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MIGRATION AND LAND DEGRADATION:

Recent experience and future trends

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CONTENTS

SUMMARY

Land degradation and migration are closely interconnected processes, which are mediated by other intervening social, economic, political, demographic, and environmental processes, operating at scales from the local to the global. To fully understand the dynamics of livelihoods, land use, land degradation, and development in developing regions, a clearer understanding of the role played by migration is essential. Households that are heavily dependent on basic ecosystem goods and services often turn to migration as a means of diversifying their livelihood strategies and sources of income, and/or as an answer to the exigency of adapting to variable environmental conditions and socio-economic uncertainty. Traditional livelihood practices, such as pastoralism, shifting agriculture, and small-scale farming are inherently mobile and well-adapted to challenging environments, but are, in many countries, being pushed aside by more intensive land use practices. In developing dryland areas, migration tends to flow from areas of more degradation to those of less, with drought often elevating migration flows. The margins of tropical and dryland forests often attract migrants from other areas seeking to establish small-scale farms, which can further drive the process of deforestation and land degradation.

This report provides a detailed analysis of how migration is connected to land ownership, land use change, and land degradation. It begins with an overview of general migration theories, and then quickly focuses on how environmental factors influence migration. After introducing a well-established conceptual model to guide further analysis, the report takes the reader through a large number of specific examples of migration associated with land degradation and droughts, from a range of countries and regions. Emphasis is placed upon the influences of socio-economic and political processes, as well as the complexity of interactions, and the heterogeneity of the potential migration outcomes. Common themes that run through the examples are highlighted, such as adaptation, diversification, social networks, gendered migration, and the importance of land tenure arrangements. The report summarizes how climate change will affect and alter existing land degradation-migration dynamics. This is followed by an overview of methods used by researchers to measure and map land degradation-associated migration, and to identify potential future 'hotspots'. The report concludes by summing up common themes and identifying important considerations for policymakers. These emphasize that, because livelihoods in degraded areas are closely interconnected with migration, any policies that do not consider the migration implications of potential interventions run a risk of failure and of impoverishing people who depend on the land. The report points to a strong need for migration to be considered and mainstreamed on an ongoing basis into international, regional, and national policies and programs to combat land degradation.

This report is based principally on peer-reviewed research and includes an extensive reference list. A two-page briefing note for policymakers accompanies this report.

1. INTRODUCTION

Land degradation and migration are closely interconnected processes in many parts of the world. Mobility, and the ability to migrate, are important components of livelihoods in developing regions, especially for rural populations that depend heavily on basic ecosystem goods and services. The connections between land degradation and migration are complex, and are mediated by intervening social, economic, political, demographic, and environmental processes that operate at scales from the local (or micro) to the global (or macro). In some areas, population pressure – through natural increase and migration from other locations – helps to drive or exacerbate land degradation. In other areas, people are actively migrating away from degraded land. In still other areas, both land degradation and migration are modest, as local populations have learned – through innovation and good land management practices – to live within the capacity of the soil, water, and biological resources available to them.

In many parts of the world, people who practice traditional livelihoods that place modest demands on the land, such as pastoralism and small-scale farming and forestry, are quite literally being pushed aside by governments and economic actors pursuing commercial resource development and intensive agricultural production. Traditional or communal land tenure rights are being converted to private ownership, facilitating the acquisition of land by outside interests. In some countries, governments proactively facilitate migration from crowded peri-urban areas to less developed forest frontiers, encouraging the clearance and conversion of forests, and thereby spreading land degradation to new areas; in other countries with weaker governance, this process happens of its own accord, as people independently search for opportunities their governments cannot provide.

As will be shown in this report, migration is a key method by which households cope with, and adapt to, rapid and ongoing environmental and non-environmental changes. The connection of the terms land degradation and migration will, for many readers, conjure up images of the large-scale, famine-related migrations of the 1970s and 1980s in Asia and Sub-Saharan Africa. These are examples of migration being used as a last-resort survival mechanism under extreme conditions of drought, economic hardship, and political instability. Although such events continue to happen, these are a less common form of land degradation-associated migration. Most land degradation-associated migration in terms of frequency and scale occurs not under conditions of absolute distress, but of economic development and diversification, as economic actors and households try to take advantage of new opportunities, generate new income sources and, in the case of households, reduce their exposure to environmental and non-environmental risks and hazards. These less dramatic forms of land degradation-associated migration tend to go unnoticed and raises few alarms; but, if one is to fully understand the dynamics of livelihoods, land use, land degradation, and development in developing regions, a clearer understanding of the role played by migration is essential.

This report provides a detailed and well-rounded analysis on how migration is connected to land ownership, land use change, and land degradation. Section 1 begins with an introduction regarding how researchers understand the processes and patterns of migration in general, and then focuses upon how environmental factors influence migration. Section 2 describes key paradigms that have shaped how researchers understand the relationship between land degradation and population processes, of which migration is a main component. Section 3 takes the reader through a number of specific examples of migration that have been influenced by various combinations of land degradation, drought, and socio-economic change, in selected countries and regions. In doing so, this section provides the reader with an appreciation for the complexity of the interactions and the heterogeneity of the potential migration outcomes, while, at the same time, flagging common themes that run through the examples, such as adaptation, diversification, social networks, gender, and the importance of tenure. Section 4 reviews how climate change is likely to affect and alter existing land degradation-migration dynamics. Section 5 describes common methods used by researchers to measure and map migration related to land degradation, and to identify potential future 'hotspots'. Section 6 concludes the report by summing up common themes, identifying important considerations for concerned policymakers, and commenting on current initiatives, such as the push for land degradation neutrality, for avoiding 'degradation-abandon-migrate' situations, and for restoring a culture of land stewardship, while continuing to foster economic prosperity and poverty alleviation in developing nations. This report is based principally on research published in peer-reviewed scholarly journal articles that are carefully cited, with a full reference list appearing immediately following the conclusions.

2. UNDERSTANDING ENVIRONMENTAL MIGRATION AND DISPLACEMENT

Rarely a week goes by without a new study or media report describing how climate change, droughts, natural disasters, or other environmental phenomena are driving people from their homes, all around the world. This reflects a growing awareness of how human activity is rapidly altering the basic functioning of natural systems, and of our vulnerability to the impacts of the environmental changes we have caused. In recent decades, an active and growing research community has emerged, spanning multiple disciplines in the natural and social sciences, that is concerned with understanding the relationship between changes in the natural environment and human migration and displacement. This section provides a brief overview of basic theoretical and conceptual developments in migration scholarship that are essential to the understanding of the relationship between environment and migration.

2.1 Why do people migrate? General theories of migration and displacement

The origins of modern migration research trace to the late 19th century writings of British-based scholar Ernst Georg Ravenstein, who used British census data to identify important patterns in domestic and international migration, and to theorize about their respective causes in his seminal work, the 'Laws of Migration' (1889). Ravenstein made many observations that hold true today, such as: that migration tended to flow from rural areas to urban centers; that migration patterns of men and women differed; that migration was tied to the availability of employment opportunities; and that distance between places of origin and places of destination was a relevant factor. Key basic terms and concepts used in migration research today are summarized in Box 1.

Box 1: Migration basics

The term migration generally refers to a permanent or semi-permanent change in place of residence (Lee 1966). Commuting to work, going on vacation, or moving to another apartment in the same town or city are actions that are generally not considered to be migration (but are part of the much broader concept of 'mobility').

Migration can have a variety of temporal dimensions. That is, people may migrate for various periods of time that can be described as seasonal, temporary (but not seasonal), or indefinite (or permanent) (Gonzalez 1961). People might also migrate recurrently between two or more places, or even migrate continually throughout a broad region without any specific end destination, such as nomadic pastoralists.

Migration often follows common spatial patterns, the most common one being from rural areas to urban centres, typically called rural-urban migration. The opposite pattern, urban-rural, also occurs but is less common. Other common spatial patterns are migration completely within rural areas (i.e. rural-rural or intra-rural migration) and between cities (inter-urban migration).

Most migration takes place within national boundaries. International migration mostly takes place between contiguous countries. Long distance international migration from low income countries to high income countries averages just over 4 million people per year, making it a relatively small contribution to the more than 200 million international migrants currently found worldwide (United Nations, Department of Economic and Social Affairs, Population Division, 2015).

Migration patterns are path-dependent; that is, migrants often move to places where people like them have gone before, using family or social networks to help with the journey and with getting established at the destination (Massey 1990). Migrant pathways often emerge between countries and places with shared histories, cultures, and languages. This is seen today in Europe, where Britain, France, Spain, and Portugal have large immigrant populations from their former colonies in Africa, Asia, and the Americas. Once established, transnational social networks facilitate future migration and exchanges of goods and services between countries.

Migration preferences change over the course of a person's life (Plane 1993). A child's migration is typically the result of decisions made by parents seeking to secure the child's welfare, such as by sending a child to stay with relatives living near a good school. Young adults, especially before they marry, are typically the most mobile people within any society, and will often move for purposes of education or employment, or simply to take advantage of cultural or lifestyle opportunities. As people become older and better established in their employment or livelihood, they tend to move less frequently. When it is time to retire from working life, people may migrate once again, in many cases returning to their place of origin.

Scholars typically make distinctions between voluntary and forced migration, using the term 'agency' to refer to the degree of freedom an individual has when making a decision to migrate or not. Often, migration decisions are neither completely voluntary nor completely involuntary. The global number of forced migrants (i.e. refugees and displaced persons) and stateless people is estimated to be 65 million (UNHCR 2016).

For much of the 20th century, the dominant approach to understanding migration behavior was grounded in classical economic theory, which assumes that people are most likely to move from places with lower wages to places with higher wages, drawing upon the information available to them about the relative costs and benefits of moving (Todaro, 1969). Migration is in this way seen as an opportunity-seeking endeavor, with a range of macro- and micro-economic factors, such as labour markets, commodity prices, housing costs, valuation of workers' skills, and competition all influencing the timing, duration, and direction of migration flows. There is considerable empirical evidence to suggest that such factors continue to impact migration patterns at the global, regional, and local scales (Hatton & Williamson, 2003; Molloy et al., 2011; Rabe & Taylor, 2012).

In the 1980s a new explanation of migration behavior emerged, also economic in nature, but different in that it saw migration not so much as an opportunity-seeking endeavor, but as a means by which households sought to reduce and diversify their exposure to economic uncertainty and unexpected difficulties, as well as to ensure the longer-term well-being of household members, collectively (Stark & Bloom, 1985). Often referred to as the 'new economics of labor migration' (or NELM), this approach corresponded well with observations of complex migration patterns of people in developing nations, where migration does not necessarily flow from areas of low wage to high wage. Subsequent research has shown, for example, that rural populations in West Africa use migration strategically to cope with the inherent seasonality of the climate (Barbier et al., 2009). Some groups have historically pursued semi-nomadic pastoral lifestyles that are inherently migratory, continually moving herds of livestock to areas with sufficient pasture and water (Hampshire, 2002). Others pursue more sedentary, farming-based livelihoods, but nonetheless use migration strategically, sending young adult household members to cities during the dry season so as to reduce the demands on household food supplies, and in the hope that they may earn money while away (Rain, 1999). In both instances, the primary aims are diversification and risk reduction.

The NELM emphasis on migration-as-diversification corresponds well with the 'sustainable livelihoods' approach frequently used in international development research (Scoones, 1998), leading many experts and practitioners to explicitly link migration and livelihoods when discussing development programs and initiatives, especially in drylands and marginal regions (Abdelali-Martini & Hamza, 2014; de Haan, 1999). Remittances feature heavily in the relationship between migration and development, and, as will be detailed in Sections 2 and 3, they are also relevant when it comes to building household resilience and adaptive capacity in difficult environments (Scheffran et al., 2012).

In many developing regions, young adults migrate in search of wage labor opportunities, with the understanding that they will remit a significant portion of their earnings back to the sending household (Adams & Page, 2005; Lokshin et al., 2010). Indeed, in many countries, remittances from migrants sent overseas represent a disproportionate amount of household incomes, and may exceed official development assistance (The World Bank, 2016).

There are many other reasons, besides economic ones, that encourage individuals and/or households to migrate, or to opt not to, with the decision usually influenced by a mix of economic, social, cultural, and other factors. Very common reasons for migration across many cultures are family related, such as the desire to be reunited with loved ones or to care for relatives in need. Migration is also often undertaken to seek out and explore non-economic opportunities, such as lifestyles or particular cultural attributes. Many young people migrate to large urban centers for what is often simply referred to as the 'bright lights-big-city' phenomenon (Argent & Walmsley, 2008), while in some cultures, leaving home and migrating elsewhere is seen as a rite of passage to adulthood (Mata-Codesal, 2015). For other people, migration may not be a matter of choice but constraint. Involuntary displacement and refugeeism are rising, worldwide (UNHCR, 2016).

Modern international refugee law and policy has its origins in the Second World War, with the *United Nations Convention relating to the Status of Refugees* defining 'refugees' as being people who are obliged to cross international boundaries for fear of being persecuted in their home country. Refugees are distinguished from internally displaced people, the latter being those who are obliged to migrate within their home countries for a variety of potential reasons, but who are not entitled to any formal protection by the international community (for a more detailed review, see Gemenne & Brücker, 2015).

2.2 How environmental change affects migration

The habitat of any species of living organism is shaped by environmental conditions, such as temperature, precipitation, and biodiversity; humans are no exception to this rule. The terms 'natural capital' and 'ecosystem goods and services' are commonly used to describe those attributes of the natural environment that are essential to human livelihoods and well-being (Millennium Ecosystem Assessment (MEA), 2005a ; Scoones, 1998). Ecosystem goods and services are not evenly distributed across the face of the earth, making certain locations inherently more suitable for human habitation than others. The motivation to gain access to ecosystem goods and services has, therefore, been a key driver of population and migration patterns for much of human history (McLeman, 2014). Through behavioral and technological adaptations, humans were able to expand in number and in geographical distribution, mobilizing ever greater amounts of natural capital, and modifying the functioning of ecosystems to better suit human needs (Behringer, 2010). The 20th century saw especially rapid transformations in human-environment relations, an important one being that, since approximately 2009, the majority of people now live in urban settings, as opposed to rural ones (United Nations, Department of Economic and Social Affairs, Population Division, 2015).

