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The use of survey data to study migration–environment relationships in developing countries: alternative approaches to data collection

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Abstract

Growing interest in the environmental aspects of migration is not matched by research on their interrelationships, due partly to the lack of adequate data sets on the two together. Focusing on the microlevel, we describe the data required to effectively investigate these interrelationships. Data sources are discussed, be collected, focusing on household surveys and remote sensing. The main section of the paper describes three alternative approaches to data collection: (a) using existing population and environmental data from different sources, illustrated by Burkina Faso; (b) adding questions to a survey developed for another purpose, illustrated for Guatemala using a DHS survey; and (c) designing a new survey specifically to collect both migration and environmental data to investigate interrelationships, illustrated by Ecuador. Methods used and summary findings are described, followed by a discussion of their advantages and limitations. We conclude with recommendations as to effective use of each approach as research on migration–environment linkages moves forward.

Keywords

Migration; Rural environment; Household survey; Remote sensing; Land use; Climate change; Burkina Faso; Guatemala; Ecuador

Introduction

Rising environmental concerns have led the scientific community and policy-makers to become increasingly interested in improving understanding of the linkages between migration and the environment. Also of interest is the association between migration–environment and poverty and sustainable development, and the implications of these associations for policy, at local, national and global scales. This has led to a growing literature, along with considerable debate about the definition of “environment migrants” and their numbers (e.g., El-Hinnawi 1985; Bates 2002; Myers 1993; Kibreab 1997; Kliot 2004; IOM 2007). In addition, research has categorized migration and environment connections according to the type of environmental event, time frame, adaptation potential, etc. (Meze-Hausken 2000; IOM 2007; Kniveton et al. 2008, 2009; Hugo 2008).

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Even so, active debate continues regarding whether environmental factors are a root cause of displacement, and indeed whether "environmental refugees" even exist (Lonergan 1998; Black 2001; Renaud et al. 2007). This is due mainly to the lack of convincing empirical studies, which in turn results from the lack of quality data covering both migration and the environment for the same population and the same time frame. Indeed, numerous authors have noted the lack of solid empirical evidence on the effects of environmental degradation on migration (apart from small-area studies of Findley 1994; Henry et al. 2004; Massey et al. 2010; Gray 2011; Gray and Mueller 2011), which has been attributed to the lack of adequate data sets that cover both migration and the environment and factors related to each (Bardsley and Hugo 2010; Leighton 2009: 331; Renaud et al. 2007; Hugo 2008; Bilsborrow 2009; Bie Lilleør and Van den Broeck 2011). This paper focuses on evaluating several alternative ways of approaching this issue, viz., how to collect appropriate, quantitative data on both migration and environment for a population. The debate is complicated by the complexity of the interactions between environmental degradation and migration which according to Renaud et al. (2007:19) makes "quantification difficult if not impossible."

In the face of the lack of convincing empirical studies, preconceived notions of environmentally induced migration, and vague statements as to migration–environment association, have proliferated (Gemenne 2010), along with unrealistic estimates of "environmental refugees" (e.g., Myers 1993, 2002; Stern 2007). Thus, Lonergan and Swain (1999:2) state that "although the estimates and projections of environmental refugees are based almost entirely on anecdotal evidence and intuitive judgments, it is important not to trivialize the role environmental change and resource depletion *may play* in population movement" (italics added). It is likely that the environment influences migration even if the scale, location and severity of the influence have not been accurately established (Bardsley and Hugo 2010); but as Newland states, existing estimates "are not informed by an understanding of migration dynamics" (Newland 2011: 1).

The main focus of this paper is methodologies for collecting data to examine relationships between migration and the environment at the local level in developing countries, particularly the use of and impact on natural resources, including the use of land for agriculture, forest clearing and the advance of the agricultural frontier; drought-induced migration and effects of rainfall variability and change on population movements; and soil degradation, whether resulting directly from excessive use of chemicals or inadequate agricultural practices. Such environmental changes may lead to increased out-migration to internal or international destinations, but since the former is generally many times the latter, this paper will focus on population movements *within* countries.

The paper is organized as follows. In memoriam, the next section has brief notes on theory and contributions of Professor Daniel Hogan to the migration–environment field. Section "Main objectives" presents the main objectives of this paper, while section "What to measure for studying the migration–environment nexus" addresses how to measure migration and the environment for the purposes of investigating their linkages, while also considering sources of data currently available. In section "Three possible approaches for collecting data to study migration–environment linkages," three alternative approaches to collecting data to study migration–environment linkages at the micro- or household level are presented and illustrated by case studies. Following this, we discuss the advantages and disadvantages of the approaches. Section "Conclusions" concludes with final observations and recommendations.

A note on theory and Daniel Hogan's contributions to the migration–environment field

Understanding of connections between population dynamics and the environment, especially migration–environment, has benefitted in important ways from both theoretical and empirical contributions of Daniel Hogan. Hogan promoted the development of the new field extensively through training many young Brazilians at UNICAMP for over three decades and as the South American representative in the inaugural Committee on Population and Environment of the International Union for the Study of Population (IUSSP) in 1990–1994. As early as 1991, Hogan called for approaches that "transcend the Malthusian vision" and noted that "migration, patterns of human settlement and linkages to the environment and degradation of resources should provide stimuli for that transcendence" (Hogan 1991) and lead to a more multidimensional policy agenda (Hogan 1995, 2001). Hogan contributed to in-depth theorizing and applied research on both "brown" and "green" issues for Brazil and globally, but it is the green that relates most to this present paper (e.g., Bilsborrow and Hogan 1999; Hogan 2007). His research productivity accelerated in recent years, working together with Eduardo Marandola, to present new and challenging dimensions for migration–environment research incorporating vulnerability and risk (Hogan and Marandola 2005, 2009; Marandola and Hogan 2007).

Main objectives

The main objectives of this paper are to (1) define migration concisely–a necessary if not sufficient condition for studying migration–environment linkages at the local scale[1] in developing countries; (2) describe types of data needed and sources; and (3) illustrate three alternative ways to obtain and use survey data. The first shows how existing data from a census or survey can sometimes usefully be supplemented by environmental data, illustrated by a study on the influence of drought on internal migration in Burkina Faso. The second shows how questions can be added to an existing (planned) survey, in this case to study the impacts of internal migration on deforestation in an area of destination of migrants, in northern Guatemala. The last case illustrates the advantages of designing a project that from the outset aimed to collect migration–environment data, applied to rural Ecuador. The three approaches are then compared and contrasted in terms of advantages and disadvantages and used to develop recommendations for improvements in data collection which in turn will make possible more informed policy recommendations.

What to measure for studying the migration–environment nexus

Migration

To investigate the migration–environment relationships, various types of migration may be of interest: internal, international, return (returning from having lived elsewhere, whether in the country or beyond), long-term/permanent versus short-term/seasonal/temporary, circular, and even daily or weekly commuting. But it is generally useful to narrow one's focus by using the standard demographic definition of a migrant, as someone who (a) *moves across a political or administrative boundary to (b) change his/her place of usual residence*.[2] International migration obviously involves a movement across a country border, while

[1]Global concerns are generally excluded here as beyond this paper's scope and also due to requiring supra-national data, different methodologies and preferably coordinated global policies.

