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# The Impact of Vulnerability and Resilience to Environmental Changes on Mobility Patterns in West Africa

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# The Impact of Vulnerability and Resilience to Environmental Changes on Mobility Patterns in West Africa\*

Caroline Zickgraf, Sara Vigil, Florence de Longueville, Pierre Ozer, and François Gemenne<sup>†</sup>

## Abstract

From the Sahel to the coast, West Africa is experiencing a variety of environmental change impacts, whether resulting from slow-onset changes or sudden shocks. They are significantly influencing migration patterns in and out of West Africa. In this region where natural resources form the foundation of livelihoods and food security (fishing and agriculture), the relationship between environmental changes and socioeconomic vulnerabilities is of particular concern. Environmental degradation affects populations' vulnerability and resilience capacity in complex ways. The presence of multiple environmental trends and shocks varies geographically. While desertification and droughts are of prime importance for some, floods, coastal erosion, and sea level rise are the main hazards for others. Even within local populations affected by the same climatic threats, their vulnerability and likelihood to migrate are affected by their socioeconomic status, their dependence on natural resources, and their demographic characteristics. Given the differentiated vulnerabilities and capacities for resilience, policy must be adapted and implemented according to particular populations and needs. Policy makers must also consider vulnerability as it is perceived by those affected. Therefore, environmental mobility cannot be treated as a strictly rational behaviour based on actual vulnerability. Local populations must be educated about current and expected changes to their natural environments to facilitate better-informed mobility decisions. Migration can also offer a significant tool with which local populations can increase their resilience to socio-environmental changes. Building infrastructure and establishing protection mechanisms for migrants and displaced persons is a necessary step in mitigating future risk. Regional authorities must work together to build the resilience of sending communities to climatic shocks, but they must also facilitate migration as an adaptation strategy by recognizing the development potential of remittances. These policy interventions may help decrease the potential for the creation of “trapped” populations, be they trapped in areas of origin, in transit, or in destination areas.

Keywords: Migration, Adaptation, Climate change, Vulnerability, Resilience, Erosion, West Africa, Senegal, Benin, Immobility

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## 1. Introduction

West Africa is one of the most dynamic regions in which to examine the human impacts of climate change. From the Sahel to its coasts, it faces the many manifestations of climate change, including sea level rise, soil salinization, floods, drought, desertification, intensifying winds, and heat waves (IPCC 2014; DARA 2013). Moreover, the consequences of climate change are only one part of the current processes of environmental degradation affecting the region. Taken together, these environmental changes are significantly influencing mobility patterns in West Africa. Yet, although environmental degradation acts as one driver of regional mobility, it cannot be isolated from other political, social, economic, and demographic pressures that together shape migration patterns (Black et al. 2011). In a region where natural resources (for example, fishing and agriculture) form the foundation of livelihoods and food security, the relationship between environmental change and socioeconomic vulnerability is of particular concern, and will be a key feature in this paper.

This paper provides an analysis of vulnerability and resilience to environmental change in relation to mobility patterns in West Africa. The 2014 IPCC report defined vulnerability as “the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt” (IPCC 2014, 5) and resilience as “the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation” (IPCC 2014, 5).

The following analysis first provides an overview of environmental change (both slow-onset processes and sudden climatic events) before detailing its role in driving internal and international mobility. Because the relationship between vulnerability, resilience, and mobility in the region cannot be adequately addressed without considering the variations among and within populations, this discussion draws from four case studies based on extensive field experience in West African countries. Each case study takes a distinct methodological and disciplinary approach to analyzing the impacts of environmental degradation on the vulnerability and resilience of communities, households, and individuals and their relationship with migration. The diversity of methods seeks to grasp the different dimensions of the interplay between environmental change, resilience, and vulnerability that are brought together in this paper. This mixed-methods approach should allow a more comprehensive view of this interplay in the region to be provided, moving beyond the particularities of each case study.