Today, many people living in developed countries, and/or in large urban centres, give little thought to where the ecosystem goods and services on which they depend originate, and only infrequently is their migration behavior directly shaped by variations or changes in environmental conditions. However, in developing parts of the world, and in rural areas especially, where access to basic livelihood needs like water, fertile soil, food, and fuel is often insecure, migration patterns continue to be strongly influenced by variations in environmental conditions. The attention of researchers to the relationship between environmental change and migration has fluctuated since the days of Ravenstein, but is today receiving growing attention, particularly because of mounting concerns about the human impacts of anthropogenic climate change. The remainder of this section traces environmental migration research from its early 20th century origins to present day paradigms; readers seeking a more in-depth account may wish to consult McLeman (2014).

In the early 1900s, there emerged a strong interest in the relationship between environment, development, and migration among German and American scholars, who pursued a line of research often now described as 'environmental determinism' (Gemenne, 2011a). According to such theories, not only did environmental conditions – such as temperatures and water availability – shape where people lived, and where they would potentially move (as scientists had long known), but the environment was also believed to influence the industriousness and economic wealth of various groups and races of people (Huntington, 1924). This 'environmental determinism' and its inherent racial biases quickly fell out of favor among scholars and, except for a brief period of interest among American sociologists and economists during the 1930s Dust Bowl years (e.g., Taylor & Rowell, 1938), research on environmental migration generally declined through the mid part of the 20th century. When researchers considered environmental influences on migration at all, it was typically in the context of amenities that might be desired by migrants once their other social and economic criteria for potential migrant destinations had been met (Abrams et al., 2012). A simple example of environmental amenity migration would be the attraction of Florida's mild climate for retirees from northern parts of the US.

In the late 1970s and early 1980s, interest in environmental influences on migration was rekindled by scientists studying the impacts of natural hazards, who observed that the same type of hazard event, such as a tropical storm, could kill thousands of people and displace many more in a developing country like Bangladesh, but result in few deaths and little more than temporary evacuations in a wealthier place like Florida (Burton et al., 1978). In trying to explain the difference, researchers began to use the concept of 'vulnerability', which, in its simplest sense, refers to the potential of experiencing loss or harm (Weichselgartner, 2001). Researchers realized that vulnerability is not simply a function of being exposed to a particular environmental risk, such as a storm, but is also a function of the sensitivity of particular livelihoods to that environmental risk, and the ability of the people exposed to those risks to adapt and cope with them; these abilities, in turn, are functions of social, economic, and political forces (Burton, 1997). A simple way of understanding this is to consider the quality of housing. People living in self-built housing on steep slopes or in poorly drained areas – a common phenomenon in the cities of many developing countries, where people live in such locations because they have no other options – are inherently more sensitive to the impacts of a severe storm than those living in solidly constructed homes on higher ground. As a result, the more vulnerable are more likely to experience serious injury or death. Further, some households, communities, or societies are better adapted to the risks associated with particular environmental hazards (Smit et al., 1999). For example, residents of Florida have for many decades had reliable weather forecasting systems that warn them of impending extreme storms, emergency plans that facilitate quick evacuation, and insurance and federal emergency funding to help them rebuild and recover following an extreme event; these are all things that are typically unavailable to people living in developing countries. Although adaptive capacity is invariably tied to wealth, as was seen in the aftermath of Hurricane Katrina in 2005, even affluent residents of the wealthiest countries can experience significant loss or harm following a particularly extreme weather event (Kates et al., 2006).

The 1970s and 1980s also saw great interest among natural scientists and development experts in the causes and consequences of famines and large-scale displacements in Asia and Sub-Saharan Africa. Although popular reports often blamed famines on soil erosion and land degradation caused by poor farming practices, research showed that land degradation was not caused by ignorance on the part of herders and small farmers, but on larger socioeconomic forces that put people in vulnerable positions, obliging them to overwork the land (Blaikie, 1985; Blaikie & Brookfield, 1987). Also influential at that time was development economist Amartya Sen's (1981) 'entitlements theory', which argued that famine was a product not simply of drought or environmental degradation, but also of social, economic, and cultural processes that determine which people within a society can financially afford, and have access to, food on a regular basis (Adger, 2006).

Within the environmental non-governmental organization (NGO) community, a new term was coined to describe people displaced by famines and other disasters: 'environmental refugees' (El-Hinnawi, 1985). The term had a broad and loose definition, and referred to people who are obliged to move not only because of the direct consequences of natural disasters, droughts, or famines, but also because of deliberate human actions, such as people forcibly relocated from their homes to make way for the construction of dams – a common phenomenon in many parts of Asia during that period (Cernea, 1995). In this conceptualization, people who move for environmental reasons are people who are unable to adapt. The term became popular in the media, especially when British ecologist Norman Myers warned that the combined effects of environmental degradation, natural disasters, and the newly recognized dangers of climate change would generate hundreds of millions of environmental refugees by the middle of the 21st century (Myers, 1993, 1997, 2002). His arguments were given additional weight when civil conflicts that emerged in Sub-Saharan Africa following the Cold War, such as those in Rwanda, Mauritania, and Somalia, were attributed by security scholars to resource scarcity and environmental degradation (Homer-Dixon, 1991, 1999). Researchers with expertise in migration and refugee studies began actively discouraging use of the term 'environmental refugee' given its overly simplistic representation of the relationship between humans and nature, its lack of theoretical or methodological rigor, and its inconsistency with international definitions of what constitutes a refugee (Hartmann, 1998). The term and its variants like 'climate refugee' remain infrequently used in current peer-reviewed academic research.

Growing interest, among social scientists, in the environmental dimensions of migration was triggered by recognition, in the 1990s, of the dangers of anthropogenic climate change. It became apparent that future decades would see rapid increases in average global temperatures, changes in precipitation patterns, increasingly severe tropical cyclones, and coastal communities threatened by rising sea levels (McCarthy et al., 2001; Tegart et al., 1990). Social scientists thus began combining the vulnerability concept used by natural scientists with the basic principles of established migration theory to assess the migration implications of climate change (McLeman, 2014). This led to the emergence of the current paradigm that dominates environmental migration research, in which migration is seen as one of any number of potential outcomes as people cope with, and adapt to, changes in the environment (Black, 2011; McLeman & Smit, 2006; Tacoli, 2009).

In the migration-as-adaptation paradigm, the potential for migration in response to any change in environmental conditions is seen as a function of the nature of the particular environmental conditions to which a population is exposed, the sensitivity of the livelihoods of the population in question, and their capacity to adapt to changing conditions through means other than by migration. This can be remembered by the simple acronym MESA (from McLeman, 2014):

M = *f* (ESA)
where
M = migration is a function *(f)* of
E = exposure to particular environmental events or conditions,
S = the sensitivity of a given population to a given exposure,
A = and their capacity to adapt through means other than by migration

The underlying drivers that shape sensitivity and adaptive capacity are linked to wider social, economic, political, and cultural processes that determine such things as household incomes, access to labor markets, livelihood choices, and social networks (Smit & Wandel, 2006). Recent years have seen multiple large-scale collaborative research initiatives attempting to better understand the underlying drivers that influence environmental migration, such as the CARE/United Nations University EACH-FOR project on environmental migration and forced migration, and the European Commission-funded 'Where the Rain Falls' study of the effects of precipitation on migration and displacement, both of which are discussed in greater detail in Section 5. Particularly influential has been the 'Foresight Project on Global Environmental Migration' carried out by the UK Government Office for Science. This multiyear project commissioned dozens of studies on various aspects of environmental migration, and in doing so devised a basic conceptual framework for understanding environmental migration that has been widely adopted by researchers, practitioners, and policymakers (Figure 1).

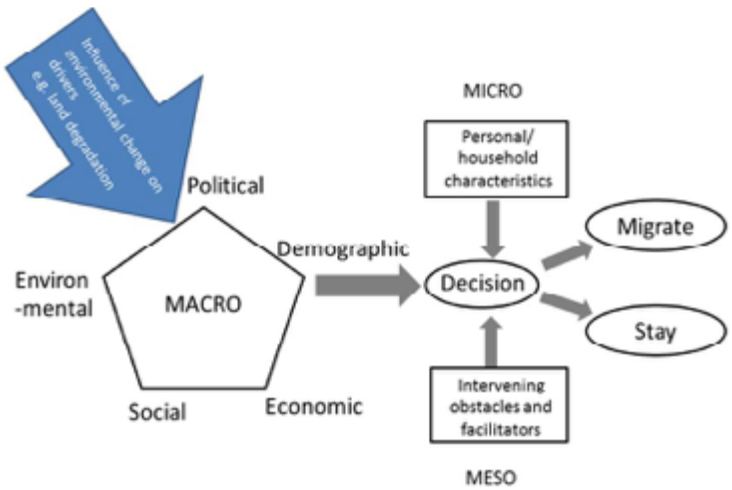


Figure 1: **Processes that influence environmental migration decisions**
Source: after Foresight, 2011

The decision of an individual or household to migrate, which is shown on the right hand side of Figure 1, is influenced by a range of factors that operate at the micro-, meso-, and macro-level scales. The micro-level refers to factors operating at the local level that directly influence the household or individual on an ongoing basis, such as livelihood options and strategies, household income, age, family size, and so forth. The migration decision is also affected by a range of meso-level factors, which can include things such as being member of a particular social network, or the ability to obtain the assistance of a migrant smuggling organization. At the highest level are macro-level forces, shown on the left hand side of the figure, that operate beyond the direct control or influence of individuals, households, or communities. These include: political processes that shape governance structures, laws and regulations; demographic processes, such as birth rates and population growth in particular areas; economic processes, such as market prices, currency exchange rates, and labor market conditions; social factors, like gender relations and cultural norms about migration; and environmental factors, such as the quality of grazing land or variability of precipitation. Environmental conditions are rarely static, and the blue arrow represents the introduction of an environmental change that may alter the system, such as land degradation. Migration decisions and behavior, on the right hand of the diagram, can potentially be influenced by the environmental change represented by the blue arrow, but only after its impacts have filtered through the macro-, meso-, and micro-level factors and interactions upstream from the migration decision.

While Figure 1 provides a detailed representation of how environmental migration is the outcome of interactions between environmental and socioeconomic processes, something that is not immediately apparent is the fact that the inability to migrate away from an area experiencing environmental stress can create trapped populations (Black et al., 2013). Typically, these would be people who lack the necessary social networks, financial means, or physical ability to move temporarily or permanently away, and cannot do so without the intervention of outside agencies or institutions. The importance of mobility, and of having the option to migrate, and the converse potential for immobile groups to become trapped, are important considerations when analyzing the relationship between land degradation and migration, as is seen in the sections that follow.

3. COMPETING PERSPECTIVES ON THE RELATIONSHIP BETWEEN POPULATION AND LAND DEGRADATION

Population processes, of which migration is one component (see Box 2), are often closely interconnected with land degradation. Historically, scholarly discussions of this relationship have been dominated by two competing perspectives. One is the neo-Malthusian perspective, best associated with the work of Stanford ecologist Paul Ehrlich, in which land degradation and other adverse human impacts on the environment are seen as being the product of the size of the human population, multiplied by its relative affluence and technological sophistication, captured by the simple formula (based on Ehrlich & Holdren, 1971):

I = P * A *T
where
I = impact
P = population
A = affluence (sometimes also described as consumption)
T = technology

Implications of the IPAT formula are straightforward: an increase in any of the variables on the right-hand side of the equation does not merely add additional pressure to the environment, but actually has a multiplier effect, so that, for example, even a small increase in population generates a disproportionate impact on the environment. Using this rationale, Ehrlich warned in his 1968 book *The Population Bomb* that the Earth was becoming overpopulated, and that the carrying capacity for human populations was already being exceeded in many regions. In the absence of actions to reduce population growth, especially in developing regions, the near future would see widespread degradation of land and water, general decline in human well-being, and large-scale population displacements.

Box 2: The relationship between migration and population change

Human population numbers are inherently dynamic. Changes in the population of a given town, city or area over a given period of time are determined by two processes – the rate of natural increase and the net migration rate. Natural increase is simply the difference between the birth rate and the death rate, while net migration is the number of people who move out versus the number of people who arrive from elsewhere.

To measure the rate of natural increase, demographers start by calculating the crude birth rate and crude death rate, usually expressed as numbers of births and deaths per thousand people, or

# of births per year/total population * 1000
# of deaths per year/total population * 1000

The rate of natural increase is usually expressed as a percentage:

(Birth rate - death rate)/10 [assuming births and deaths are reported in thousands]

In most countries, the overall rate of natural increase is positive, although there may be considerable internal variation. Japan and several European nations have birth rates so low that the rate of natural increase is actually negative. In the absence of a large, positive net migration rate, the populations of these countries will decline over time. Calculating the net migration rate for a given area is done as follows:

(# of incoming migrants - # of outgoing migrants)/population * 1,000

Where the net migration rate is positive, migration contributes to population growth, assuming the rate of natural increase is not negative. Where net migration is negative, it detracts from overall population numbers. Syria currently has a negative net migration rate, as people flee that country's civil conflict. Countries like Australia and Canada that are popular destinations for international migration have positive net migration rates. Net migration rates are actually very difficult to calculate, since reliable data on the comings and goings of people are usually scarce (see Section 6 on methods and data).

Although it is not often operationalized for empirical research exactly as outlined, the IPAT formula has been used, for example, in studies that look at the relationship between population and greenhouse gas emissions at both global and local scales (DeHart & Soulé, 2000; MacKellar et al., 1995). Its greater influence is a conceptual one, being often used to guide interpretations of the general nature of the relationship between humans and the environment, causing it to feature in most introductory classroom textbooks for environmental science. A well-cited example of the neo-Malthusian perspective applied to land degradation is found in Westing (1994), who argued that the large, famine-related population displacements in Sub-Saharan Africa in the 1980s and early 1990s were due to an imbalance between population numbers and the human carrying capacity of the land. In this view, growing numbers of people in rural areas made for smaller per capita natural resource bases, triggering overuse of land, desertification, and eventually, conflict and displacement. Westing's prescribed solution was a mix of participatory governance, conflict resolution mechanisms, and population control measures.