[2]Social scientists of various persuasions have debated and invented many definitions of "migrant," as exemplified in a stimulating discussion in Standing (1984), "A Typology of Migrants." See also definitions in UN documents (UN 1998, p. 10), and demography textbooks: e.g., Siegel and Swanson (2004: 453) define migration as "a change of residence between clearly defined geographic units …or between specifically designated political or statistical areas or …type-of-residence areas (e.g., rural to urban movement)."

internal migration within a country is distinct according to the nation's specification of administrative borders, such as provinces or states, districts or *municipios*, subdistricts, etc. Changes of residence *within* the lowest level administrative units recognized by the country are *not* considered migration for analytical purposes. This definition is useful for data collection in censuses and surveys to focus on longer term and more spatially significant forms of migration that involve not only shifts in residence but also in activities, such as employment, use of local infrastructure and businesses, and social relationships.

For most purposes, especially for policy formulation, it is *recent migrants* that are of particular interest, viz., those who migrated within the past X (e.g., 2, 5 or 10) years. Nevertheless, for studying the relationships between migration and the environment, a longer time perspective is often useful, since the impacts of migrants on the environment in the place of destination are *cumulative* over time, such as clearing land and land use. Similarly, environmental change that stimulates or forces people to move may result from gradual environmental changes, such as the loss of soil fertility from many years of agricultural use. On the other hand, some migration-inducing environmental changes, such as drought, floods and other natural disasters, may be either sudden or of longer gestation. In this paper, we are mainly concerned with the *cumulative* effects of such environmental processes, such as prolonged drought.

For studying the determinants or consequences of migration, including the role of environmental factors, it is desirable to obtain data on key characteristics of migrants and non-migrants at both individual and household scales. At the individual level, such data include age, sex, education and marital status; economic activity/employment and individual earnings and other income; and reasons for migration. At the household level, data are needed on household size and composition, education of the household head and other members, household assets/ wealth; previous out-migration of household members and current residence (creating migration networks); and location of dwelling relative to the nearest road, town/community, and urban center. Each of these factors may be reciprocally associated with migration. Following Hogan and Marandola ("A note on theory and Daniel Hogan's contributions to the migration–environment field"), it is also useful to try to capture the vulnerability of households to environmental change. To do so, useful household-level data include remittances received and the impact of these remittances, as well as support provided to the migrant at the time of the move and subsequently.

The information described above is the minimum necessary to collect about migration in a survey to adequately investigate the relationships between migration and the environment at the micro- or household level. This is true whether the individual or the household (or both) makes the decisions about land/resource use, work/employment, or migration, and whether the focus is the effects of migration on the individual, the household[3] of origin or destination, or the community or country of origin or destination.

Environment

There are far more dimensions to the natural environment than can be dealt with here. We focus on aspects of the natural environment *which may be linked causally* (in either direction) to human migration including *changes in land use*, such as: (1) deforestation, or clearing of other vegetation cover ("agricultural extensification"); (2) intensification of land use for agriculture, whether due to reduction of plot size resultant of population pressures or other reasons (and manifest in and measured by decreased fallow time, increased use of

[3]While decisions to migrate are often viewed as made by households in developing countries (e.g., De Jong and Gardner 1981, and many subsequent studies), individual-level factors are often found more important (e.g., Laurian et al. 1998).

fertilizers/herbicides/pesticides, increased irrigation, change to more land- or labor-intensive or higher value crops, or increased labor per unit of land area); (3) switching between subsistence and cash crops; (4) changes in energy use by rural households, such as from fuel wood to petrol; (5) increasing pressures on common property resources (including changes in land tenure regimes, for example, the enclosure movement in nineteenth-century England, privatization of communal lands in developing countries); (6) movement of populations into national parks/protected areas; (7) soil erosion and soil degradation, such as from prolonged land use and nutrient depletion; and (8) flooding/drought, and precipitation excesses and deficits.

Most of these can be measured using either survey or remote sensing data–some better with surveys (2, 4, 5) and some with remote sensing (8, re. precipitation). For example, household surveys are the only source for measuring land tenure and privatization, changes in energy use, and most forms of land use intensification, while even inexpensive satellite imagery can usually distinguish major forms of land use change (pasture vs. crops vs. forests) and higher resolution imagery can distinguish some crops from others. Remote sensing can also detect (legal or not) intrusions into national parks, but requires ground-control points to link this land clearing to individual farms and communities reliably. Each has advantages and disadvantages in detecting and measuring deforestation in general [(1) above], use of common property lands, soil erosion and degradation, and the scope and impacts of flooding or drought. For measuring excess/deficit precipitation, satellite imagery provides modeled gridded rainfall, but weather station precipitation collectors remain the most reliable source, although the station network is often insufficient, providing erratic data.

For each of the variables listed above, it is crucial to capture changes that occur over time, and at the spatial level of analytical interest (e.g., farm household or region). In these regards, remote sensing has some important advantages over survey data: it is repetitive and covers broad areas, and the large spectral resolution of satellite systems allows detailed assessment of land cover. The data are easy to update, comparable over time and space (the same all over the world) and accessible for all areas (even dangerous or conflict regions); nevertheless, for some regions, as in the tropics, cloud cover can severely limit their ability to observe the earth's surface. For example, not a single cloud-free image (LANDSAT or ASTER) was available for the 8-year study period in one of the three Ecuador study sites described below (see section "Some limitations of the study").

Remote sensing data from a time series of satellite images make possible examining *changes* in land cover over time (since the early 1970s) and at a variety of scales–from the parcel to the farm to the community, the landscape, and the nation–depending on the spatial resolution of the imagery. For small agricultural plots, using very high resolution (VHR) satellite imagery (accurate to 5 m or better) is desirable to obtain useful data, such as from QuickBird, Ikonos or Hyperion imagery. For studying changes in vegetation at the community or even the farm household level for medium-to-large farms, images from Landsat Enhanced Thematic Mapper (30 m accuracy) or Haute Resolution Géométrique (high geometric resolution, from French SPOT 5 satellite, accurate to 10 m) are sufficient and less expensive if not free. At coarse resolution, Advanced Very High Resolution Radiometer on NOAA-series satellites (1 km/8 km) or SPOT Vegetation (1 km) can capture changes at a larger scale (district, province, region or national level).

Importantly, using remote sensing to measure environmental changes at a coarse spatial resolution does not imply that migration must be measured at the same resolution: In fact, even at the household level, a migration model may include environmental drivers measured at a coarse scale, such as a community, region or administrative area, because it is the scale

at which the environmental change usually occurred. Of special interest is whether *changes* in any of the above types of environmental variables (a) influence rural out-migration or (b) contribute to in-migration.

