this indicator has to be measured based on biomass data rather than on remotely-sensed vegetation index data.

Some aspects of the effects of the environment on migration were not investigated in this study. The environmental conditions are likely to have a greater influence on the migration of farmers (the majority of the population) than of herders. Migration is just one coping strategy among others. Some potential migrants could anticipate unfavourable environmental conditions and move before suffering the next unfavourable year. Others could stay and develop non-farm activities. Furthermore, the effects of migration on the environment were not considered here. It is another but related problem as refugees are exceptional resource degraders (Leach, 1992, cited by Black & Sessay, 1997).

Is the environment a proximate or underlying cause of migration? Hugo (1996) states that "the deeper underlying causes of environmental migration are not environmental but related to political, economic, sociological and demographic processes". This study made possible the evaluation of the proportion of migrations that can be directly attributed to environmental conditions. The results suggest that environmental conditions interact with other factors to cause migration. Actually, the differences between conditional probabilities from areas with favourable and unfavourable environmental conditions were not very high. Unfavourable environmental conditions are thus unlikely to be the unique ''cause'' pushing people to migrate. Socio-demographic and economic disparities within Burkina Faso are also expected to explain migration. For example, population density and market opportunities largely differ across regions. Moreover, the interactions between environmental conditions, livelihood strategies and migrations are likely to be different in the pastoral production systems in the Sahelian part of the country compared to the rain-fed agricultural systems in the Sudanian zone. Pastoralists depend on mobility to cope with their harsh environment while farmers are more vulnerable to droughts and land degradation. Actually, farmers engaged in cotton cultivation for example largely depend on high crop yields to cover the cost of seeds, fertilisers and pesticides. Finally, land degradation and inter-annual rainfall variability are not independent processes given that droughts may trigger or increase land degradation. Nevertheless, this study is one of the first to describe individual migratory pathways according to rainfall and land degradation typologies. In future analyses in search for causative relations, the interactions between multiple causes of migrations should be tested.

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ENDNOTES

1. This categorization was arbitrarily defined but several tests were performed. The criterion of having a sufficient number of observations in each category was determining.

2. If the individual lives in birth department at age 20, the first residence to be analysed will be the next one. If he does not leave the home department, he is left-censored and not included in the analysis.
3. Recall that these figures have been weighted but not extrapolated.
4. In the following section, figures indicate conditional probabilities to migrate, not percentages.
5. Recall however that this concerns relatively low population numbers and that the LIFEHIST software does not offer a significance test of differences between groups.

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