The second perspective is the Boserupian perspective. It originated from the work of Danish economist, Ester Boserup, who hypothesized that growing population pressure and increasing competition for ecosystems goods and services stimulate innovation, intensification, and/or collaboration in food production (Boserup, 1965). Although degradation of land or depletion of natural resources could be a short-term consequence of population growth, over the longer term stability is achieved as people begin to make more efficient use of the resources available to them. In other words, food production does not determine human population numbers; rather, population numbers drive food production. In this scenario, migration is a means of achieving equilibrium between human use and resource quality while intensification and other innovations are being developed (Gould, 1994). In an example often been cited as evidence of the Boserupian position, research in the Machakos region of Kenya found that an area that once suffered from severe soil erosion had been improved by more intensive practices stimulated by a growing population (Tiffen et al., 1994). The authors suggested that higher population levels lead to less soil erosion, findings that were also made by researchers in rural Ghana (Codjoe & Bilsborrow., 2011). An important element in the Boserupian dynamic is land tenure: where people have certain and secure land tenure, they are more likely to make the necessary investments in land conservation and protection (Kabubo-Mariara, 2007).

There are many examples in the research literature to support elements of both the Boserupian and neo-Malthusian perspectives, suggesting that neither is universally applicable (Lambin et al., 2001). Indeed, there are also many instances of land degradation where population pressure is not a relevant factor at all (Kiage, 2013). The next section considers in greater detail the role of migration and its association with land degradation in particular ecological regions.

4. CASE REVIEW: THE COMPLEX RELATIONSHIP BETWEEN LAND DEGRADATION AND MIGRATION

The research literature contains examples where migration is a primary driver of land degradation, where land degradation is a primary driver of migration, and still others where both processes happen concurrently – such is the complexity of the relationship. As is suggested in Figure 1, the relationship between migration and land degradation plays out within a larger context of interacting environmental and non-environmental processes, operating at the macro-, meso-, and micro-level scales. As a result, land degradation-migration interactions and outcomes will inherently vary from one geographical location to another, and will equally change over time. Even though each case will have its own local particularities, it is still possible to observe some general similarities and patterns in examples identified in the research literature, as is seen in the following sub-sections.

4.1 Do traditional migratory livelihoods cause land degradation? Pastoralism and shifting cultivation

Governments and popular media often paint traditional livelihoods such as nomadic pastoralism and shifting cultivation (also known as swidden agriculture) as being inherently destructive and important causes of land degradation in tropical, dryland, and montane environments (Lambin et al., 2001; Shanahan, 2016). The evidence for such claims is mixed. In traditional dryland pastoral systems where the movement of pastoralists is unrestricted, herds are rarely grazed in one area long enough to cause significant or lasting degradation (Kiage, 2013). Similarly, in montane regions, pastoralists have historically maintained relatively small numbers of animals, and moved them regularly between pastures at different elevations according to the seasons – a very effective and practical form of transhumance pastoralism. Given the harsh climate and limited amount of accessible land, montane populations also often combine pastoralism with small-scale farming and collection of native alpine plants, although in some areas of the high Andes, groups continue to this day to specialize in semi-nomadic pastoralism (López-i-Gelat et al., 2015; Postigo et al., 2008). In both montane and grassland environments, rights to use grazing areas have traditionally been communal, with an emphasis on preserving the quality of the resource base (Nyong et al., 2006; Place, 2009; Postigo et al., 2008).

A key driver of land degradation in traditional pastoral regions today is a growing trend toward land enclosure and the conversion by governments of communal tenure to private tenure, so as to facilitate commercial development and intensification of livestock and agricultural production. In East Africa, for instance, pastoralists that once ranged over wide areas and whose herds would therefore place relatively modest pressure on grasslands, are increasingly confined to smaller areas, are obliged to keep more animals on degrading pastures, and must purchase supplemental fodder or graze their herds in areas that put them into conflict with other land users (Galvin, 2009; Goldman & Riosmena, 2013; McDermott et al., 2010; Meshesha et al., 2012; Place, 2009; Wario et al., 2016). This dynamic creates a growing need for cash, which spurs the outmigration of young people from pastoral communities to urban centers so that they can remit money home (McCabe et al., 2014; Nyberg et al., 2015). These factors create a self-reinforcing process of growing sedentarism, wage labor migration, and greater integration of formerly pastoral peoples into the market economy.

A similar process is taking place in the Andes, where the collective *campesino* model of land management is being actively undermined by governments seeking to foster intensive commercial agricultural production, and to support the mining industry (Bury, 2005; Vergara & Barton, 2013). Grazing lands are being fragmented, resulting in higher stocking rates and increasing degradation on the lands still accessible to pastoralists (López-i-Gelat et al., 2015). Many households now send adult members to towns and cities to seek out temporary wage labor opportunities as they attempt to diversify their income sources, and growing numbers of young people are leaving the mountains permanently (Mark et al., 2010; McDowell & Hess, 2012; Vergara & Barton, 2013).

In Mongolia, significant changes in pastoralist behavior occurred after the government de-collectivized the agricultural system and shifted to a market economy (Lkhagvadorj et al., 2013). While pastoralists initially kept to their traditional areas, they began stocking greater numbers of goats and cattle to generate more cash income. With the passage of time, pastoralists began altering their movements to be closer to towns, where their children are sent to school, and also began using motorcycles and cars to move between towns and their herds and flocks. As a consequence, some of the most productive grazing areas in central and western parts of the country have become chronically overgrazed, and are at greater risk of irreversible degradation (Gao et al., 2015).

In all the preceding examples, it is not the traditional land use practices of pastoralists that are the catalyst for land degradation, but the transition away from those practices, which is being driven by macro-level forces beyond the pastoralists' control. A similar case can be made for shifting or swidden agriculture. Shifting agriculture is a logical means of farming in tropical areas where soils are poor and frequent rains leach away nutrients. It was once widely practiced in the forested regions of southeast Asia, central Africa, and South America (Coombes & Burt, 2001). Traditional swidden farmers typically clear small patches of land and, after a few years of good production, leave them fallow long enough for native vegetation to regenerate, and for soil fertility to recover (Dove, 1993). Today, shifting agriculture persists only in remote areas far from markets, and is elsewhere being replaced by more intensive, ecologically destructive farming practices, that in many cases generate new migration patterns (Rerkasem et al., 2009; VanVliet et al., 2012). For example, in northern Vietnam, shifting agriculture was practiced for generations in mountainous regions – a wise adaptation to the region's thin soils and steep slopes that are easily eroded and damaged when overused (Vu et al., 2014). In recent decades, however, government policies have sought to restrict people's movement and access to forested areas, and have encouraged greater commercial harvesting of forests and intensification of agricultural production. At the same time, there is a relatively high rate of natural population increase among the traditional population of the region. Constrained mobility and population growth causes people to place increased pressure on the remaining areas of forest to which they have access; for instance, by shortening the periods in which they leave fields fallow, or by eliminating fallowing altogether. Again, it is not the traditional practice of shifting agriculture that is the trigger for land degradation, but the move away from a proven traditional land use practice.

4.2 Land degradation, drought, and migration in drylands regions

Drylands are inherently susceptible to degradation, given their low levels of annual precipitation, and high degree of seasonality in precipitation patterns. Approximately 40% of the Earth's surface is made up of drylands, the largest areas being found in Asia and Africa (UN Environmental Management Group, 2011). The United Nations Convention to Combat Desertification (UNCCD) defines drylands as areas where the ratio of annual precipitation to potential evapotranspiration is between 0.05 and 0.65 (i.e., where annual precipitation is significantly less than the amount of moisture that may be lost through evaporation and transpiration). Soil and vegetation vary across dryland regions, and may consist of grasslands, savannah (i.e., grasslands interspersed with shrubs and trees), shrublands, and dryland forests. Native grassland vegetation is naturally adapted to dryness, and is able to tolerate browsing and grazing, provided that its regenerative capacity is not exceeded (Thomas et al., 2014). Traditional livelihoods in grasslands typically involve activities such as pastoralism, small-scale farming, and gathering of wood and non-wood products from forests, where available.

As was briefly touched upon in the preceding section, traditional pastoral and shifting agriculture livelihoods are undergoing rapid change because of larger social, economic, and political forces, with land use increasingly becoming dominated by more sedentary agro-pastoral farms that mix farming and livestock production. The emergent agro-pastoral system is particularly vulnerable to the impacts of drought, which is a recurrent phenomenon in dryland areas. Much of the existing research on land degradation and migration in dryland areas focuses on the effects of precipitation variability and drought, and illustrates how migration is used as an adaptation strategy. The interactions between drought and migration vary from one dryland country and region to another, reflecting local differences in culture, land use systems, political regimes, economics, and other factors. Three examples now follow, from West Africa, Ethiopia, and Mexico, to illustrate the complexity of migration in drought-prone areas, and how precipitation variability interacts with land degradation and with non-environmental processes to influence migration outcomes.

4.2.1 Precipitation variability, land degradation and migration in West Africa In West Africa, livestock production has become increasingly specialized, and oriented to supplying urban markets. Older members of pastoralist groups such as the Fulani continue to maintain their former semi-nomadic patterns of movement, but this livelihood strategy appears to be in decline, with young adults preferring instead to engage in livestock trading in cities and towns (Adriansen, 2006). Many of these new urbanites raise livestock and/or grow crops on the edge of cities and towns; it is estimated that fully half the households in Ouagadougou farm or keep cattle (Thys et al., 2005). The transition from nomadic pastoralism to urban-oriented production among the Fulani was, in part, stimulated by severe droughts two decades ago, during which time subsistence pastoralists' herds were badly depleted (Adriansen, 2008). Specialization and intensification in livestock production came to be seen as less economically tenuous than subsistence nomadism; by switching from dairy cattle to beef cattle and goats, pastoralists are able to generate cash incomes that further help households cope with droughts.

Precipitation variability, drought, and land degradation also affect the migration decisions of small-scale farmers in rural in West Africa, albeit in a different manner to that experienced by pastoralists. Longer term migration processes within countries, particularly the trend toward growing rural-urban migration, is driven primarily by social and economic processes (Neumann et al., 2015), but slow progression land degradation is also a factor which affects internal migration patterns. Generally, migration tends to flow from areas where land is relatively scarce, and where land degradation is relatively high, to areas where land is more plentiful, and degradation, relatively low (Abu et al., 2014; Braimoh, 2004; Henry et al., 2003; Neumann et al., 2015). However, there is considerable variability at the subnational scale, and the relative strength of environmental factors on migration decisions – as compared to socioeconomic ones – varies considerably. In regions where land degradation is high, and/or where precipitation is especially variable, these and other environmental factors dominate the migration decision process, whereas in areas where such factors are not quite so acute, economic considerations in particular dominate migration decisions (Henry et al., 2003).

Small-scale dryland farmers use seasonal labor migration strategically to cope with the general variability of precipitation. During the dry season, young men, and – depending on the cultural group – young women, will migrate out of the countryside to nearby cities, or to agricultural regions with year-round production (Hampshire & Randall, 1999; Rain, 1999; Quaye, 2008). When the rains return to the farmland in question, migrants follow suit, because their labor is once again needed. In years when precipitation is good and crop yields are high, families may decide to send a member of their household to a more distant international migration destination (Henry et al., 2004). This long distance migration is costly in terms of direct expenses and lost labor, since the migrant will not return in time for the next farming season. There is, moreover, the risk that the migrant may not obtain a well-paying job at the destination, being thus unable to remit money home. For these reasons, long distance international migration has in recent decades been most frequently initiated when household incomes are at their strongest. Very poor households that lack the necessary financial means may meanwhile be restricted to less distant migration destination choices within their home region. When drought strikes, migration patterns change (Barbier et al., 2009; Henry et al., 2003, 2004; van der Geest et al., 2010). Long distance international migration tends to drop sharply, as households conserve their resources, but there is an increase in short distance, temporary migration of young people within seeking work in unaffected rural areas, in nearby towns and cities, and/or in neighboring countries. In the case of Ghana, migration may also increase toward artisanal mining areas (see Section 3.4), which can potentially provide income at any time of year (Schraven & Rademacher-Schultz, 2015).

4.2.2 Droughts, land degradation and migration in Ethiopia For those old enough to remember, the term 'drought migration' will immediately call to mind images of the multiple famines and distress migrations of the 1970s and 1980s in East Africa, particularly in Sahelian regions, the Central African Rift, Somalia, and the Ethiopian highlands. Indeed, these events provided impetus for the movement to create the UNCCD. While droughts may have provided the spark that triggered large-scale population movements, most researchers agree that the antecedent conditions for famine were created by civil conflicts, oppressive and incompetent government regimes, indifference on the part of the international community and, in the case of Ethiopia, a controversial government strategy to forcibly relocate people from northern to western parts of the country (Block & Webb, 2001; Maharatna 2014; Mberu, 2006; Mortimore, 1989; Quddus & Becker, 2000). Large numbers of people were ignored by institutions and left to fend for themselves; in one example from Ethiopia, after years of struggle, large groups of Mursi people finally abandoned their traditional lands and cattle, and relocated themselves to an area with better rainfall, where they took up crop farming with some success (Turton, 1984). The influence of environmental disasters in Africa during this period was also detectable in flows of migration to international destinations in Europe and the US (Reuveny & Moore, 2009). Today, food price shocks combined with drought can still trigger food security crises in the region, with conflict and weak governance structures continuing to present challenges (Devereux, 2009). Although vegetation cover has regenerated and increased in many parts of Sahelian Africa that had been badly degraded during the droughts of the 1970s and 1980s, soil erosion and forest loss persists in large areas of Ethiopia today, including the dry highlands and the less arid, forested southwest (Kassa et al., 2016; Lanckriet et al., 2015). In view of these continued strains, migration continues to be an important coping strategy.

Frequent short-term intra-rural and rural-urban migration are important components of rural livelihoods in Ethiopia, consistent with the NELM theory of migration described earlier (Mberu, 2006). In normal times, most migration has traditionally occurred within the drought-prone rural areas, including temporary, seasonal and indefinite migration, with notable differences in the patterns of male and female migration that are attributable to marriage customs (Ezra & Kiros, 2001; Gray & Mueller, 2012). Migration out of rural areas has typically been a last-resort strategy of households experiencing the loss of crops or livestock due to drought (Meze-Hausken, 2000). When drought hits the Ethiopian drylands, the first strategies households undertake include changing their patterns of consumption, selling off their livestock or other assets, eating less, and depleting the reserves of food most households keep for precisely such situations. Once migration becomes the final available option, in most instances people travel to the nearest town in search of either wage employment or food aid, if available. Marriage-related migration declines (Gray and Mueller 2012). Because they have depleted all their existing assets, the migrants may not be able to return to farming immediately once the drought has broken, but instead must remain in town until they have earned enough money to buy new seeds, livestock, and tools.