A common scenario worldwide is soil degradation in areas long used for agriculture (alas, the best global data may continue to be those of the GLASOD survey, reported in Bot et al. 2000), which decreases the income potential of the land that may in turn stimulate out-migration. That migration may in turn be to frontier areas, where migrants clear the forest or the bush to establish new farms to raise crops or animals, creating new environmental degradation, referred to as "environmental cascading" (Charnley 1997). Thus, several changes in the environment may be attributable to in-migration: Migrants moving to areas they are not familiar with may have particularly deleterious effects settling in or raising crops in those areas (Grandia et al. 2001; Oglethorpe et al. 2007) or otherwise.[4] For example, migrants sometimes adopt cultivars inappropriate for the destination area, particularly when it is quite different in climate, soils, etc., from their area of origin. Or they may adopt monoculture cultivation, displacing multiple species previously there (and sometimes the people practicing polyculture as well, such as indigenous populations in the Amazon basin). The migration of people to an area may also increase local demands for fuelwood for cooking/heating and/or of trees for house construction, either of which can further impact forest or vegetation cover (Marquette and Bilsborrow 1998).

If migrants cannot find land of their own in the destination area, they may use common property resources or resources from protected areas, an important process to measuring using surveys or in combination with satellite imagery. Common property resources are often used *first* when land becomes scarce relative to population, leading to degraded public lands (Hardin's tragedy of the commons, 1968). This tends to worsens poverty since the poorest are usually the most dependent on common lands. In many African villages, traditional (communal) land tenure systems are based on the principle of hospitality, which accommodates the settlement of migrants (Mathieu 1993). In the Philippines uplands, indigenous peoples did not traditionally practice private land ownership. But as lowland migrants arrived in search of land for private ownership and permanent agriculture, the state intervened in 1997 by enacting the Indigenous People's Rights Act to demarcate and secure their ancestral lands (De Vera 2007). In settled areas with agricultural households with private landholdings, in-migration increases pressures on the land, which may lead to smaller farms, and, in the absence of compensating changes in agricultural practices, can lead to increased soil erosion/degradation.

As noted in section "A note on theory and Daniel Hogan's contributions to the migration–environment field," not only can migrants impact the environment in areas of destination, but their migration may also be stimulated by environmental processes in areas of origin. Thus, the deterioration of the natural environment by soil degradation, drought or floods may stimulate out-migration. However, sometimes inferences about the impacts of environmental change on migration are ambiguous. For example, if forests are cleared for agricultural use, this retains population; but it may have been a response to prior in-migration. In contrast, the loss of forests can indicate environmental degradation, reducing access to forest resources and increasing time to collect fuelwood, leading to out-migration (Massey et al. 2010). Thus, it is complex but important to identify cause and effect, and the sequence of events with retrospective data. As another example, a switch from land- and labor-intensive short cycle crops to pasture results in a decrease in demand for labor, which frees labor to out-migrate; but the direction of causation may be the opposite, with

[4]For example, Liu et al. (2003) found that the promotion of tourism in the Oolong Panda Reserve in Szechuan province of China led to an influx of not only tourists but Chinese to cater to them, threatening the Reserve.

autonomous out-migration creating labor shortages, switching modes of production to less (labor) intensive forms of land use, such as pasture for cattle (see discussion of Chayanovian changes over the life cycle in Marquette 1998; also Chayanov 1966 ed.).

Three possible approaches for collecting data to study migration–environment linkages

There are three possible options for studying the migration–environment linkages at the local scale based on household data: (a) use existing secondary data; (b) add questions to an existing or planned survey; and (c) design a new survey for the specific purpose of investigating migration–environment linkages. This section describes three research projects using these different approaches.

Using existing secondary data: a case study of Burkina Faso

Project purpose—This project investigated the impact of environmental conditions on migration in Burkina Faso, chosen because of wide variation in environmental and demographic characteristics and the expectation that climate variations could be environmental drivers of migration. Rainfall variables were introduced into a household migration model. At the beginning of the project, the only household-level data on migration were from the latest population census, but subsequently data were available from an event-history survey to better model migration.

Migration data and socioeconomic data—Demographic data for Burkina Faso were initially available only from the most recent population census of 1985 (INSD 1991). Comparing people's residence at the time of the census with that 1 year before provided a matrix of 870 flows between the 30 provinces. The census also provided socio-demographic variables although it was not possible to differentiate migratory flows by gender, age or economic activity. Such a macroscale analysis suffers from the homogenization of individual migratory behavior through data aggregation, which can lead to ecological fallacies (Robinson 1950). In addition, the analysis based on a single cross-section gives only a snapshot of the process and assumes it is in statistical equilibrium (Blossfeld and Rohwer 2001), most unlikely as changes occur across age, cohorts and historical time periods. This makes an event-history approach preferable if changes can be adequately controlled (Blossfeld and Rohwer 2001).

Event-history data were later found from a nationally representative, retrospective migration survey, EMIUB (Enquete "Dynamique migratoire, Insertion urbaine et environnement au Burkina Faso"), conducted in 2000 by the Institut Supérieur des Sciences de la Population at the University of Ouagadougou, University of Montreal, and Centre d'Etudes et Recherches sur la Population pour le Dévelopement (CERPOD) (Poirier et al. 2001). The EMIUB project collected individual-level data to analyze the timing of events from individual life histories and the influence of household and community characteristics on individual behavior. It used a two-stage cluster sample design to select 3,570 households from eight strata based on geography, climate and ethnicity. Each person aged 25–64 and half of those aged 15–24 were interviewed, which reduced the censoring of life histories of working age persons that occurs in many studies of migration based only on young persons, such as sons and daughters of the head (e.g., Laurian et al. 1998). A total of 9,612 individual life histories were collected, including data on out-migrants provided by a proxy household member remaining behind usually, in the absence of the migrant. A household questionnaire obtained data on household members, housing quality, economic conditions, house environment and household expenses on cooking fuel (in urban areas only).

The person history questionnaire covered family origin and childhood residence; personal characteristics (sex, age, place of birth, education, etc.), residential mobility (date, place and characteristics of each residence); land access and purpose of migration), economic activity, and marriage and fertility. Migrants were defined as members away more than 3 months, to include temporary migrations in the dry season and migration related to short-term urban work (Poirier et al. 2001). The EMIUB data allowed following the residential pathways of each individual since age 6, within the country or abroad.

The fact that the EMIUB was a single-round retrospective survey rather than a longitudinal survey leads to several limitations, the most important being possible memory lapse (Beckett et al. 2001; Som 1973), since events further back in time are less well remembered, more so in Burkina Faso where calendars are little used and most of the population is illiterate (76 % in 2000: UNESCO 2002). Thus, dates were collected using the AGEVEN[5] calendar (Antoine et al. 1987) to help respondents situate main events in their life over time.

Community-level data—Community-level data were available from one of the first national retrospective community surveys conducted in a developing country, carried out in 600 settlements in 2002 (Schoumaker et al. 2006). This survey was linked to the individual migration survey, covering a third of the villages cited in the individual survey, that is, villages where people lived at the time of the survey plus a large sample of villages where they had lived in the past. The questionnaire covered a broad range of topics, including land availability, transportation, agriculture, infrastructure and employment. Efforts were made to obtain retrospective information as far back as 1960 by interviewing groups of community informants (administrative officers, village chiefs and other knowledgeable informants). For example, informants were asked to recall when uncleared land became no longer available. A village calendar, including national and local events (such as school construction), was used to improve the quality of dates. The interview of several informants together is believed to improve data quality (Bilsborrow et al. 1984; Axinn et al. 1997; Frankenberg 2000). In addition, a detailed study of data quality was performed by comparing responses of interviewees to external data (Schoumaker et al. 2006).