The objective of such an approach is to reflect the diversity of environmental migration flows in the region specifically tied to slow-onset environmental changes by touching upon different environmental stressors, economic sectors tied to natural resources, and the heterogeneity of vulnerability and resilience among local populations as it affects their mobility responses. In addition to demonstrating the complexity and diversity of the environment-migration nexus across the region, several connective threads run throughout these case studies that are of critical importance to West African policy makers: the importance of local perceptions of environmental change and of differentiated and cumulated vulnerabilities within each studied population as they determine mobility decisions and outcomes for resilience.

## 2. Current Environmental Trends in West Africa

A significant increase in the frequency and intensity of natural disasters in West African countries has been observed in recent decades and attributed to global warming (IPCC 2012). Floods, droughts, strong winds, and heat waves are the most tangible extreme weather events affecting populations (DARA 2013). According to data from the International Disaster Database of the Centre for Research on the Epidemiology of Disasters (CRED 2015), natural disasters such as droughts and floods affected more than 28 million people in West Africa from 2010 to 2014. Strong coastal erosion and sea level rise are further compounding the vulnerability of populations along the entire coast, from Mauritania to Nigeria (UEMOA 2010). Desertification and soil erosion are happening continuously as a result of the climatic events (Stringer et al. 2011), adding pressure to food insecurity and thus further exacerbating the vulnerability of local populations (Ozer et al. 2010).

A study on livelihood security in West Africa led by the United Nations Environment Programme identified 19 “climate hotspots” severely affected by natural disasters and climate change (UNEP 2011). These hotspots are mainly located in the central part of the Sahel, Niger, Burkina Faso, northern and coastal Ghana, as well as in northern Togo, Benin, and Nigeria and often straddle international borders, highlighting that risk management requires an interstate response. These areas have been heavily hit by floods in recent years and also recorded significantly increasing temperatures and a substantial increase in the frequency of droughts. The latter primarily affect the most arid countries (Mauritania, Mali, Niger), which account for nearly 90 percent of drought victims (50 million cumulative people) since 2000 in West Africa (Gemenne et al. 2014). These recent changes are affecting the livelihoods of millions of people who depend directly on natural resources.

The agricultural sector employs 60 percent of the workforce in West Africa while it contributes only 35 percent of GDP (Jalloh et al. 2013). The national economies in this region are particularly vulnerable to climate change because the populations are heavily dependent on rain-fed agriculture. The effects of climate change are strongly felt by rural people, regardless of their geographical position and the reporting rainfall zone. A majority suffer from a decrease in the length of the rainy season caused by a delay of its starting date and an earlier end, an increase in extreme rainfall events, and dry periods within the rainy seasons that may compromise agricultural production. A majority of farmers in the Sahelian arid zone believe that precipitation changes have occurred during the past 20–30 years, whereas in wetter areas (Guinean zone) effects were felt during the past decade (Ozer and Perrin 2014; de Longueville et al. 2016).

According to UN estimates, the population of West Africa increased from 86 million people in 1961 to 340 million in 2014, and is expected to increase to 815 million people by 2050 (FAO 2014). Mainly cities will be affected by rapid demographic growth, partly because of rural-to-urban migration trends (Foresight 2011). In Sub-Saharan Africa, 70 percent of rural-to-urban migrants move into slums where populations are particularly vulnerable (UN Habitat 2010). Therefore, migration to urban centers can also increase the vulnerability of urban communities to climate impacts. The urban population accounted for 16 percent (14 million) of the total population in 1961, 47 percent (159 million) in 2014, and is expected to reach 66 percent (534 million) in 2050 (FAO 2014). Urban areas are ill-equipped to absorb such population growth, and are simultaneously increasingly threatened by global environmental change (Foresight 2011). Furthermore, these demographic changes and associated vulnerabilities contribute to the decrease of cities’ capacity for

resilience. The effects of annual floods reflect the explosive growth of cities, poverty, and the lack of urban planning policies. Human activities are responsible for the increased flooding caused by urban sprawl into risk areas (floodplains of rivers, depression areas, axes serving as natural outlets of the water, and so on). Nouakchott, Ouagadougou, Cotonou, Dakar, and Niamey are some examples of cities more and more regularly affected by flooding, as are a large number of primary and secondary cities of all countries of the West African region (Ould Sidi Cheikh et al. 2007; Descroix et al. 2013). According to a report from the Intergovernmental Panel on Climate Change, the cities of developing countries with health services, housing, and good-quality water disposal systems will more easily adapt to climate change (IPCC 2014), but this unfortunately is not the case among West African cities.