4.2.3 Drought and dryland migration in Mexico Drought has significant impacts on migration patterns in dryland regions of Mexico, but these play out in different ways than those in Ethiopia or West Africa. In rural Mexico there is a culture of temporary labor migration out of rural areas as a means of gaining additional income to remit home; in poorer households, off-farm employment may comprise over half their annual income (de Janvry & Sadoulet, 2001). The bulk of this migration takes place within Mexico, but large numbers of young rural adults, mostly male, also migrate to the US (Kaestner, 2015). Migrants from the poorest rural households tend to remain in Mexico, while those with better incomes are more likely to remove to the US. When droughts occur, migration to the US from rural areas in Mexico tends to drop in the short term, but – within two years after the drought – will rise, especially among households with social networks strongly connected to the US (Hunter et al., 2013). Most of this additional US-bound migration originates in rural areas of Mexican states that are already relatively arid, underlying the importance of migration as an adaptation strategy for dryland farmers (Nawrotzki et al., 2013). Feng et al. (2010) estimate that a 10% decline in crop production in rural Mexico translates into an approximately 2% increase in migration to the US. By contrast, when precipitation is above average and agricultural productivity is better than usual, migration to the US drops sharply (Puente et al., 2015).

4.3 Migration, deforestation, and land degradation in the tropics and sub-tropics

Migration and mobility are important components of the subsistence livelihoods of indigenous forest peoples, and customary forest users. They engage in a wide range of activities, such as swidden farming, fishing, gathering of wood and non-wood forest products, and harvesting of game animals, to name but a few (Alexiades, 2009; Barham et al., 1999; Nasi et al., 2011; Ndoye & Tieguhong, 2004; Rerkasem et al., 2009; Shackleton et al., 2011). Sustainable forest livelihoods typically depend on the ability to move within the forest, and to travel to settlements along the forest margins to trade for products that cannot be procured directly from the forest. Such activities rarely stimulate deforestation or land degradation on any significant scale. Most deforestation, globally, is generated by outside interests. These include: commercial logging companies; market-oriented livestock, farming, and plantation enterprises; and settlers who seek to establish small farms along the forest margins. There is an ongoing debate among researchers regarding the relative contribution of these various actors to global deforestation (Lambin et al., 2001).

In many parts of Amazonia and in large areas of Southeast Asia, forest loss is increasingly being driven by the exploitation of forests by outside commercial interests using unsustainable harvesting practices (Hosonuma et al., 2012; Wunder, 2001). The forest products, and the wealth generated from commercial forest exploitation, are not intended for local benefit, but for the benefit of distant consumers, investors, and capital markets. Evidence from Cambodia finds that areas where outside corporate interests are conducting forestry operations have much higher land degradation rates, as compared with areas where small-scale forestry is conducted (Rudel, 2015). Areas cleared of forests may be replaced by commercial grazing, or by commercial production of export commodities, such as coffee, eucalyptus, palm oil, and soybeans, which alters local hydrological cycles and triggers rapid declines in biodiversity and soil fertility (MEA, 2005a). Alternatively, areas cleared by commercial logging may be taken up by small-scale farmers, who often migrate from other places in order to do so (Kröger, 2012; López-Carr & Burgdorfer, 2013; Meyfroidt et al., 2013). This process uproots and displaces indigenous and customary residents of the affected forest areas, who are no longer able to pursue their traditional livelihoods. Commercial forestry companies often actively avoid employing local people, preferring to import migrant workers from elsewhere, that are more easily controlled and perceived to be harder working (Dewi et al., 2005; Mulley & Unruh, 2004).

While outside commercial interests are the fastest growing drivers of deforestation globally, forest clearance in Central Africa and in many areas of Central and South America is still driven primarily by migrants, who clear the forest to harvest timber and establish small-scale farms on which to grow cereals and raise livestock (Carr, 2008; Fisher, 2010; Hosonuma et al., 2012). The cutting of timber to make charcoal is also a contributor to deforestation in localized areas, although it is usually a by-product of forest conversion, as opposed to the main driver (Mwampamba et al., 2013). The forest conversion process, as driven by migrants, has been well-documented in Guatemala, where high population growth rates in more accessible agricultural areas are making it increasingly difficult and expensive to get access to good land (López-Carr, 2012; López-Carr & Burgdorfer, 2013). In some cases, these migrant source areas suffer from land degradation. This prompts growing numbers of people to migrate to the forest frontier in northern, mountainous parts of Guatemala, where regulations against forest clearance are weakly enforced. Migrants may find that their new land is easily exhausted, prompting them to move on to new areas where they start the process over again. In other instances, small farms are acquired and consolidated by more successful landowners, seeking to expand and intensify their farm operations, which again stimulates the vanguard of families who conducted the initial clearance of forests to move on to clear new areas.

Guatemala is an example where forest clearance occurs because there are few regulations against it, and those that do exist are poorly enforced. In other countries, such as Indonesia and Brazil, governments have implemented programs that actively encourage people from densely populated areas to resettle in forest frontiers (Caviglia-Harris et al., 2013; Elmhirst, 2011). In these cases, government policies seeking to relieve perceived 'overcrowding' in one area may be contributing to land degradation in another.

Although people who migrate to the forest margin in Central and South America are often represented as being impoverished migrants seeking to earn a quick dollar in a 'degrade-abandon-migrate again' fashion (see discussion in Section 6, below), the influx also often includes many people who seek to establish permanent homes, often originating from relatively prosperous areas (Caviglia-Harris et al., 2013). As the forest margin retreats, there is a significant amount of migration within the cleared areas, as families seek to acquire the better land and consolidate smaller parcels (Richards & VanWey, 2015).

As settlement in the formerly forested region becomes better established, the population begins to rise. Growing numbers of young adults begin leaving to seek out wage labor opportunities elsewhere, typically in cities. In South America, many forest frontier households become 'multi-sited'; that is, members will move between rural and urban locations, depending on the economic opportunities and household needs at any given moment in time, and will share remittances, food, and resources with one another (Pinedo-Vasquez & Padoch, 2009).

An important question concerns the use of remittances sent back by migrants: do they reduce pressure on the land, or intensify it? The answer depends upon a number of factors, such as prices for agricultural products, accessibility to markets, the value of the remittances received, cultural attributes, characteristics of migrants, and other non-environmental factors (Lambin & Meyfroidt, 2011). Examples can be found where outmigration and remittances have slowed degradation and allowed badly damaged lands to recover and regenerate (e.g., Bolivia and El Salvador [Hecht & Saatchi, 2007; Preston et al.,1997]), as well as others where land use has remained unchanged, or has expanded because of remittances (e.g., Ecuador, Brazil and Central America [Davis & Lopez-Carr 2014; Gray & Bilsborrow, 2014; VanWey et al., 2012]), and still others which show mixed results (e.g., Yucatan, Mexico [Schmook & Radel, 2008]). While scientists have expressed hope that out-migration and remittances will, over the long term, allow many heavily deforested and degraded areas around the world to regenerate (Aide & Grau, 2004), the preceding examples suggest this may not necessarily happen without outside interventions.

4.4 Migration and artisanal mining

In many rural areas of Central and South America, south and southeast Asia, and Sub-Saharan Africa, rural migrants, in search of wages, seek out artisanal mining, a practice which is often unregulated, or carried out clandestinely (Appleton et al., 1999; Banchirigah & Hilson, 2010; Seccatore et al., 2014). Estimates of the number of people worldwide who engage in artisanal mining range between ten and twenty million people (Seccatore et al., 2014). Although the relationship between migration and land degradation in the context of artisanal mining is less studied than it is for small-scale agriculture and commercial logging, in areas where it occurs, artisanal mining is a significant driver of environmental problems, which can include deforestation, water pollution, and mercury contamination of soils, water and groundwater (Amankwah & Anim-Sackey, 2003). Artisanal mining workers are typically young males who often travel long distances to reach the best mining sites, but impromptu mining settlements that spring up can quickly attract large numbers of women, both married and unmarried. In Tanzania, for instance, where artisanal mining is legal, such impromptu mine settlements provide income opportunities for non-miners in the economy which springs up around the mine; these include working at restaurants and bars, mending or selling used clothes, trading food and supplies, and prostitution (Bryceson et al., 2014). In rural western Nigeria, residents tolerate the migrant miners because they provide a market for locally produced items, and because creation of new roads and other infrastructure often follows in the miners' wake (Adeoye, 2016). By contrast, in the Geita district of Tanzania, even though similar economic benefits were derived from the presence of miners, illegal mining pits compromised the small-scale farms of local indigenous residents, prompting many to abandon their land (Kitula, 2006).

4.5 Land grabs, land degradation, and migration

'Land grabs' are a growing phenomenon in Central and South America, Africa, and southeast Asia. The term refers to the acquisition, by outside interests, of rights to harvest timber or establish large-scale commercial farms, plantations, or livestock operations on lands in developing nations where tenure has historically been communal or customary in nature (Cotula et al., 2011). The exact size and number of global land grabs is not known, since many of these transactions are conducted without public notice. The most publicized cases are those of large investment companies, based in the Middle East and Asia, acquiring farmland in Sub-Saharan Africa; however, investors from North America and Europe are also active 'land grabbers'.

Additionally – most common of all – are land grabs initiated by domestic investors working with the blessing of their own governments (Cotula et al., 2014). It is estimated that over 12 million people worldwide experience loss of household income as a direct consequence of land grabbing, with the greatest impacts being felt in Gabon, Liberia, Malaysia, Mozambique, Papua New Guinea, Sierra Leone, South Sudan and Sudan (Davis et al., 2014). There is limited empirical information about the ecological impacts on lands that have been grabbed, although scientists have raised alarms about the volume of water that is being captured and used in dryland countries and about high deforestation rates in land-grabbed areas of southeast Asia and Brazil (Oliveira, 2013; Rudel, 2015; Rulli et al., 2013). Although it is widely assumed that large numbers of people are being displaced globally, as traditional lands are converted to intensive monoculture crop production and forests are strip-mined by outside commercial interests, little empirical data are available in any region. Nonetheless, such assumptions are reasonable, given that the land uses to which grabbed lands are converted typically require less labor than the small-scale farming, agro-pastoral and agro-forestry uses they replace (Li, 2011).

In a detailed study of foreign land grabs in Ethiopia, Ghana and Tanzania, Cotula et al. (2014) found that the amount of land that has been purchased or leased by foreign companies represents a small percentage of the total available agricultural land. However, these acquisitions are not randomly distributed, but cluster in particular locales where transportation and access to markets are especially good – in other words, the best agricultural settings in these countries. Examples from Tanzania and Kenya show that land grabs often occur against the will of existing inhabitants, that corruption is rife, and that local socioeconomic divisions increase after the land grab takes place (Galaty, 2013; Greco, 2015). There is also concern that land grabs increase tensions, and there is potential for conflict within communities, and between affected groups and governments that facilitate the process (Peters, 2013). In Brazil, state efforts to regularize the tenure and titles of smallholder farmers on the forest frontier are aimed at reducing deforestation and rural poverty; however, and perhaps counterintuitively, in areas where this has been done, it has instead facilitated the systematic intensification of forestry and commercial agricultural developments by larger corporate interests that can easily buy out small landholders (Oliveira, 2013). Given the potential land grabbing has to exacerbate land degradation in developing countries, as well as to stimulate changes in migration and settlement patterns, further research attention to this subject is warranted.

4.6 Land degradation and migration in China

China warrants separate mention in this section given the land use controls and household registration (*hukou*) system that make migration patterns within that country distinctive in comparison with other countries. The use of agricultural land is regulated by the state, and recent decades have seen growing intensification of agricultural production, as well as large areas of agricultural land being consumed by infrastructure projects and urban expansion, with an estimated fifty million people having been directly displaced in this way (Siciliano, 2013). In western and central China, large areas of dry forests and grasslands experienced high rates of degradation during the 1990s and early 2000s due to overgrazing and conversion to cultivated land (Hao & Ren, 2009; Lepers et al., 2005). In the Xinjiang and Gansu provinces, governments actively encouraged expansion of agricultural production in marginal dryland areas (Chen et al., 2014).

In the grasslands of Inner Mongolia and Tibet, governments have actively relocated and resettled pastoralists and rural populations to towns or other rural areas, often citing overgrazing as a reason, with mixed results in terms of the welfare of those relocated (Dong et al., 2012; Foggin, 2008). In the absence of outside intervention, impoverished rural households in degraded dryland areas use migration as a means of adapting, although the way they do so depends on the location, and on their relative degree of poverty. Households that are relatively less poor, and are situated relatively close to larger cities within their home county or region, are likely to send young adults to the city with the intention that they will remain there permanently and pursue higher education and non-agricultural jobs (Hu et al., 2011). This migration is done in accordance with the hukou laws, which require that people seeking to migrate first obtain official permission from local authorities. By contrast, impoverished households in more remote areas send young adult males to migrate on a circular basis, to and from distant urban centers, where they seek wage labor opportunities in factories or in the transportation sector (Hu et al., 2011). These migrants do so without permission, and join the continually growing 'floating population' of undocumented migrants living primarily in coastal cities, whose economies boomed following the relaxation of economic and trade restrictions in the 1990s (Shen, 2013). The size of this floating population is estimated at 120 million people or more (Zhu, 2007), and consists primarily of migrants from rural areas and small towns. High rates of out-migration from remote rural areas contribute to a growing phenomenon of 'hollowed-out' villages, where few adults of working age remain, and agricultural productivity declines accordingly (Chen et al., 2014).

The nature of institutional arrangements in China means that the government has a disproportionate role, relative to other countries, in managing both land degradation rates and population flows. The results to date have been mixed, with dynamics differing across various regions within China. In some areas, rural out-migration creates less pressure on the land, and remittances allow remaining household members to switch away from using wood and charcoal as fuel, permitting vegetation to regenerate and expand. In other areas, remittances can lead to agricultural production being expanded and intensified on depopulated lands as a form of domestic 'land grab' process (Chen, 2014; Siciliano, 2013).