Rainfall data—Rainfall data were obtained from the Climatic Research Unit at the University of East Anglia (New et al. 2000), interpolated at a spatial resolution of 0.5° latitude and longitude from a network of global rainfall stations. The analysis covered 1960–1998 (given gaps in the data prior to 1960), but this still allowed covering more than one drought event as Burkina Faso experienced major droughts in the early 1970s and mid-1980s.

Rainfall was measured at fine spatial and temporal resolutions to define drought conditions when and where migration occurred, independently of reasons given by migrants. Monthly rainfall was extracted from this database and two rainfall variables prepared to capture two dimensions of the potential impacts of rainfall on migration: mean annual precipitation in 1960–1998, which affects agricultural productivity and vulnerability to drought; and the ratio of mean rainfall in the three preceding years to the 1960–1998 mean, to indicate short-term variation from long-term rainfall conditions. Besides simplicity, the two indicators were selected based on an expectation of being predictors of occurrence of poor/not poor harvests reported in the community survey.

[5]AGEVEN (for AGE-EVENT) calendar includes the main events in the interviewee's life (birth, residential movements, employments, marriage, etc.) with precise dates.

Linking the three databases to study the influence of rainfall on migration—It was necessary to find a common denominator in the spatial and temporal resolutions, including a scale at which processes are observed (Petit 2001), to consider multiscale drivers of migration. Table 1 illustrates the issue. Given the focus of the project on migration determinants, the individual database was chosen as the key spatial scale, to be filled in with community and rainfall data. The sample covered the rural population in 1970–1998. Each person is "followed" from age 15 up to his/her first migration or the time of data censoring in 1998. The data are organized in a person-period data file in which each line represents a three-month period, the dependent variable indicating whether migration occurred. To link the individual data and the community data, each line representing a three-month period was filled by the characteristics of the settlement where the individual lived during the year. For example, if Dieudonné lived in January-December 1985 in Diébougou, the characteristics of Diébougou in 1985 were assigned to Dieudonne for all four lines of 3-month periods (e.g., presence of a primary school). To link rainfall data to the person database, the department level was chosen. Burkina Faso comprises about 350 departments (the second administrative level below provinces). Rainfall data, at a half-degree resolution, were thus aggregated to the department level using geographic information systems (GIS), and monthly rainfall data computed for 3-month time periods.

Preliminary results—This project investigated the impact of rainfall variability on migration in a West African country characterized by low rainfall. To provide a more complete picture of the relationships, several scales of analysis were used. At the province level, census data were modeled using Poisson regression, showing the inclusion of environmental variables improved the prediction of migration controlling for other variables, though explanatory power was low (Henry et al. 2003). Although preliminary due to coarse data resolution, this was among the first quantitative studies to study drought effects on internal migration in a developing country.

These preliminary results were confirmed and amplified by an event-history multilevel model of migration at the individual level, using another existing set of data, from a household survey, in which the dependent variable is whether the person migrated. Thanks to the wealth of data in the survey and from the global monthly precipitation database, many factors could be controlled, including age, gender, education, ethnic group and economic activity. Findings suggest that people from the drier regions were more likely to engage in both temporary and permanent migrations to other rural areas. Also, short-term rainfall deficits tended to increase long-term migration to rural areas and decrease short-term moves to distant destinations (Henry et al. 2004). Using the same three databases, a recent study examines choice of destination by introducing characteristics of the environment at both origin and destination in the same random utility model (Henry and Bilsborrow 2009).

Adding questions to an existing survey: a case study of Guatemala

Overall purpose and context of the project—This project aimed to investigate relationships between migration and deforestation in northern Guatemala. In an unusual and innovative experiment, questions were added to a standard Demographic and Health Survey (DHS) to collect data on both migration and the environment to test the value of such an approach. This was done for the 1999 Guatemala DHS for the department of Peten, where the sample size was also expanded by 20 %, resulting in data for 1073 households. Petén has experienced substantial net in-migration from elsewhere in Guatemala since the 1970s, along with extensive deforestation: half of its 1950 forests had already been cleared by 1985 (Leonard 1987). This continuing deforestation had been linked to migrants coming from areas where they were thought to have left due to rising population pressures on the land, increasing fragmentation of plots, and rural poverty (Bilsborrow and Stupp 1997).[6]

Questionnaire design—The questionnaire (Grandia et al. 2001, Appendix 4) contains modules of questions added to the basic questionnaire on migration history and experience of the household head in coming to the Petén (20 questions including date of birth, education, etc.), migration within the department after arriving (18 questions), future migration intentions (9), sources of family sustenance (9), the land in each plot used by the household (17), land use (up to 46 questions) and attitudes toward the environment (one question). The questions on migration *within* the region proved important since most people had moved at least once within the region after arriving. On household sustenance, the occupation of each person was ascertained although only the major source of household income was queried in addition to the responsible household member. Questions on land area began with the number of parcels owned by the household, and then for up to three, the area, location, ownership and duration, whether located in a national park or recognized buffer area, and whether the output from the parcel(s) is sufficient to sustain the household. Questions on land management queried about corn and other crops raised on the parcel, whether sold or not, number of consecutive years the plot had been used for that crop, how many years it is or will be left fallow, whether crops are inter-planted (mimicking in part the biological complexity of the forest) or monocropped, use of natural/chemical fertilizers and other inputs, whether crops had problems due to nature (poor soils, insect infestations, weeds, animals destroying corn plants, insufficient rain), whether the household collected anything from the forest (wood, medicinal plants, food, *chicle* for making gum, etc.), whether the household has cattle or other domesticated animals and how many, and whether the household uses fuelwood for cooking and who is responsible for collection.

Main results—The survey found that the vast majority of respondents moved to the Petén to seek land, as has been true throughout the developing world where people are advancing the agricultural frontier into forested areas (e.g., Keller et al. 2009). Indeed, 77 % lived in rural areas at the time of interview, 59 % were primarily agriculturalists (with another 13 % also involved in agriculture), almost all with a single parcel of land, with the median size landholding being 14 hectares (ha), used primarily for corn, followed by beans; 15 % had cattle, with a median of 13 head (Grandia et al. 2001). How the land was prepared for planting (burning vegetation, plowing with oxen or tractor, fumigation….) is relevant for the environment since hand clearing and burning, or using natural fertilizer, is less harmful to the soil than plowing with a tractor, cutting with a chainsaw and burning, or using fumigation. The vast majority practice monoculture on their parcel, use short fallow periods, and apply herbicides (58 %) or chemical fertilizers (42 %) more than natural nitrogen-fixing fertilizers (39 %). Questions in the survey on how many consecutive years a plot is planted in the same crop and then how many years it is left idle are both relevant for the environment, as the former depletes soil nutrients and the latter restores them.