Current projections show that Sub-Saharan Africa will be the area most affected by climate change, along with small island states and coastal and deltaic regions (Gemenne 2011a). IPCC (2014) mentions that temperatures could rise by 3°C to 6°C in some parts of Africa, including the Sahel, by 2100, which is likely to be accompanied by a significant increase in natural disasters. The recurrence of extreme events makes people more vulnerable. Adverse effects are expected on major crop production and livestock and the availability of drinking water, and will probably cause the collapse of the fishing industry. In addition, climate change contributes to food insecurity and worsening health problems (IPCC 2014). Faced with these threats, policy responses are urgently needed because the effects of global warming are a serious obstacle to development and regional resilience.

### **3. Environmental Context as a Driver of Migration in West Africa**

Although there is now consensus that environmental factors play a role among the many interacting causes of migration, debate as to their importance continues (Perch-Nielsen, Bättig, and Imboden 2008), given that human migrations are explained by a combination of factors—economic, political, demographic, social, and environmental (Black et al. 2011). In West Africa, population movements, including displacement, are caused by economic crises, armed conflict, generalized violence, violations of human rights, large-scale development projects, environmental change, and natural disasters (Ferris and Stark 2012). The relationship between environmental change and migration is further complicated by the indirect nature of the impacts of many environmental changes (Mortreux and Barnett 2009; Foresight 2011). For example, it is through livelihood systems that migration is affected by rainfall variability (Warner and Afifi 2014).

The environment-migration nexus literature typically distinguishes between forced displacement and voluntary movement in response to environmental change, as well as between people who flee a disaster and people who gradually leave because of environmental degradation, but also between internal migration and international migration, and permanent and temporary migrants (Bates 2002; Gemenne 2011b; Renaud et al. 2011). However, environmental changes include a set of different processes: rapid-onset hazards, loss of ecosystem services, and slow-onset hazards that consist in accelerated or gradual degradation of ecosystems (Renaud et al. 2011). In response to rainfall variability for example, four patterns of migration can be distinguished in West Africa (Warner and Afifi 2014): (1) households that use migration to improve their resilience (successful migration); (2) households that use migration to survive, but not flourish; (3) households that use migration as a last resort, an erosive coping strategy; and (4) households that cannot use migration and are struggling to survive in their areas of origin. Whether migration is a forced

movement or an adaptation strategy depends on a number of factors, such as the type of climate shock, the characteristics of the affected population, and the capacity of institutions (local, national, and international) to prevent the adverse effects of climatic shocks (Coniglio and Pesce 2010).

The concept of immobility is fairly new (Black et al. 2013) yet very important, as environmental change increases the vulnerability of people and can make them less able to migrate in a number of cases. This is particularly true in West Africa—several studies show that migration decreased during the severe drought years in the 1970s and 1980s in Burkina Faso (Henry et al. 2004) and Ghana (Van der Geest 2011). This decrease in migration can be explained by the fact that migration requires financial resources that cannot be mobilized in times of crisis. Research indeed proves that it is not generally the poorest people who migrate (Tacoli 2009). In some cases, the migrants themselves increase the vulnerability of their communities of origin because they represent a depletion of the workforce, skills, and wealth (Cissé et al. 2011). But sometimes migration has conversely positive impacts on origin communities and on the environment in the origin area. Migrants can reduce the vulnerability of their communities of origin through remittances and information (Adger et al. 2002; Tacoli 2011). Thanks to skills transfer, migrants share new techniques for managing soil fertility, and as they leave they alleviate the pressure on local resources. This kind of positive feedback helps to maintain the livelihoods of original populations by improving both their living conditions and their environment.