4.7 Dams, mega-disasters, and displacement

There are examples where wide areas of land have become permanently degraded by human activity, stimulating large-scale out-migration, or complete abandonment of settlements (McLeman, 2011). In all cases of mass displacement, whether deliberate or unintentional, it is inevitable that large numbers of people are made socioeconomically worse off. The most common of these are deliberate displacements caused by the construction of large dams, especially in China, India, Indonesia, other parts of Asia, and Brazil. In the year 2000, the World Commission on Dams estimated that between 20 and 40 million people worldwide had been displaced by dam projects. The Three Gorges dam project in China, completed in 2012, alone displaced an estimated 1.3 million people, who were relocated to various rural areas and urban centers within the same region, and to other provinces of China (Wilmsen et al., 2011; Xi, 2016). Many of the new lands to which farmers were relocated were on steep slopes and were more erosion-prone than lands in the river valley floor, further exacerbating the difficulties faced by those displaced (Tan et al., 2003). Many consequently migrated a second time to urban centers elsewhere in search of employment, joining the previously mentioned floating population (Wilmsen et al., 2011). Dams are part of a larger category of drivers of population displacement known as 'development induced' displacement, which can include activities that degrade agricultural land and forests (e.g., infrastructure construction), but also projects intended to preserve and improve land (e.g., establishment of national parks). There are concerns that, if unwisely implemented, reforestation activities undertaken as part of recent international REDD+ initiatives[1] to control global greenhouse gas emissions may have unintended consequences of undermining rural livelihoods and displacing rural populations (McDermott et al., 2012).

Another, more infrequent source of large-scale displacement and abandonment are 'mega-disasters', caused unintentionally, or through poor planning. Some of the more notorious examples of recent decades include the need to abandon lands around the sites of nuclear accidents in Chernobyl and Fukushima, as well as what is colloquially known as the 'Aral Sea disaster'. This latter case refers to the aftermath of large-scale diversions of rivers flowing into the landlocked Aral Sea by the former Soviet Union, for the purposes of irrigating commercial rice and cotton crops in this arid region (Micklin, 2007). The Sea shrank dramatically, exposing sediments heavily laden with agricultural chemicals and other toxins, and the region's population subsequently began experiencing chronic respiratory illnesses and renal problems well above national averages (Crighton et al., 2003; O'Hara et al., 2000; Stone, 1999). Over time, farmland became increasingly unproductive, and groundwater became chemically contaminated. With the collapse of the Soviet Union, a hundred thousand people, many of them young, skilled workers – including many health care professionals – migrated out of the region, leaving the remaining population highly vulnerable and impoverished (Small et al., 2001). Although efforts have been made, in recent years, to restore some of the water and biodiversity to the Aral Sea basin, the degradation caused by decades of mismanagement will take many more decades to overcome, if it is possible to do so at all, and the remaining population will continue to be, for the foreseeable future, tremendously impoverished and vulnerable (Lioubimtseva, 2015; Micklin, 2016).

1 REDD+ refers to UNFCCC initiatives to reduce greenhouse gas emissions from deforestation and forest degradation through conservation, sustainable management of forests and enhancement of forest carbon stocks

4.8 Indirect impacts of land degradation on urban ecological decline and migration.

All examples detailed thus far have considered the direct consequences of land degradation and related factors, such as drought, on migration. Recently, there has been additional research describing a series of impacts on migration that are, instead, indirect. Researchers studying the causes of migration to Canada from Haiti and from several Sub-Saharan African nations found that, although the countries of origin experience persistent deforestation, land degradation, and consequent internal migration for environmental reasons, most international migrants in fact originate from urban centers (Mezdour et al., 2015; Veronis & McLeman, 2014). These urban migrants have not themselves experienced land degradation or deforestation, but describe it as being a secondary factor that influences their migration decision. Land degradation prompts growing numbers of the rural poor to migrate into cities, creating greater demand for housing, food, water, and services that the city is unable to provide. Pollution, food and water insecurity, overcrowded transportation, and lack of personal safety all accumulate; in view of this, urban professionals, who have the means to migrate overseas, begin to do so. These are some of the first studies to document the effects of urban ecological decline on migration, and corroborate recent reports in the popular media on outmigration of skilled workers from cities in China and Bangladesh for environmental reasons. Researchers have also shown that local scale urban-to-rural migration occurs from some African cities, although this appears to be more related to urban economic problems (Beauchemin, 2011; Potts, 1995, 2005).

4.9 Drought, land degradation, migration, and violent conflict

There is a long-running debate in academic research about the relationships between land degradation, droughts, migration, and violent conflicts. Case studies of African conflicts in the 1990s and early 2000s suggested that land degradation, resource scarcity, and periodic events like droughts were key causes of conflict (Homer-Dixon, 1994; Percival & Homer-Dixon, 1996; UNEP, 2007; Uvin, 1996). In most cases, the conflict was not between states, but between rival factions within states (Homer-Dixon & Deligiannis, 2009). Migration was seen as playing a two-fold role; people would migrate away from areas experiencing drought and degradation, thus bringing them into competition with other groups and triggering land degradation in new areas, which would, in turn, stoke new conflicts and trigger new distress migration (Brown & McLeman, 2009). This narrative may be accurate in some instances, but subsequent research has found the processes and connections to be far more complex (Barnett, 2000). Not all cases of land degradation and drought degenerate into violent conflict; indeed, in some instances, they can lead to greater cooperation and resource-sharing (Rønnfeldt, 1997).

Using Geographic Information Systems (GIS) models of climate conditions, land and water resources, population patterns and conflicts, Raleigh and Urdal (2007) found very little association between patterns of land degradation and conflict occurrence. The current paradigm in environmental conflict research is one of the 'threat multiplier' effect, where resource scarcity, degradation and sudden climatic changes do not in and of themselves cause conflicts, but exacerbate tensions and increase the risk of violence breaking out in areas where tensions are already high. For example, Raleigh and Kniveton (2012) have shown that areas of Ethiopia prone to rebel activity and communal conflicts experience an upswing in hostile activity during droughts and extreme rainfall events; meanwhile, across the Horn of Africa, fluctuations in vegetation tend to influence existing conflicts among pastoral groups, especially when other non-environmental influences on conflict are concurrently strong (Meier et al., 2007). Although drought has also been blamed for past conflicts in northern Mali, Benjaminsen (2008) found the causes to be more complicated, suggesting that droughts spurred migration of young Tuareg men to Algeria and Libya where they were exposed to more militant ideas which, when brought back to Mali, made Tuareg communities more resistant to interference from Malian authorities.

4.10 Out-migration as a cause of land degradation

Although it may seem paradoxical, there are examples in the scholarly literature of situations where migration out of rural areas has helped accelerate land degradation. In villages in southwestern Niger, researchers found that small-scale farming households that diversified their income sources through labor migration would often make strategic choices about how well they would care for particular fields (Warren et al., 2001). Fields with sandier soils that were more distant from the house, and which required greater ongoing fertilization, would sometimes be deliberately neglected, the household choosing to devote its limited labor to other fields and other activities. The neglected fields would be more prone to soil erosion as a result. In Pakistan, research by Tabassum et al. (2014) found that the out-migration of adult males from mountain villages in search of work has led to localized degradation of pastures. The remaining women, children, and elderly are less able to enforce the traditional user limits of their pastures, allowing outsiders to move in and take advantage by grazing large numbers of animals. Also, the lack of males means households lack the necessary labor to keep cattle. Women switch to keeping goats, which are easier to maintain while still managing the household, but the damage to fragile mountain vegetation caused by goat browsing is greater than that of cattle grazing.

5. IMPACTS OF CLIMATE CHANGE

The preceding section illustrated the complexity of the relationship between land degradation and migration, and the heterogeneity of possible outcomes, which vary from one location and context to another because of intervening social, economic, demographic, political and environmental variables that are themselves continually changing (as was summarized previously in Figure 1). An additional layer of complexity will be added to these interactions in coming decades as the impacts of anthropogenic climate change become more pronounced. Two key ways through which the impacts of climate change will affect the dynamic interactions of land degradation and migration are:

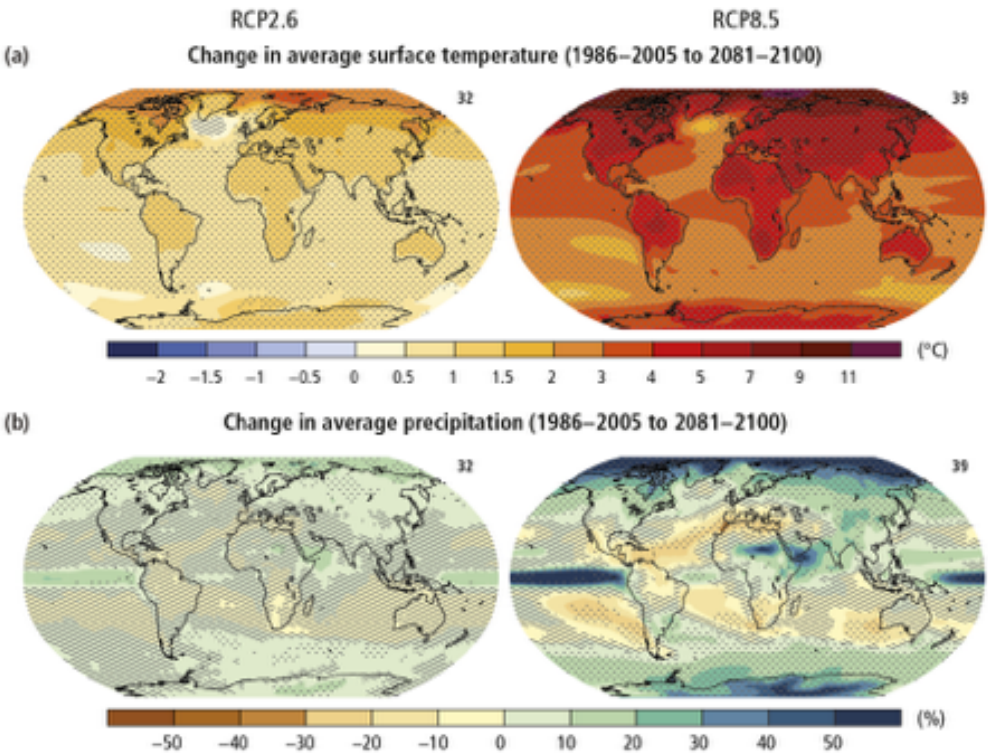
- by exacerbating natural phenomena that influence land degradation, such as precipitation variability, droughts, and extreme weather events;
- by affecting agricultural productivity, which in turn affects household incomes and market prices for food.

It is worth noting that the second of these refers to both the direct impacts of climate change on crops and livestock at local levels, as well as the potential for shocks to global food production that alter market prices for food. Both can be expected to have adverse implications for rural incomes, creating conditions often referred to in the climate science literature as 'double exposure' (Mendelsohn et al., 2007; O'Brien & Leichenko, 2000). Although the direct physical impacts of climate change may be the most visible, the less visible indirect ones can be just as harmful; Holden and Shiferaw (2004) observed, for example, that for small-scale farmers in Ethiopia, price shocks can have as great an impact on household incomes as local droughts.

The impacts of climate change are expected to become increasingly severe during the second half of the present century, although there is considerable uncertainty about the precise scale and nature of these impacts, given the lag between the emission of greenhouse gases (GHG) and the realization of their effect on global temperatures. Current GHG emissions will translate into future climate change, while current climate trends are a reflection of historical emissions (Rummukainen, 2015). Climate trends beyond the next two decades will consequently depend heavily on GHG emissions yet to be made. The Intergovernmental Panel on Climate Change (IPCC) uses standardized scenarios that assume various levels of future GHG emissions when making long-term projections about future climate. The most likely future changes in climate can be summarized as follows (from IPCC, 2013):

Global average temperatures are expected to increase by 0.3°C to 0.7°C over the next two decades; changes beyond that date will depend on future emissions. In low-emissions scenarios, average temperatures will increase by an additional 0.3°C to 1.7°C by the year 2100; in upper-range scenarios, there will be a further 2.6°C to 4.8°C increase by 2100. There will be considerable variability across geographical regions (Figure 2). *Extreme temperature events* will become more frequent over the course of this century, and longer-duration heat waves will likely occur.

Figure 2: **Recent and expected changes in global average temperatures and precipitation patterns in low- and high-emission scenarios**
Source: IPCC, 2013



Annual mean precipitation will increase over the course of this century in high latitudes, the equatorial Pacific Ocean region, parts of Sahelian East Africa, South Asia, and mid-latitude regions currently characterized by wet climates (Figure 2). Mid-latitude and sub-tropical dryland regions are expected to experience declining average precipitation levels. *Extreme precipitation events* are expected to become more frequent and more intense over the course of this century, especially in mid-latitudes and the wet tropics.

The frequency and intensity of droughts has already increased since 1950 in the Mediterranean region and in West Africa. By 2100 the Mediterranean region, southern Africa, and the southwestern US are expected to become increasingly dryer.

Average sea levels are rising at a rate of approximately 3mm per year, although this rate varies by location and depends on other non-climatic processes such as subsidence. The front margins of coastal deltas, low-lying coastal plains, and atoll states are most highly exposed to the impacts of sea level rise, such as the potential of salinization of soils and ground water.

The inherent spatial and temporal variability of the impacts of climate change means that it is not possible to make precise predictions of the frequency or extent to which specific areas or countries will experience particular climate risks or hazards. However, it is possible to make a general identification of locations where climate change has the greatest potential to influence future land degradation patterns by considering the physical vulnerability of specific ecosystem types. Watson et al. (2013) investigated the relative impacts of climate change on global ecosystems by mapping climatic stability (i.e., the difference between current climate conditions, and those expected for the year 2050) and the proportion of natural vegetation currently intact in each ecological region. By doing so, they were able to identify regions where climatic conditions will remain suitable for today's existing range of biodiversity through to the coming mid century (i.e., areas which are most likely to be stable in terms of climate-vegetation dynamics). By doing so, the authors found that the ecological regions most vulnerable to climate change (i.e., both climatically unstable and prone to degradation) are located in southern and central Europe, India, China, Mongolia, southeast Asia, central North America, eastern Australia and eastern South America (the cream, tan and orange colored regions in Figure 3, below).