The extensive questions on land access and management included whether the household had any land in forest and whether it was using any land in the national park or the buffer zone (which is illegal but much more common than the 12 % of respondents who mentioned doing it). The fact that most respondents (58 %) reported having migrated within the region since arriving may indicate that the productivity of parcels was declining over time due to loss of soil fertility. However, most soils were likely poor from the beginning, as SEGEPLAN, the National Planning Agency, declared that only 17 % of Petén land is adequate for agriculture (Grandia et al. 2001). This plus the very high human fertility in the region (a total fertility rate of 6.8 vs. 5.0 nationally) plus continuing in-migration do not

[6]Subsequent research revealed that the situation was more complex, as the majority of migrant settlers in Petén had come from regions of Guatemala other than the highlands or altiplano (INE 2003; Carr 2008).

bode well for the national parks: Increasing population pressures will represent a growing threat to the environment, notably the Maya Biosphere Reserve (*ibid*).

The survey also found that farmers report the area becoming more dry over time, as deforestation spreads (*ibid*), a phenomenon increasingly reported in other areas of the tropics as well (c.f. studies on the Brazilian Amazon in Keller et al. 2009). Farmers also often complained about infestations of plant pests, despite high herbicide use.

Main limitations—First, a minor point: the intention was to address the migration–environment module to household heads, usually males, but the main survey was directed to women of child-bearing age (15–49), consistent with the focus of DHS surveys on fertility and health. Thus, women were also often asked the questions instead and might not have been as familiar with the topics queried. Unfortunately, data are not presented on the final numbers of respondents, their gender, nor differences in response by gender.

Most questions in the survey are straightforward, but there are key gaps. First, there are no questions on the situation of the migrant or his/her household in the *previous* place of residence, limiting the ability to study determinants of migration, nor the role of environmental factors: The only relevant datum is in response to the question about why they left their previous residence, which included a response code for land not being fertile (6 % gave that reason). Questions on the use of chemicals would have been more useful if linked to the parcel and particular crop or land use (and if the chemical or brand name, and approximate quantity used, were also obtained). More importantly, there was no question on the *quantity of land* the household had in forest, nor on whether that quantity or the area in any use had *changed over time*, which is crucial to link to migration into and within the region by household members. While such questions would have stretched the data collection effort even further from the DHS focus on the demography and health of women and children, nevertheless, without this, land use (change) cannot be linked to in- or out-migration from the household (in contrast to the Ecuador case study, described below).

The single environmental attitudes question is “what do you think is the best use of the Petén forests: to preserve them, use for tourism and natural forest products, clear them for more agriculture, or clear them for more pasture for cattle?” The wording of this question is likely to elicit more responses in favor of the environment than the reality. Finally, the published report does not provide the results from questions on the number of years a parcel is used continuously for the same crop, nor the number of years it is left fallow between cycles of use–both key aspects of land use intensification.

Overall, the experiment is laudable and produced interesting results, although adding just a few questions on *changes* over time in land use and yields would have provided considerable additional useful information on the environment. Also, adding questions on antecedents to migration before coming to the Petén, and before migrating within the region, would have generated a quantum leap in the capacity of the survey to provide insights about the environmental and other determinants and consequences of migration, following the discussion in section “Migration.”

Designing a new survey to study migration–environment linkages: a case study of rural Ecuador

Overall project purpose and design—This project is unusual in being designed from the beginning to collect data from multiple sources and specifically to investigate whether environmental conditions have influenced out-migration from rural areas of Ecuador–although there was a secondary interest in studying out-migration’s environmental consequences. Data were collected in 2008 from a household survey, a community survey

and satellite imagery, complemented by ground-truthing of land use and geodetic control points.[7] Data covered the time period from 2000 to 2008. At the outset, it was decided that a number of conditions were necessary for a successful project:

a. *Clearly define migrants*, which were taken to be persons (or households[8]) who left to live outside the local *parroquia* (smallest administrative unit in Ecuador, akin to a US township, or a subdistrict in many countries) in the previous 8 years. Data were collected in June–October 2008 and inquired about persons out-migrating from sample households since January 1, 2000—an easily remembered date.

b. Consider the *full range* of migration movements involving changes of residence, to both internal (urban and rural) and international destinations, which is desirable to investigate differences in the determinants and consequences of migration by the type of destination.

c. Use specialized sampling and survey design methods to ensure finding sufficient numbers of *recent migrants* (along with non-migrants) to address the "rare elements" problem inherent in surveys of migration (Bilsborrow et al. 1997). This required the use of (i) stratification and (ii) two-phase sampling (see below).

d. Develop and test measures of natural resource endowments of farm households and communities, of environmental change, and of changes in other socioeconomic and infrastructural contextual factors, to investigate the *relevance of context* on migration.

Sample design—The first step is always to seek or create a suitable sampling frame. Data from the most recent 2001 census were tabulated by the National Statistics and Census Office (INEC) on the *proportion of population who out-migrated* from rural areas in the 5-year period prior to the census. Budgetary limitations led to the limitation of the project to three study areas with relatively high rates of out-migration: a primarily coastal and transition province (Santo Domingo/Tsachila), parts of two contiguous central Andean highland provinces (Chimborazo and Cañar), and a still hilly but drier southern province (Loja). In each of the three, the next lower level political units, *cantons* (similar to *municipios*, districts or US counties) were identified with relatively high proportions of out-migrants. In each, the proportion of the population reported as having out-migrated in the 5 years prior to the census was tabulated for all rural *parroquias* (one to 12 parishes per study canton) and listed. Systematic sampling was then used to select a sample of 30 parishes, with probabilities of selection proportional to the proportion of households with an out-migrant. These parishes constituted the primary sampling units (PSUs) and were, therefore, the lowest level political units with data on the prevalence of migrants available from the census. Census sectors were then selected randomly from sample parishes, usually two per parish, a total of 51 census sectors ultimately, constituting the Ultimate Area Units (UAUs). In each, 2-phase sampling was used, involving, first, listing all occupied dwellings according to whether the household had any former member aged 15–39 who had left to live elsewhere since 2000, by the type of destination. Supervisors were trained in how to sample households from the list, with written protocols to use taking into account any size

[7]Geodetic control points refer to the use of GPS receivers to document on the ground key locations observable from satellites, which can be used to precisely fit satellite images to ground observations, such as road intersections, rivers, bridges, large buildings, etc.

[8]Reliable data on whole households migrating away cannot be obtained from surveys conducted in origin area households only since there is no one left to provide data. A new methodology was accordingly tested, asking community leaders to list households departing since 2000—name of head, number of persons leaving, when (last person in household) left and destination. This can produce usable data in small rural communities, where community leaders know everyone and are, therefore, cognizant of when whole households left. Almost all studies of out-migration are based on originarea-only household surveys, which cannot obtain reliable data on whole households leaving. To the extent, the factors affecting their migration are different from those affecting the out-migration of individuals, understanding of migration is biased.

community and any prevalence of migrants, oversampling households with migrants (especially international) compared to those with non-migrants, who would then be interviewed in the second phase. This ensured that (a) results would be generalizable to the population of the 17-canton study area of the four provinces, and (b) sufficient households with recent out-migrants would be captured, including to each type of destination of interest.