Floods are among the most frequent natural disasters in the West African region, and the resulting population dislocations constitute one of the most visible examples of displacement. The number of people affected by floods in West Africa has increased steadily since 1980. According to statistics from the Emergency Events Database (EM-DAT) (CRED 2015), floods affected 13.6 million people in West Africa during the 2004–13 period, though not all of them were displaced. In total, 600,000 people were affected by the 2009 floods in Burkina Faso, Ghana, Niger, Senegal, and Sierra Leone. According to estimates by the Internal Displacement Monitoring Centre (IDMC), in Nigeria, 6,818,000 people were displaced because of natural disasters between 2008 and 2012. The devastating floods of September and October 2012 caused the displacement of 6,112,000 people in this country—representing 3.6 percent of the total population. Thousands of homes, bridges, and other infrastructure, as well as large agricultural areas, were completely devastated (Yonetani and Morris 2013). According to estimates, the number of people threatened by coastal flooding will dramatically increase along the Gulf of Guinea and the Senegalese and Gambian coasts (UNESCO 2012). In West Africa, 40 percent of the population lives in coastal cities, and it is expected that the 500 kilometers of coastline between Accra and the Niger Delta will be populated by more than 50 million people in megacities by 2020 (Hewawasam 2002). Studies show that among African port cities most exposed to sea level rise, six are in West Africa (Lagos, Abidjan, Lomé, Conakry, Dakar, Accra) (Nichols et al. 2008). Sea level rise can also cause soil salinization and thus damage land, agricultural productivity, and food security.

Although most mobility related to natural disasters occurs within national boundaries, studies have shown that rural communities affected by drought and slow-onset events can cross borders, especially where borders are more permeable as in the Sahel (Findley 1994). Mobility due to economic, social, and political vulnerability can have indirect effects on resilience to environmental factors, just as environmental factors may aggravate existing and fragile social, political, and environmental conditions. For example, the drought that affected the Sahelian region in 2012 combined with the political instability and conflict occurring in the

north of Mali displaced hundreds of thousands of people from the drought-affected communities in the south and in neighboring countries. A special feature of West Africa is its unusually high level of intraregional migration, with the highest number of mobile peoples of any region in the world. According to the bilateral migration matrix developed by the World Bank (2011), more than 58 percent of migration flows in West Africa take place within the subregion. The importance of intraregional migration in West Africa can be partly explained by the creation in the late 1970s of an area of free movement of people within the Economic Community of West African States. In fact, migration between West African countries is mostly from neighboring countries (World Bank 2010). It is the only region of Africa where intraregional migration is greater than outward migration (34.5 percent, mainly to Europe) (Ndiaye and Robin 2010). Numbering some 8.4 million people, West Africa also has the largest stock of migrants of any subregion in the world (UN DESA 2009). Despite these statistics, lack of reliable data on population dynamics in the region (especially as they relate to environmental migration) makes it difficult to assess vulnerability and mobility on a regional scale. It is thus essential that governments cooperate to collect reliable data upon which policy makers can shape long-term strategies. Political, social, and environmental crises existing in the region will be exacerbated by the effects of climate change in the coming years, likely leading to more frequent migration (IOM 2014).

#### **4. Perception versus Reality of Rainfall Variability in West Africa**

Climate change has been affecting the economic and social vulnerability of populations for decades, particularly in West Africa where the populations are largely dependent on rain-fed agriculture (Juana et al. 2013). Economic loss, damage to water resources, decreases in crop production, and mortality are some of the direct and indirect impacts (Crétat, Vizzy, and Cook 2014; Meehl et al. 2000; Mouhamed et al. 2013). Are such impacts due to increasing frequency of extreme events and climate variability, to growing vulnerability, or to both (Easterling et al. 2000)? It is currently difficult to answer this question because of a lack of thorough empirical evidence. What is more certain is that populations must adapt to environmental changes. In arid and semi-arid areas, climate change adaptation strategies implemented by farming communities vary according to region and depend on a multitude of factors, including cultural ones (Adger et al. 2009; Nielsen and Reenberg 2010). Temporary or permanent migrations are part of these households' adaptation strategies to maintain their standards of living through the diversification of livelihoods (McLeman and Hunter 2010; Wouterse and Taylor 2008).

An increasing number of studies about the impacts of environmental change on migration are available, but they are based on objective determinations of environmental changes (Foley et al. 2013; Ahouangan et al. 2014; Sow, Adaawen, and Scheffran 2014). Populations' migratory responses are made based on their perceptions of environmental changes and their own vulnerability to them; thus, taking into account the perception of change by local populations can improve the understanding of the environment-migration nexus and help provide insights into the magnitude and character of future migration patterns.