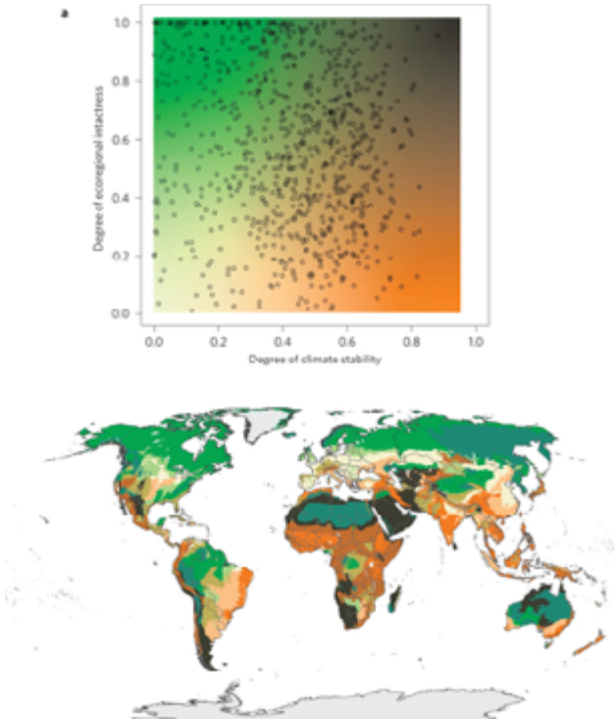


Figure 3: **Relationship between ecoregional climate stability and vegetation**
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Figure 4 identifies areas in developing countries that have particularly high concentrations of rural populations living in areas with observably high rates of land degradation (Barbier & Hochard, 2014), many of which fall within the areas identified in Figure 3 as being both climatically unstable and prone to degradation. People living in developing countries generally have lower capacities to adapt to climate change because of the limited financial resources available to households and to institutions, and rural populations are particularly vulnerable given their high degree of dependency on livelihood activities that are highly sensitive to fluctuations in climate (IPCC, 2014). As was outlined in previous sections, migration is widely employed by rural populations as a means of diversifying livelihoods, reducing exposure to risks and hazards, and increasing household incomes. Assuming future migration responses to land degradation behave in ways comparable to those at present, it is reasonable to expect that – in the absence of interventions to reduce and reverse land degradation – there will be increased migration within and out of the regions highlighted in Figure 4 as a result of climate change. The caveat in the preceding sentence is an important one. Reversing land degradation will not in itself halt migration from those areas, for migration patterns are the result of far more factors than land degradation alone. However, land degradation places increased pressure on rural livelihoods and household incomes, and its reversal raises the potential that households will be able to adapt to a changing climate through means other than migration.

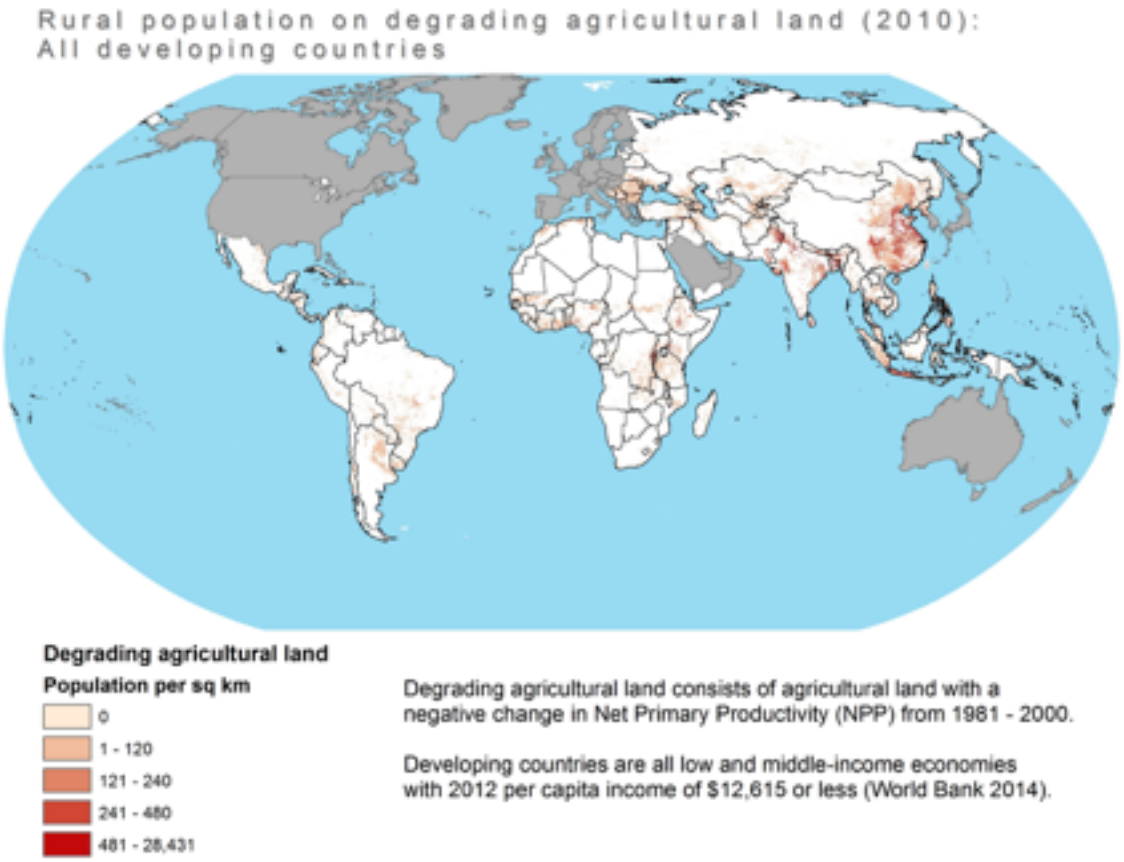


Figure 4: **Rural populations in developing countries living on degraded land, 2010. Reproduced from Barbier and Hochard (2014) with authors' permission.**

6. MEASURING THE MIGRATION EFFECTS OF LAND DEGRADATION

This report has thus far avoided providing any information regarding the number of people, globally, who may have been induced directly or indirectly to migrate because of land degradation. This is deliberate, for there are no scientifically reliable statistics currently available. Estimates do periodically appear in reports generated by NGOs, multilateral agencies, and the popular media. A common one suggests that each year 200 million people are "affected" by the impacts of desertification, although this does not necessarily mean that they migrate. The 200 million figure traces to a 2006 UNCCD policy brief that cites a 2005 study prepared for the Millennium Ecosystem Assessment (MEA, 2005b) that does not actually make such a claim, but that does suggest that 10% of global drylands currently experience desertification, and that 2 billion people live in drylands. Another common estimate comes from the 1994 Almeria Declaration on Desertification, which states that 135 million people have been displaced by desertification, a figure for which no citation was given and no source is readily identifiable.

Through circular citation, these have become common go-to estimates, and while they fall within the range of plausibility, they are not based on empirical evidence. The lack of global statistics for land degradation-induced migration is not unique; there are few reliable global estimates for any form of environmental migration. In a lengthy review of literature as it existed up to that point in time, Gemenne (2011b) found many examples of normative, educated guesses of global environmental migration, many of which appear to have been generated primarily to feed media interest in the subject (Box 3). The most common of these is an estimate of global environmental refugees made by British ecologist Norman Myers (2002), who suggested that by the mid-21st century there would be approximately 200,000,000 environmental refugees (as he termed it) worldwide, including people displaced by the impacts of desertification. Again, while this number is cited frequently in media and non-scientific reporting, it is not actually based on quantitative measures, but represents, instead, a knowledgeable expert's best guess.

Box 3: One more normative estimate

The author of the present report reluctantly offers another normative estimate of global migration that is directly related to land degradation: X*107 people annually (i.e. tens of millions of people in any given year). This figure is not meant to be alarmist; on average, only a small proportion of that figure consists of distress migration (i.e. migration where people have no survival alternative but to move). The estimate is based on having reviewed the numerous examples of recent and ongoing migration cited previously in this report, and the author's own past research experience. Indirect migration related to land degradation, as described in Section 3.8, is not included in this estimate. As has been detailed throughout this report, most migration linked to land degradation and/or to droughts in degraded areas goes undetected, is undertaken to diversify livelihoods and to adapt to changing conditions, and takes place within the context of larger global trends such as growing rates of rural-urban migration. Large-scale drought- and degradation-related migration events can and do occur periodically, but often these coincide with conflicts, weak governance structures, macro-economic decline, market price shocks, and other non-environmental forces. Readers are strongly discouraged from citing this estimate without at very least qualifying it as an educated guess. The remainder of this section outlines methods that are likely to soon yield more reliable global estimates. RM

6.1 Measuring and mapping land degradation at global and regional scales

From a methodological standpoint, it is possible to generate reliable global estimates of migration associated with land degradation; there are key impediments, however, regarding definitions and data acquisition. These problems exist when it comes to making global estimates of environmental migration of any kind, but are particularly challenging as relates to slow-onset events, such as land degradation, desertification, and drought. A first hurdle to overcome concerns what is meant by land degradation or desertification. There are no universally agreed-upon definitions (Prince, 2016), and without a clear definition of what constitutes land degradation or desertification, it is difficult to objectively measure the migration that such phenomena might cause. That said, once a definition is selected for what constitutes land degradation, the necessary environmental data, tools, and methodologies already exist to estimate it (Neumann & Hilderink, 2015). The current trend in land cover change (LCC) monitoring is to make use of NDVI (normalized vegetation index) data that are obtained from satellites or aircraft at periodic intervals. NDVI data are used to infer changes in net primary production (NPP) – that is, to make estimates of the amount of plant photosynthesis taking place in particular locations at particular points in time. Areas that display less NPP over time are assumed to be potentially degraded, with the opposite assumption made for areas that show increasing amounts of NPP. Variations of this technique have been used to generate global estimates of land degradation (Bai et al., 2008) and of global deforestation patterns (Hansen et al., 2013).

Most definitions of land degradation refer not simply to the amount of vegetation cover, but also to the quality and species composition of that vegetation, as well as the condition of local soils. As such, LCC data obtained through remote sensing should ideally be 'ground truthed'; that is, field investigations should be made on the ground to assess the value of the ecosystem goods and services represented by the observed changes in NPP. At any given location where there is a net increase in the amount of vegetation, it is possible that this increase could be attributable to invasive species, to growing dominance of particular species that are more tolerant to changing environmental conditions than others, or to other factors that make the location actually less favorable in terms of agricultural productivity, grazing suitability and/or native biodiversity. Herrmann et al. (2014) found this to be the case in rural Senegal, which has areas that have considerably more vegetation now than they did during the severe droughts of the 1980s, but the quality of pasture and the diversity of tree species are both much poorer today than they were thirty years ago.

Other factors, such as droughts, can have short-term influences on NPP measures obtained through remote sensing, although drought typically does not explain long term trends in LCC to the extent that human land use does (Vicente-Serrano et al., 2015). Nonetheless, the timing of data collection can have a significant influence on the outcome of any study. Instead of focusing on gradients of NPP change, some researchers focus on changes in the state of land cover, such as the shift from grazing land to cultivated land, since the latter is typically more prone to erosion, desertification, and soil degradation than the former (Bestelmeyer et al., 2015). At local and regional levels, researchers are able to incorporate additional sets of environmental data to better map land degradation. Examples include identification of grazing-induced rangeland degradation in Tanzania (Thompson et al., 2009), ranking of lands in eastern Zimbabwe in terms of susceptibility to degradation (Mambo & Archer 2007), and the penetration of soybean farming into Brazil's Amazon forests (Arvor et al., 2013). In the map shown in Figure 4, land degradation is calculated by combining data obtained from (1) the University of Maryland's Global Land Cover Facility's AVHRR Global Production Efficiency Model (GloPEM), which contains annual measures of NPP change for the period 1981–2000 measured in grams of carbon sequestered per square meter per year, and (2) agricultural land extent data from the International Food Policy Research Institute's Pilot Analysis of Global Ecosystems.

6.2 Measuring population change and migration

A greater challenge is obtaining the necessary population data to measure and map human migration. Part of the problem is the determination of migration causality. As shown in previous sections and in Figure 1, migration in the context of any form of environmental stress is rarely a simple push-pull or stimulus-response phenomenon. Rather, the choice to migrate (or not) is a product of decisions made at the household or individual levels that are influenced by a range of environmental and non-environmental factors, operating at macro-, meso-, and micro-level scales. Isolating any one of these factors and determining the nature of its influence on a migrant's decision to move is extremely difficult to do.

A classic example is a 1939 survey done for the US government of 6,655 rural migrants recently arrived in California from the drought-stricken Great Plains (Holzchuh, 1939). The majority of respondents stated that they came seeking employment, or provided other economic reasons for their decision to migrate. Although many came from areas where drought and severe degradation of agricultural lands had been taking place, and although they had been labeled as 'drought refugees' in official government statistics (Rowell, 1936; Taylor & Rowell, 1938), the migrants themselves did not report environmental reasons for migrating as often as might have been expected. In other words, most did not consider themselves to be environmental migrants, but economic migrants or employment seekers. Further, there is evidence to suggest that, had there been more local off-farm employment available in the drought areas, fewer people would have migrated to California (McLeman et al., 2008). The question therefore becomes: what caused their migration? Drought and land degradation, or the lack of local employment opportunities? There is no clear-cut answer, but depending on how their motivation is interpreted, these migrants might equally be categorized as economic migrants or drought/land degradation-induced migrants. This simple example illustrates the significance of the definitional decisions that would first need to be made in order to generate a scientifically reliable global estimate of land degradation-induced migration.

Assuming a reliable definition can be agreed upon as to what constitutes migration induced by land degradation, the next challenge becomes finding reliable data. The most common sources of migration data are censuses, household registration documents, and surveys (Fussell et al., 2014). While efforts are ongoing to consolidate a global census, at present there is no completely reliable global population database, and even at national scales, population estimates are often irregular, especially for developing nations (McLeman, 2013; Neumann & Hilderink, 2015). Censuses also often lack questions that relate specifically to migration. Household registration systems exist in a number of countries in Europe and Asia, but as noted in the preceding section devoted to China, much migration occurs that is not captured in these. Further, censuses and household registration documents rarely record individuals' motivations for migration, particularly not environmental motivations. While dedicated surveys are the most ideal method for conducting environmental migration research, they are expensive, time consuming, and difficult to execute at local scales, much less global ones. Despite these challenges, there are a variety of methods by which researchers have been able with increasing success to obtain data and conduct analyses of the links between environmental change and migration at the local and national scales, several of which will be briefly reviewed, below.