Household and individual questionnaire designs—It is useful to summarize the questionnaire design for collecting data on the household and pertinent individuals since it facilitated collecting data on multiple persons each year over the nearly 9-year study period, in a rectangular data array. Briefly, the interview was based on a Household Questionnaire (HQ), administered to the head of the household or proxy, and an Individual Questionnaire (IQ) for each current household member who was aged 15–39 at any time in the interval 2000–2008, as well as for each out-migrant (who had left at age 15–39), for whom data were obtained from a proxy respondent–the person identified as most knowledgeable about the migrant. To capture circumstances pertaining to out-migration at the time of the migration, key data were collected for both the household and individuals on current conditions and also their situation *each year* during the 8.5-year reference period. Since the intention was to analyze the effects of household and individual factors on migration decisions using proportional hazard models, it was necessary to have data for *each* year in the study period on all individuals subject to the risk of migration.[9] This included time-varying (e.g., household size, age composition, land area and land use) and time-invariant variables (e.g., education of head, location of house).

The HQ included a roster of current members by age, gender, relationship to head, dwelling conditions, household assets as an indicator of wealth, geographic location (using GPS), road access and the major source (albeit not amount) of household income (from farming, a family business, agricultural or non-agricultural, labor, remittances from migrants, etc.) each year from 2000 to 2008. A screening question inquired as to the number and size of agricultural parcels the household owned or managed each year. For all parcels together (separate would have been preferred, but take more time), the household respondent was asked the total area planted in each crop in the past 12 months, production and sales, whether used modern inputs (e.g., chemical fertilizers) since 2000 and starting when, and whether the area planted in each crop changed and reasons for these choices—including several environmental reasons such as favorable/unfavorable climate/rainfall and good/bad soils.

For each parcel, the household was asked the size, whether owned or rented, and major land use each year since 2000 (forest, fallow, pasture, crops, other). Further questions inquired about the intensity of land use a la Boserup (use of irrigation, fertilizer, herbicides, hybrid seeds), the perceived quality of soil and changes in yields since 2000. Questions were also asked about access to, and use of, communal or public lands and resources (including national parks), whether for grazing animals or fuel wood. Inquiries were also made about the household's experience with natural disasters, drought and floods.

The IQ obtained data for each year since 2000 on all persons aged 14+, both current household members and out-migrants. Data were collected on both migrants and non-migrants, so their characteristics each year since 2000 would be available to compare *at the time of migration*. Data for migrants and non-migrants were pooled so statistical models could be formulated to estimate individual, household and community factors affecting

[9]Note that young individuals age into the relevant age pool during the reference period, while those in their thirties age out.

migration. To control for the effects of migration networks, data were obtained on residential location of close relatives.

The format of the IQ (and land use in the HQ) creates a rectangular array of data for investigating migration through event-history analysis using proportional hazards models. It facilitates analysis of *all changes in residence* over the given time period and allows links to an array of variables representing individual and household characteristics related to migration timing. This approach has the disadvantage of not being able to collect as much *detailed* data on the situation or events just prior to migration as is possible with a questionnaire that collects data on only the *last move*. The latter can collect more precise data in relation to the *timing* of the move[10] and more detailed and/or reliable data on more sensitive topics such as income, motives, etc. The migration history and last move approaches represent philosophically distinct approaches to data collection and analysis. The former, used in this survey, recorded data on the dependent variable (migration or not) each year together with basic individual factors potentially affecting migration, while the HQ and community questionnaires (below) collected data to formulate control variables, including environmental variables.

Community survey data collection—The population interviewed in each sample census sector identified itself with a local, small rural community. In each such reference community, a questionnaire was implemented to obtain data from a group of community leaders and informants on the situation of the community in 2008 as well as in 2000, and on some changes in the interim. Questions were asked about number of households and population size: in- and out-migration of individuals and entire households, and perceived effects on the community. Data were also collected on the main source of income of households, agricultural wage rates, seasonal labor migration and a host of infrastructure, including the year it became available. Related to the environment are questions on the community land area, including area in forests and public lands; approximate farm size distribution and households with no land; principal crops; prevalence of irrigation and use of modern agricultural inputs; cattle raising; soil quality; fuel wood use; major natural disasters since 2000 (earthquake, drought, flood, etc.) and number of households affected; and transportation and communications linkages with the nearest town, regional urban center, and the national capital, Quito. These data make possible the creation of contextual factors to include in the estimation of the determinants/consequences of migration, including environmental.

Spatial data collection and use to measure environmental conditions—Remote sensing data were collected to investigate additional environmental variables beyond those collected in the household and community surveys. A second reason for collecting these data was to facilitate measuring environmental conditions at different scales—household, community and regional, as an alternative to the subjective and potentially inaccurate data provided by household and community respondents on variables such as forest cover on their lands.

Landsat TM and ASTER satellite imagery were acquired for the study areas for the baseline year 2000 and each subsequent year as available up to the time of the survey in 2008. Standard image pre-processing was performed. Based on image time series, land use and land cover (LULC) changes were classified through a hybrid approach (Walsh et al. 2003) and enhanced using vegetation indices (including analysis of seasonal trajectories of

[10]The precise month of the move, rather than only the year, can be obtained, so information on the migrant (employment, marital event, wages) and the household (e.g., composition) can be obtained for a period just before the decision rather than only contemporaneous, in the same year.

vegetation to better discriminate land cover). GPS points were collected in the field by the interviewing teams on the locations of communities, sample households and main agricultural parcels. Two geographers also collected GPS points on main roads, rivers, road intersections, bridges and major types of land use, to assist in both geodetic control and to use to ground-truth land-cover classification of satellite imagery in 2008. Thus, the major forms of land use on the ground (bare ground, water, urban area, forest, pasture and main crops in each of the three study areas) were identified using GPS and matched to the spectral imprint of the satellite image at that same precise location to "teach" the satellite the land use corresponding to that imprint. Other locations (pixels) in the image with the same spectral imprint were then assigned that same land use—a procedure that "classifies" land use in satellite images.

A GIS was used to encode digital spatial coverages from Landsat at 30-m resolution to characterize resource endowments of study communities (soils, terrain slope, hydrography, potential soil moisture), LULC change patterns,[11] generated using the classified image time series and the derived vegetation indices and geographic access and connectivity (via roads) for survey households and communities. Pattern metrics were used to describe the spatial structure of LULC, including land fragmentation, forest fragmentation and secondary growth (Read and Lam 2002; Walsh et al. 2003). These data were drawn upon to develop measures of environmental factors at community and household levels to explore the extent to which environmental factors are statistically linked to out-migration from survey households.

Some preliminary results—This work is currently ongoing, and illustrative preliminary results are presented here. Households that contained a member aged 15–39 in one or more years in the period 2000–2008 constituted the eligible households for the study of migration. Migrants were members who left the local community for at least 6 continuous months in this time period. Taking into account the 3 % who refused to be interviewed and a few others with incomplete data, 843 households were used in the analysis, containing 5,141 persons and 716 out-migrants aged 15+. The number of corresponding communities for which community-level data were collected was 107.

Survey data, remote sensing data, topography and road map data, and GPS readings of households, communities, roads, and land use were put into a GIS to draw upon for formulating (and experimenting with different measures of) variables for statistical analysis. Multinomial discrete-time event-history models were developed and tested to estimate the determinants of (out-) migration from the rural study households, that is, why each eligible person migrated or not each year from the sample household in a community, and what role environmental factors played in the decision once all the other factors available were controlled for at the individual, household and community levels.

Preliminary results show that environmental factors do affect out-migration decisions, though the effects are both modest and more complex than anticipated. Better quality land was associated with higher migration to international destinations (interpreted as facilitating financing) but lower to internal ones (since it provides a better income and perhaps more farm work). Higher mean rainfall reduced migration to international destinations, but did not affect migration to internal ones. Yet, yearly deviations from the mean increased migration to internal destinations while reducing movement to international ones. Further analyses are under way using the other environmental variables available from the satellite imagery, at

[11]Pattern metrics measures were used as dependent variables to capture aspects of land use change and fragmentation at the farm level in Pan et al. (2004) for the Ecuadorian Amazon. Metrics used were fragmentation of land use, patch density and total edges per unit area, for each farm.

both the household and community levels. The preliminary findings also clearly demonstrate the importance of taking into account the type of destination.

Overall, having a survey design from the outset that aims to collect detailed and appropriate data on both migration and the environment has the great advantage of better measurement of both processes and their determinants, thereby reducing misspecification of models due to missing variables and yielding more robust results.

Some limitations of the study—Although a desirable approach, the survey method described above is not without limitations. First, the number of households found and listed in the 51 sample census sectors and the number with an eligible young adult member aged 15–39 any year in the period were both smaller than anticipated from the 2001 census. This was likely due to the out-migration of households since 2001, as part of the secular rural–urban migration ongoing in Ecuador (as elsewhere in Latin America) for decades. Second, cloud cover in one of the three study areas (Santo Domingo) was so widespread around 2000 that no baseline imagery for classifying land use could be obtained, so environmental variables based on that imagery were not available for approximately a quarter of the sample. In addition, rainfall data were available from only 20 rainfall stations in the three study areas combined, which is insufficient to capture local variations well. Third, due to the lack of resources, data were not collected at all on a potentially important environmental variable, soil quality, which is, therefore, absent from the analysis.

Discussion

The case studies illustrate alternative approaches, each with advantages and disadvantages, which are elaborated below. It is also useful to compare these quantitative approaches to data collection and analysis with those of qualitative methods.

Regarding using existing survey and other data

Using existing data from a census and/or household survey has several major advantages and should not be neglected. The biggest is, of course, that the data are already collected, so the significant costs of new data collection are eschewed. However, to capture the multiple dimensions of the migration–environment nexus, different databases are typically needed, requiring both technical and substantive knowledge in a variety of areas—demographic, socioeconomic, land and climate, for example.

Given the timeliness of the topic and dearth of scholarship, many sources of potentially useful existing data should be considered. But combining existing sources to create data files that can be merged for analysis is often not a simple task, since it requires that the data refer to (a) the same time period or years, and (b) the same geographic areas. For some existing types of data, (a) is often not a problem since the data are collected continuously—for example, satellite imagery, precipitation and temperature data. But even here, with regard to the latter items, many developing countries have few stations collecting meteorological observations, while others have too few to provide reliable data for the spatial resolution of precipitation and temperature data to be sufficient for analysis at the household level (note the case of Ecuador above, where the number of weather stations was only 20 in the three study areas combined). The latter requires mathematical interpolation between points—and its related assumptions—or resorting to using data with a coarser resolution (and hence less reliable). Indeed, this is already being done implicitly in using publicly available data such as the WorldClim data, which are available for most of the planet since the 1950s at a one km^2 resolution (Hijmans et al. 2005).

Even more important is the substantive coverage of existing data, since their value is limited by (a) the questions in the existing questionnaire and (b) the sample. It is rare (though worth checking) that either will conform well to the needs of migration–environment researchers in providing *either* the desirable migration data or the needed environmental information, much less both. For example, in the Burkina Faso case, the questionnaire was not developed to capture environmental variables, so very little data were collected; in addition, the restricted area covered by the existing sample made it impossible to investigate results by ecological or climatic zone (although the eight strata were not totally different from agro-climatic regions). Thus, for example, it was possible to determine odds ratios of someone in the sample moving after a drought event but not to estimate the number of migrants who moved after a specific drought, such as 1984–1985.

Regarding adding questions to an ongoing or already planned survey

The example of adding questions to an ongoing survey, in Guatemala, illustrates both the advantages (principally the low incremental or marginal cost) and the limitations of adding questions to a survey with a different topical focus. As noted in section “What to measure for studying the migration–environment nexus,” extending a survey with questions of a different nature may meet resistance from the survey’s established stakeholders. In addition, a more lengthy survey could reduce respondent cooperation and data quality.

Thus, there are thus two important factors to consider with regard to adding questions to an existing survey: (1) the length of the existing questionnaire; and (2) whether it is already collecting some data on either or both migration and the environment, thereby reducing necessary additions. Of course, an existing questionnaire should also (3) be collecting extensive data on many other factors useful in investigation of linkages between migration and the environment— control variables. Finally, there is an additional consideration—evident from the discussion of the Burkina Faso case above—(4) sample coverage of the existing planned survey must cover an area (or areas) of significant environmental interest.

From the points of view of (3) and (4), the DHS-Guatemala survey was a good choice, as it was already collecting a wealth of data, some relevant to migration–environment research, and also had a good sample size and coverage of the area of greatest environmental interest in the country, Petén. The choice of DHS had the additional value of potentially being not just a one-time effort since it could be replicated (or learned from and improved) in many other countries. On the other hand, DHS was not an ideal survey to “piggyback” on from the perspectives of points (1) or (2): The questionnaire length was already long, and DHS normally collects very little data on migration or the environment. Finally, its primary purpose is well-defined and quite distinct from understanding migration–environment relationships, so that trying to mix two such different survey purposes may confuse respondents about the objectives of the survey. Nevertheless, in Guatemala, it was possible to add a large number of additional questions. While these have led to interesting findings, as noted above, considerably more could have been achieved with some alterations in questions.

Regarding creating a new survey

A specialized survey designed to collect the data desired on both migration and the environment has great advantages over the other two approaches. Data collection (including questionnaires) can be designed from the outset to collect more relevant data on both topics, which can be used in turn to create better formulated and measured migration and environmental variables. This makes possible better analyses of their relationships, which is particularly important as the main causal linkages between migration and environment are still not well understood or estimated.

This approach requires, however, an ambitious project with an interdisciplinary team, including specialists on sampling and survey design, migration and the environment, which may comprise a statistician/sampler, economist and/or sociologist, and a geographer. The main disadvantage of this approach is the *significant monetary cost* compared to the other two options described above, since they involve data that already exist or have only small marginal costs required, whether to locate the existing data (e.g., Burkina Faso) or to add questions to an existing survey (the Guatemala case).