6.2.1 National and cross-regional statistical models of migration timing A common approach used by demographers and population geographers is to compare the timing of changes in environmental conditions with the timing of migration movements of individuals and households, through combining existing census or household survey data with environmental datasets (Fussell et al., 2014). There are many countries for which reasonably reliable census data sets exist, and these are consolidated on an ongoing basis by the Minnesota Population Center in its Integrated Public Use Microdata Series (IPUMS). There are also many country-specific surveys, long term health surveillance studies and other population datasets available, such as the World Bank's African Migration and Remittances Surveys, and Princeton University's Mexican Migration Project. Using multi-variate statistical techniques, these can be combined with environmental change data – again, of which there are many sources, such as the National Aeronautics and Space Administration (NASA) and the University of East Anglia's Climate Research Unit – to identify possible environmental 'signals' in migration patterns. Several examples of this research have been cited already in this report, such as: the influence of droughts on migration in Burkina Faso (Henry et al., 2004); rainfall variability and migration in dryland Mexico (Feng et al., 2010; Hunter et al., 2013; Nawrotzki et al., 2013, 2015); and drought effects on migration in Ethiopia (Gray & Mueller, 2012). These are all examples of national studies, but this methodological technique can, data permitting, also allow for comparative studies across countries. A recent study, for example, compared migration patterns across five Sub-Saharan African nations and found that extreme temperatures appear to have a detectable influence on internal migration patterns within countries, although the specific nature of the influence varies from one country to another (Gray & Wise, 2016).

With the exception of a study undertaken by Henry et al. (2003) of the relationship between soil erosion and migration patterns in Burkina Faso, the techniques described in this section have not often been used in peer-reviewed research on the specific association between migration and land degradation (in isolation from droughts), but it is likely only a matter of time before additional examples appear. In addition to previously described studies on precipitation variability, which exacerbates human activity that causes land degradation, there is the potential to combine general soil quality data with migration data, such as was done by Gray (2011), who found that land-poor Kenyan households living in areas with low soil quality are particularly dependent on labor and temporary migration.

While studies using this technique provide strong evidence of potential causal associations between environmental events and migration outcomes, they, too, benefit from being 'ground truthed' through comparison with empirical field work, to verify that population patterns on the ground are consistent with datasets, and that the motivations for migration as described by migrants themselves are consistent with the inferences derived from statistical models. In doing so it may be found that additional data are needed to better explain the links between cause and effect.

6.2.2 Geospatial and 'hot spot' models A second set of methods, which can be used in conjunction with any of the others described in this section, combines environmental and population data in geospatial models to visualize the spatial and temporal connections, and/or to identify potential 'hotspot' locations which may be more likely than others to experience particular outcomes. Geospatial models and hotspot models are not intended to demonstrate causality; rather, they take known or assumed associations between particular factors and illustrate them in a powerful way that guides further research, identifies areas for priority action, and informs policy decisions (de Sherbinin, 2014). This method has gained popularity in recent years because of increasing computing power and the availability of large georeferenced data sets for environmental variables (such as temperatures, precipitation, vegetation, biodiversity, and soils) and population data (from georeferenced national census datasets such as those available from IPUMS, and global estimations such as the Global Rural Urban Mapping Project [GRUMP] data set from the Center for International Earth Science Information Network [CIESIN]). Researchers are not limited to current or historical data; future projections may also be made by incorporating data from general circulation models and models of possible future population patterns, such as large-scale population projections created by the Institute of International Applied Systems Analysis (IIASA). Curtis and Schneider's (2011) study of potential future population displacements due to sea level rise in the US provides an example of future population-migration scenario modeling.

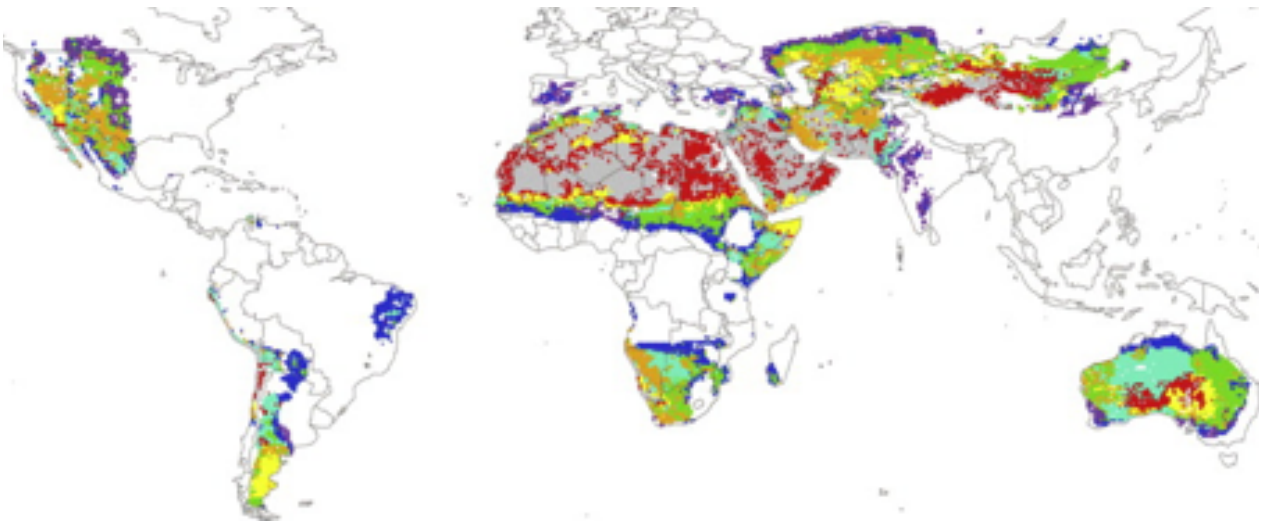
These techniques typically start by entering sets of data into GIS software as individual layers, with each data point having a georeferenced location. As layers are added, the researcher can control and modify the outputs to display combinations of selected data from multiple layers. Figure 5, for example, shows an extract from a GIS model displaying data layers for soil classifications and gridded population change during the 1930s for an area of southern Saskatchewan, Canada, experiencing severe droughts; the red boxes highlight locations where high levels of out-migration coincided spatially with areas of poor or moderate quality soils (adapted from McLeman & Ploeger 2012).

Figure 5: **Sample output from soil-population GIS model for southern Saskatchewan, Canada.**

A recent example of how this technique may be used to identify potential hotspots of land degradation comes from Neumann et al. (2015), who combined six different environmental data sets, created by CIESIN, of estimated net population flows by ecosystem type from 1990-2000 (de Sherbinin et al., 2012) to identify potential environmental drivers of migration in dryland regions. The authors draw attention to areas in Figure 6 coded in purple, dark blue, and light blue, which are agriculturally productive areas that have few limitations on productivity in terms of water scarcity or general soil quality, but which nonetheless experienced net out-migration. The implication is that these are possible hotspots where land degradation may be responsible for stimulating out-migration. By contrast, red and grey colored areas are primarily desert areas, where water scarcity is likely the greatest environmental driver of out-migration.

Figure 4 (displayed earlier) shows the results of a GIS model that combines measures of NPP change with CIESIN's GRUMP population estimates. The dots show concentrations of rural poor living in areas where NPP is declining (Barbier & Hochard, 2014). Via this model, the authors were also able to estimate that in 2010 approximately 1.5 billion people lived on degraded or degrading agricultural land, the largest numbers living in China and East Asia (770 million), followed by South Asia (336 million) and Sub-Saharan Africa (157 million). It should again be emphasized that maps generated using these techniques do not prove that land degradation is causing out-migration in particular areas, but do suggest that these would be priority areas for further investigation. For more examples of this this research approach and further discussion of strengths and limitations, refer to de Sherbinin (2014).

Figure 6: **Areas of net out-migration, color-coded by environmental classifications**
Notes: The color codes are as follows: Red and grey = desert environments with moderate and poor soils; gold = grazing areas with water constraints; green and tan = grazing with good or moderate soils; light blue = areas with moderate water and soil constraints; purple = areas under crops; dark blue = areas with little water scarcity.
Reproduced from Neumann et al. (2015) with authors' permission.



6.2.3 Simulation models: Bayesian models, systems dynamics models, and agent-based models Another set of methodological techniques seeks to determine the likelihood of particular migration outcomes under specific current or future environmental conditions. These types of models go by a variety of names, depending on the techniques used. One approach uses Bayesian belief networks, which calculate the mathematical probability of particular combinations of factors leading to selected outcomes. A simple example is to consider the relationship between eating a lot of candy, brushing your teeth, and having to visit the dentist with a sore tooth. Eating a lot of candy increases the chances of having a tooth cavity, and the probability of it doing so could be estimated through questionnaires of people's candy consumption and then reviewing their dental records. Brushing one's teeth does not in itself cause cavities requiring a trip to the dentist (therefore the direct causal probability = 0) but the frequency of brushing will moderate the number of visits to the dentist required to treat cavities associated with eating candy. A set of probabilities can therefore be calculated for various amounts of candy eaten, frequency of brushing, and the likelihood of having to visit the dentist. This same approach has been used by researchers to estimate how particular combinations of environmental events (such as drought) and socio-economic factors (such as education and livelihood type) are likely to influence the duration and destination of migration patterns, for instance, in Senegal and Mali (Drees & Liehr, 2015; Liehr et al., 2016). Often, to determine the relative probability of particular combinations of interactions environment and migration requires a mix of quantitative data and qualitative assessments of likely relationships.

In a related, but more simplified approach, Ginnetti and Franck (2014) outlined a detailed methodology for creating a system dynamics model that would identify conditions under which East African pastoralists were likely to be displaced by droughts. In order to create such a model, in addition to access to drought data the researchers also need access to data on the total number of pastoralists in the region, the number of cattle, and the number of people typically displaced in past events. Notable is that in conducting their study, the authors found that in United Nations High Commissioner for Refugees (UNHCR) statistics of millions of Somalis displaced between 2009-2012, less than 1% cited environmental reasons for moving, despite there having been widespread environmental degradation and severe drought conditions. This raises once again the thorny question of how to define causality when studying environmental migration.

Agent-based modeling techniques were developed by Kniveton et al. (2011, 2012) to replicate interactions between climate, socioeconomic processes, and migration in Burkina Faso for the period 1970–2000, and to simulate future migration flows to 2060. This technique requires taking existing data about climatic influences on migration patterns, generating hypotheses about how the factors interact (such as by using results from the aforementioned study by Henry et al. (2004)), and then running computer simulations. The 'agents' in the model are individuals or households who are mobile, and who will have interactions with both the environment and with other agents. Agents are assumed to behave rationally, and to learn from their own past experiences and from those of other agents with which they interact. Using this technique, the authors were able to offer projections of potential internal and international migration patterns for Burkina Faso under a variety of potential future climate scenarios. Agent-based modeling techniques have also been used to simulate migration responses to tropical cyclones and drought in Bangladesh (Hassani-Mahmooei & Parris, 2012). Agent-based modeling and other simulation-type modeling techniques have considerable potential for application to projecting future land degradation-migration dynamics in specific countries and regions.

6.2.3 Surveys, qualitative research, and mixed-methods approaches The preceding methods are used to generate broad-brush representations and analyses of environmental migration, and alone are unable to demonstrate or confirm the relative contribution of potential causal variables that influence migration decisions and outcomes. A final set of methods requires establishing contact with people and gathering information directly from them in the form of surveys, questionnaires, interviews, or focus groups. The resulting data may then be analyzed using a variety of quantitative and qualitative techniques, depending on its nature. As with all research, the nature of the study design has a considerable impact on the data obtained, its reliability, and utility. Findings are typically reported as case studies, with researchers aiming to understand both the specific and more general systems interactions between environmental and non-environmental factors in shaping migration patterns and behavior. It was primarily through targeted case studies that research moved beyond early, simplistic narratives of 'environmental refugees' to generate the theoretical and conceptual approaches currently used in environmental migration research, numerous examples of which have already been cited in this report.

Worth mentioning again are two noteworthy research efforts to gather case study evidence on environmental migration, the European Commission-funded EACH-FOR project on environmental causes of forced migration, and the CARE/UN University 'Where the Rain Falls' project on how precipitation patterns influence migration patterns. The EACH-FOR project conducted primarily interview and focus group research across twenty-three countries in Africa, Asia, Europe, Latin America, and Oceania, and generated a wealth of descriptive information and conceptual understanding of the connections between environment and migration that continues to be influential. Some of the many methodological challenges encountered during this ground-breaking project included deciding upon a standardized definition of environmental migration and deciding upon the independent variables that would be considered as environmental change (Warner, 2010). The 'Rainfalls' project represents a mixed-methods approach, in that the research team used a variety of qualitative research methods, gathered survey data from 1,300 people in eight countries (Guatemala, Peru, Ghana, Tanzania, Bangladesh, India, Thailand, and Vietnam), and conducted an agent-based modeling exercise in Tanzania (Warner & Afifi, 2014). As might be anticipated from the preceding discussion, the project concluded that precipitation variability can indeed influence migration, but that the effects vary across countries, and are affected by other socioeconomic variables particular to each study area.

Readers interested in more detailed reviews of the above methodological approaches, or who seek inventories of environmental migration research and case studies are encouraged to consult recently published meta-analyses of the literature such as those by Hunter et al. (2015); Morrissey (2014), Neumann and Hermans (2015), Neumann and Hilderink (2015) and Obokata et al. (2014), or the CliMig database of environmental migration research literature maintained at the University of Neuchâtel (CliMig 2017).

7. SUMMARY OF MAIN FINDINGS AND CONSIDERATIONS FOR POLICYMAKERS

The review of relevant scholarship conducted for this report has found clear evidence that migration and land degradation are strongly interconnected processes, and that a comprehensive understanding of the causes and consequences of land degradation, and identification of the most promising future steps to address it, will be difficult to achieve without considering the migration dimensions. The relationship between population processes and land degradation is complex. This report contains examples where land degradation has caused migration, and others where migration into an area has caused or exacerbated land degradation. It also found examples where migration out of an area has led to land recovery, and others where it led to greater degradation. While no reliable global estimate exists of the number of people who migrate for reasons associated with land degradation, it is reasonable to assume the total is in the millions, likely tens of millions of people each year, most of whom live in rural areas of developing and middle-income countries. Most migration related to land degradation is not of the type that features on television news programs, of people fleeing in refugee-like fashion from conditions of extreme deprivation. Rather, most migration related to land degradation takes place in the context of larger regional and local migration systems, in which households and individuals use migration as a means of diversifying livelihoods and income sources, of reducing their exposure to environmental and non-environmental risks, and of coping with adverse situations.

Land degradation itself is typically not the sole cause of migration from affected areas, but instead interacts with other environmental and non-environmental processes in ways that undermine the sustainability of household livelihoods, and increase the likelihood of migration being used as an adaptive response. Not all households living in areas affected by land degradation have the same adaptation options or the same migration options, because not all households have the same financial resources and access to social networks that facilitate adaptation and migration. Socioeconomic inequality is thus a key factor in shaping migration patterns in areas where land degradation is occurring. Governments, institutions, and commercial interests play important roles in shaping the nature and scale of land degradation itself, as well as the migration patterns that emerge in its wake.