Nevertheless, not all data desired can be collected in a household survey or even a household survey combined with a community survey. Some data, both socioeconomic and spatial, may need to be obtained from other existing sources, with all the advantages and disadvantages indicated in "Regarding using existing survey and other data." Thus, there may be data available from an economic census, an agricultural census or a village census (common in some Asian countries, accompanying the population census, viz., Indonesia, Vietnam, India) that provide useful contextual data on employment conditions, wages, infrastructure, and land distribution and use—at local and larger scales. Climate data cannot be obtained reliably from households; data on precipitation and temperature are available from weather stations in the country, or WorldClim, though the resolution may be coarse, as was the cases in both Burkina Faso and Ecuador here. The point is that even with a new survey designed to collect appropriate data on migration and the environment (as well as a host of important control variables), it will usually be desirable to also examine existing data from censuses and surveys for useful data, as well as draw upon satellite imagery, soil samples and other sources for pertinent environmental measures.

How can we improve our understanding of migration–environment linkages?

Improving migration data—For migration data, it is necessary to improve data collection systems to produce accurate, comprehensive and timely information on migration flows (Bardsley and Hugo 2010; UN 2009). First, it is necessary to improve data on migration from the population census, as recently reiterated by experts at various UN meetings on internal and international migration (including UN 2009). This was also one of the recommendations of the Center for Global Development (Washington DC), which lists five steps toward better data on international migration (Santo Tomas et al. 2009). Having such data is extremely helpful for studying the migration–environment nexus since it can provides an excellent sampling frame for selecting a sample of households and communities to conduct the new survey data collection. Nevertheless, household surveys, as is well-known, are far more flexible than census data and allow collecting data on a broader range of topics and in much more detail on migration (Bilsborrow et al. 1984, 1997).[12]

Improving environmental data—Environmental data also need to be expanded and improved, particularly in the developing world, where, for example, there has not been a comprehensive study of soil degradation since GLASOD (Global Assessment of Soil Degradation) in 1994 (Bot et al. 2000). For climate data, several databases exist, mainly, however, based on a network of weather stations generally inadequate in both number and geographic distribution in developing countries (such as Climate Research Unit[13] or NOAA/National Climatic Data Center[14]); in addition, real-time records of local rainfall and improved forecasts are needed in order to cope with natural events and mitigate the effects of disasters. Automated weather stations and river discharge monitoring stations should thus be located especially in critical areas. This would also help research by allowing making

[12]In this context, it is important to highlight the initiative of the Internal Migration around the Globe (IMAGE) project that aims to collect and compare data on internal migration in more than 150 countries (http://www.gpem.uq.edu.au/image).
[13]University of East Anglia, UK, http://www.cru.uea.ac.uk/.
[14]http://www.ncdc.noaa.gov/oa/ncdc.html.

finer links between environmental measures and population movement in places particularly important for policy.

New agricultural censuses would be useful for the collection of comprehensive data on land ownership and land use–in forests, crops, pasture, etc. (see section "What to measure for studying the migration–environment nexus"). There has actually been a serious decline in the implementation of agricultural censuses in developing countries in the 1980s–1990s, though the UN Food and Agricultural Organization now has a program to promote implementation of these censuses more widely once again.[15]

Developing comparative studies—Because of the complexity of causal linkages between migration and the environment, as individual country/region studies are completed, it is increasingly desirable to also develop several larger projects based on a comparative approach in multicountry sites. The EU EACH-FOR project had that goal, but funding was a limiting factor. It is necessary to collect data for measuring and investigating multiple measures of the environment (e.g., forest cover, land use, soil degradation and desiccation, etc.), in a variety of physical contexts and ecosystems, including mountain, agricultural, tropical forest, semiarid and coastal areas. It is also useful to consider different types of migration, since that will make it possible to examine interrelationships and trade-offs between, say, long- and short-term internal migration and international migration, and their relationships with the environment, including environmental degradation and stressors, at different times and spatial scales.

Combining qualitative and quantitative approaches—Another useful way of collecting data to investigate the migration–environment linkages is to integrate quantitative and qualitative methods. One example of the latter is focus groups, with groups of similar persons (migrants, non-migrants, farmers, men, women, young persons, etc., in different locations); another is in-depth interviews with individuals in different locations and environmental conditions. Respondents for in-depth interviews may be sought out *prior to* developing the household survey and questionnaire, to help develop hypotheses and identify topics pertinent to investigating the nexus (and which may otherwise be neglected), providing guidance on questionnaire design; or they may be selected from survey households *after* the survey has been finished. In the latter case, the goal is to learn more about why certain things occurred, whether and how the respondents view migration and the environment as linked, as well as provide historical details. The greater time trained ethnographers spend in developing rapport with respondents can lead to more complete and better quality data. This can be especially useful in case of sensitive questions (e. g, for undocumented international migrants, or data on income, assets, relationships, motivations).

On the other hand, qualitative data collection involves additional time and personnel costs, and the small sample size cannot be representative of the study population. Its value also depends on the skills of the interviewer, in creating an environment of confidence or *confianza*, to deal with sensitive issues. In any case, using both quantitative and qualitative approaches can be the most powerful method of data collection and are particularly useful in situations where there is little prior knowledge of the study population's behavior with respect to migration and the environment.

Using a broader theoretical approach than migration—Using a livelihood theory approach could provide a broader theoretical framework useful for better conceptualizing the relationships involved, including between migration and the environment. For a long

[15]FAO, World Programme for the Census of Agriculture, 2010 (www.fao.org/es/ess).

time, migration scholars have neglected the role of the environment as a potential migration driver, focusing on economic, social, demographic, household and political factors (Gemenne 2010). A similar approach has been developed by Davis (1963) and Bilsborrow (1987), the theory of the multiphasic response. Integrating environmental factors in these evolving, multifaceted approaches is an important challenge requiring further conceptualizing advances, but may prove most fruitful. In this context, Professor Hogan made important contributions, calling for a broad, interdisciplinary livelihood approach, examining relationships in both directions and, in his last publications, integrating the concept of environmental vulnerability (see "A note on theory and Daniel Hogan's contributions to the migration–environment field").

Conclusions

Some years ago, in her Presidential address to the Population Association of America, Ann Pebley (1998) argued that demographers should pay more attention to the effects of the spatial distribution of populations on the environment. Certainly, this has been occurring, although significant data limitations persist. Studying the relationships between migration and the environment is an extraordinarily complicated undertaking, as each topic is complex in its own right. Interdisciplinary data and research teams are required.

The population–environment field is new in terms of careful quantitative studies, but has much to gain from using not only better designed surveys but drawing upon and integrating data from remote sensing, which continue to improve in accessibility and quality. Within the broader environmental demography realm, the migration–environment field is only in its infancy. Even so, with sustained efforts at using existing data, and collecting new data in a variety of locations, important advancements are well within hand.

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Table 1

Comparison of temporal and spatial resolutions in Burkina Faso

	Temporal resolution	Spatial resolution
Individual data	3 months	Settlement
Community data	Annual	Settlement
Rainfall data	Monthly	0.5° lat. and long