Significant progress has been made in recent decades in the theoretical and conceptual understanding of the interactions between environmental and non-environmental factors that shape migration, and in the methodological and technological tools used to identify and measure environmental migration. The main hurdle to making precise estimates of land degradation-associated migration at the global and regional scales has been access to reliable population and migration data, but this is improving, and it is reasonable to expect better results within the next five to ten years. It is already possible to make reasonably reliable identifications of likely hotspots of land degradation-associated migration, examples being shown in Figures 4 and 6, meaning that policy- and decision-makers increasingly possess the requisite tools for developing and implementing good land use policy. The remainder of this section provides a summary of the general characteristics of land degradation-associated migration; identifies key factors that increase the potential for distress migration, as well as factors that reduce this potential and instead create greater agency for populations at risk; and discusses important considerations for concerned policy- and decision-makers, going forward.

7.1 Common characteristics of land degradation-associated migration

Section 2 of this report introduced a general model of environmental migration (Figure 1), developed as part of the Foresight (2011) study, which provides a useful guide to understanding how land degradation influences human migration patterns and behavior in affected areas. As is shown in the model, and was seen in the numerous case studies reviewed in Section 3, land degradation alone is rarely the sole cause of migration, but at the same time, migration patterns in areas where land degradation is occurring often cannot be fully explained without taking it into consideration. In such areas, it is most commonly the combination of land degradation with other sources of stress that puts pressure on livelihoods and stimulates households to potentially respond through migration. The potential sources of stress may come from macro-level forces, such as global food price markets, national household registration policies, or cultural norms about migration, or they may originate at local levels, such as the failure of a family's crop because of drought, or the intrusion of a commercial forestry company into a particular area. Migration decisions are made at the household or individual level, meaning that migration outcomes ultimately reflect mixes of factors and influences that are particular to any given household or individual, and no two migration outcomes are going to be exactly the same. That said, it is possible to make a number of observations about common characteristics of land degradation-associated migration that are important for policy- and decision-making, going forward.

7.1.1 Internal vs international migration: Most land degradation-associated migration takes place within countries, and any international migration that does occur is most often between contiguous countries, where it is facilitated by pre-existing social networks, such as between Mexico and the US, or between Burkina Faso and Côte d'Ivoire. However, international migration patterns are very sensitive to changes in other influences, such as droughts, political relations between host and receiving countries, and economic growth. It was noted earlier that migration from rural Mexico to the US is influenced by precipitation patterns, and that drought-related declines in crop yields can, after a short interlude, stimulate additional migration to the US, mostly from Mexican states that are persistently dry, and from communities that have strong social linkages to the US (Feng et al., 2010; Hunter et al., 2013; Nawrotzki et al., 2013). Conversely, above-average rainfall in rural Mexico tends to temporarily reduce migration to the US (Puente et al., 2015). At the same time, this particular set of migration dynamics takes place within the much larger context of Mexican migration patterns that are shaped by other factors, including macro-scale ones – such as the economic performance of the US economy, and its need for labor – and micro-scale factors, such as the size of a rural family's landholding, its income, and educational level (Kaestner, 2014; Passel et al., 2012; VanWey, 2005).

7.1.2 Importance of natural climate variations:
Precipitation variability, extreme temperatures, and droughts are important influences on migration patterns in many dryland areas prone to land degradation. In addition to the Mexican example, considerable evidence exists for the influence of drought on migration patterns across Sub-Saharan Africa. However, the migration outcomes vary in nature from one country and region to another. For example, unlike in Mexico, international migration from Burkina Faso tends to decline during droughts, researchers believing that households conserve their financial resources until better conditions return (Henry et al., 2004). In the meantime, households use short term, short distance migration as a coping strategy (Barbier et al., 2009). Shifts in rural migration patterns during droughts have also been documented in Ethiopia, Ghana, Mali, Niger, and Tanzania (Afifi, 2011; Basset & Turner 2007; de Haan et al., 2002; Gray & Mueller, 2012; May & Kayo, 2007; van der Geest et al., 2010), as well as in Bangladesh (Hassani-Mahmooei & Parris, 2012), Brazil (Neumann et al., 2015), India (Deshingkar & Start 2003; Jülich, 2011; Venot et al., 2010), and Nepal (Chapagain & Gentle 2015).

7.1.3 Most migration is labor migration: Large-scale involuntary displacements of people from degraded areas can occur, especially when severe drought conditions coincide with political instability, economic uncertainty, and/or conflict. However, the most widespread type of migration associated with land degradation is labor migration. This type of migration is used strategically by households to overcome the risks associated with living in a challenging environment by diversifying their income sources, consistent with NELM theories about migration behavior, and sustainable livelihood approaches to development. This type of migration was routinely identified in the case studies and empirical reports that were reviewed for this project. Historically, labor migration has been short term or temporary in most regions, usually occurring within rural areas (i.e., rural-to-rural migration) or to nearby towns and urban centers. However, labor migration patterns are changing, with larger numbers of people migrating for longer periods of time, or leaving rural areas altogether; this phenomenon is being experienced in countries as disparate as Ecuador and Ethiopia (Gray, 2009; Mberu, 2006). As urbanization rates accelerate throughout developing countries, seasonal and short term outmigration from degraded and drought-prone regions should be expected to shift increasingly to long term, rural-urban migration. An important concern is the use of remittances received from labor migrants by households in areas prone to land degradation; research shows that there is no clear pattern in terms of their impacts. In some areas, remittances are used to expand and intensify existing land use, while in other areas households reduce their use of the land. In some cases reduced land use allows regeneration of natural vegetation and a decline in degradation, but in other areas neglected lands may actually further degrade or be taken up by new users.

7.1.4 Migration flows into and out of degraded areas: Migration generally tends to generally flow out of areas with higher rates of land degradation to areas with lower rates of land degradation, as was shown in preceding examples from Burkina Faso (Henry et al., 2003) and Guatemala (Lopez-Carr, 2012). However, flows of migration into and out of degraded areas should be looked at in the context of particular ecoregions. In dry grassland areas, migration tends to flow out of degraded areas on an ongoing basis, especially from relatively densely populated areas that are particularly drought prone and heavily degraded. In forest fringe regions, however, the dynamic is more complex. Initially, migrants coming into forest fringe areas are important drivers of deforestation, as they seek to create small farms or work for commercial loggers. Population numbers in the cleared and degrading areas initially rise, and there is considerable movement within the forest fringe area as families and/or larger agricultural operators seek to acquire better land. As the cleared areas become longer established, migration starts to take on the patterns more common to rural areas, generally – greater outmigration of young adults seeking labor market opportunities.

7.1.5 Migration rates are high in places where governments don't help: It is not coincidental that land degradation-associated migration is high in countries where governments and institutions have limited capacity or willingness to help people adapt by other means. This was reflected in the case studies of countries with weak or underfinanced institutions, such as Guatemala and Ethiopia, as well as in the case of people living in remote areas of rural China, who ignore state restrictions on mobility because it is the only way to support their families. Section 3.5 provided examples where corruption and overt state support for land grabs actively contributes to the involuntary displacement of people living in accessible, desirable agricultural areas.

7.1.6 Tenure is important: Land degradation and involuntary migration is, in many areas, being driven by the conversion of traditional or communal land rights to private tenure, leading to the enclosure of traditional grazing areas, deforestation, and the facilitation of agricultural land grabs by outside commercial interests. Traditional, customary, and small-scale users may subsequently be pushed off the land altogether; may respond by increasing stocking rates and/or intensifying farming activities on lands they can still access; may change their livelihood activities; and/or may engage in higher rates of labor migration to offset lost income. Growing socioeconomic inequality typically emerges in such situations, increasing the vulnerability of poorer parts of the population.

7.1.7 Social networks facilitate migration: Social networks are an important force for shaping migration in general, and this is also true in the case of migration associated with land degradation. Social networks make migration less costly, channel migration to particular destinations, and facilitate the flow of remittances between migrant sending and receiving areas. Examples mentioned in preceding sections include the facilitation of rural migration from Mexico to the US (Hunter et al., 2013) and the formation of 'multi-sited' rural-urban family networks in Amazonian Brazil (Pinedo-Vasquez & Padoch, 2009).

7.1.8 Migration is gendered: Again, this is a characteristic of migration per se, and is not uniquely associated with land degradation. This aspect comes up in numerous examples cited in this report, including those from China, East and West Africa, South Asia, and Central and South America. In countries where labor migration is dominated by men – which is common – a disproportionate number of women, children and older people are left behind to manage land in degraded areas.

This has implications for both the management of the land, and for the well-being of the people left behind. For households where the male migrants are able to successfully earn and remit wages, the long term returns may be worth the short term risks, but for less successful households, vulnerability and socioeconomic marginalization may grow.

7.1.9 Land degradation and migration aggravate existing societal tensions: There is little evidence to suggest that land degradation itself, and the associated migration it may cause, are direct causes of violence and civil conflict. However, there is a general belief among researchers that in areas where violence and civil conflict is already a possibility, land degradation and migration likely exacerbate other political, social, economic, and cultural factors that drive groups into competition and conflict.

7.1.10 Climate change will lead to migration change: The impacts of climate change will exacerbate processes of land degradation in many regions and will have direct and indirect effects on rural household incomes, by causing increased risks of crop losses and fluctuating commodity market prices. Assuming future migration patterns and behaviors continue to follow current trends, it should be expected that migration flows out of drought-prone and degraded areas will grow as households adjust and adapt to changing conditions.

7.1.11 Measuring and monitoring capabilities are getting better: New research tools, methods, and datasets are increasing researchers' ability to detect, measure, and monitor land degradation and associated migration. Researchers have the ability to identify potential hotspots that warrant closer study and greater attention from policy-makers. A main stumbling block continues to be obtaining reliable population datasets that are rich in migration data, something that could be overcome through relatively modest investments by the international community.

7.2 Some final considerations for policymakers

A wide number of suggestions, recommendations, and potential considerations for policy- and decision-makers might be made from the findings of this report. A first important one concerns the nature of the report itself: it should be seen as a baseline study that provides a starting point for greater research, and more policy and planning consideration, about the linkages between land degradation and migration. It is far from being the final word on the subject. Although this report has highlighted the rapid development in scientific understanding of this phenomenon in recent years, it has also shown the gaps in available knowledge. For example, much of the existing research focuses on the impacts of drought on migration patterns, with less attention being paid to the migration consequences of longer term changes in vegetation or soil quality induced by human activity. Another reality is that, although the evidence shows that migration outcomes are highly context-specific, a disproportionate amount of existing empirical evidence comes from a small number of relatively well-studied locations. In many cases this is simply because there is data available for these locations. A more comprehensive understanding of land degradation-associated migration will ultimately require a wider and more diverse set of empirical evidence.

That said, there is still ample, reliable information available for policy- and decision-makers to work with, as was summarized in the preceding section. While international attention is rightly attracted by short-term crises where land degradation, drought and other forces coincide to create distress-migration and human suffering, the evidence shows that migration associated with land degradation is actually much wider in scale and variable in nature. Developing strategies to combat land degradation and desertification requires engaging with governments, commercial interests, and local populations to change land use activities from ones that are destructive to ones that are sustainable. Because livelihoods and household incomes in degraded areas are closely interconnected with migration, any policies and initiatives that do not consider the migration implications of potential actions run a higher risk of failure, and of impoverishing people whose livelihoods depend on the land. This report points to a strong need for migration to be considered and mainstreamed into international, regional, and national policies, as well as into programs to combat land degradation.

There is growing discussion within the UNCCD and wider policy-making community about the need to achieve land degradation neutrality, and the need for a wider change in paradigms about land use, from one of exploitation to one of stewardship. Specifically, it is said that there must be a shift from 'degrade-abandon-migrate' to 'protect-sustain-restore' (UNCCD, 2013).

The phrase 'degrade-abandon-migrate', which is not generally used in scholarly research, is consistent with certain examples in the research, such as in cases of migration to the forest fringe and to areas of artisanal mining. However, the phrase somewhat oversimplifies the relationship between land degradation and migration, and may conceal a deeper problematic: the lack of abandonment. As noted in section 3.7, outright abandonment of degraded lands is relatively uncommon; usually there is continued occupancy and residual land use even in highly degraded areas that experience outmigration. Those who remain behind may be left impoverished or find their livelihood options constrained, and in many cases this continued occupancy is maintained by remittances received from migrants who have left the degraded area. Recall that in preceding sections in which the effects of remittances are discussed, there are examples where households receiving remittances have allowed the land to regenerate and restore itself, but also others where the remittances were used to further intensify and expand land use and thus exacerbate degradation. A challenge is therefore to find ways of ensuring that remittance flows into degraded areas are used in ways that promote and enhance sustainable livelihoods and ecological restoration and do not prolong unsustainable activities. There is evidence that such outcomes are possible, one example being research from the use of remittances received by families in coastal Vietnam (Adger et al., 2002).

This raises a larger set of challenges facing policy-makers seeking to tackle the root causes of land degradation that are, in turn, part of a wider tension within the international development community. Many of the solutions promoted by development agencies and national governments for reducing rural poverty and coping with additional challenges like climate change, population growth, and food security prescribe the expansion, intensification, and modernization of agricultural production in developing nations. Is it possible to foster such development while simultaneously preventing or reversing land degradation, and avoiding the involuntary displacement of people? There are no quick and easy, one-size-fits-all solutions to be found in the existing environmental migration research literature, although there are a number of examples of undesirable outcomes to be learned from. Because land degradation, rural livelihoods, and migration are so fundamentally intertwined, any long-term transition to a 'protect-sustain-restore' future will inevitably have a migration component.

It was noted in the preceding section that migration rates are often high in areas where governments and institutions are least willing or able to help people adapt through other means. The MESA function introduced in Section 1 reminds how migration is one of a variety of ways by which households and individuals adapt to adverse circumstances. Common development goals, such as building social programs, basic infrastructure, and policies that support local empowerment and innovation are not simply good development practices, but are also important ways of growing the adaptive capacity of rural populations. Migration in and of itself is neither good nor bad; it is the conditions under which it occurs that make it desirable or undesirable. Migration under conditions of low agency – i.e., when there are few other alternatives – is undesirable from both the perspective of the migrant and of the sending and receiving communities. Increasing the prospects that migration undertaken in areas of land degradation is 'high agency' requires making investments that enhance rural prosperity more generally, and providing institutional supports that grow the overall adaptive capacity of rural households.

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