This case study therefore compares the perceptions of rainfall changes experienced by people in different climatic regions of West Africa with the actual trends recorded in the same period. Then, assuming that migration decisions are made based on the perception of changes rather than changes themselves, the second objective is to assess migration intentions as direct responses to future climate change to frame the importance of migration in this region in the coming decades.

### 4.1.1. Methods

A request by keywords was carried out using the Scopus and Google Scholar databases since 2000 to find studies on perceptions of rainfall change in West Africa. A distinction was made between studies in the arid zone (300–500 millimeters of annual precipitation) and in the semi-arid zone (500–900 millimeters). Results of these studies were compared with real climate trends available in the literature. The data on the intention to migrate were taken from socioeconomic surveys of the African Monsoon Multidisciplinary Analyses project conducted in five West African countries between November 2007 and June 2008. Questions related to intentions to migrate, either temporarily or permanently, in response to three potential situations—a drought, a more arid climate, and a more humid climate—were posed to 1,342 households distributed in two climatic zones (Mertz et al. 2011). This analysis examines the main strategies considered by respondents in case of rainfall change and assesses the place of their intention to migrate.

### 4.1.2. Findings

#### *Perception of rainfall change vs observed trends*

The literature review shows that the most important change felt by the West African populations is a decrease in total annual rainfall, but populations also perceived a decrease in the length of the rainy season (later starting date and earlier end date), and increases in dry spells during the rainy season and in periodic droughts and irregular rainfall (table 1). These perceptions show the same trends in the two climatic zones but are somewhat more pronounced in the arid zone than in the semi-arid zone.

**Table 1. Perception of Change in Rainfall in Arid and Semi-Arid Zones of West Africa**  
(percentage of interviewed people; if the total is not 100 percent, the rest is “without opinion”)

		Arid zone			Semi-arid zone		
		Decrea sing	Stable	Increas ing	Decrea sing	Stable	Increas ing
Total annual rainfall	(Akponikpè et al. 2010)	91	2	2	61	4	21
	(Mertz et al. 2009)				82	5	13
	(Mertz et al. 2012)	83	4	13	82	10	8
	(Diessner 2012)	90	6	3			
Length of the wet season	(Akponikpè et al. 2010)	91	2	4	61	6	14
	(Nielsen and Reenberg 2010)	60	6	26			
	(Mertz et al. 2012)	82	6	12	84	10	6
Dry spells during the wet season	(Akponikpè et al. 2010)	6	6	85	13	4	68
	(Nielsen and Reenberg 2010)	14	0	74			
	(Mertz et al. 2009)				23	0	45
	(Mertz et al. 2012)	20	6	74	10	6	84
Start of the wet season	(Akponikpè et al. 2010)	85	4	6	67	9	15

		Later	Stable	Earlier	Later	Stable	Earlier
End of the wet season	(Akponikpè et al. 2010)	70	7	11	48	13	24

There is an overall pessimistic perception of rainfall change. Results show that the population believes changes in rainfall have occurred (table 2) even though such changes in rainfall trends are not clearly reflected in climatic data (New et al. 2006; Lebel and Ali 2009). The differences between observations and perceptions are more likely a reflection of a progressive decline in socioeconomic conditions (resulting notably from a loss of profitability in the agricultural sector) due to other factors (demographic pressure, environmental degradation) co-occurring with climate change (Müller et al. 2014). The people of West Africa have become increasingly vulnerable because of the region's population growth and poor infrastructure, and they will find it increasingly difficult to be resilient, even in the face of low-intensity changes (Müller et al. 2014).

**Table 2. Significant Changes in Rainfall Felt by Populations in Arid and Semi-Arid Zones of West Africa According to Results from Focus Groups** (the first change is the most important)

		First change	Second change	Third change
Arid zone	(Ouédraogo, Dembélé, and Somé 2010)	Decrease in rainfall	Changes in the onset and offset of seasons	Increase of dry spells
	(Dieye and Roy 2012)	Decrease in rainfall	Irregular rainfall	Changes in the onset and offset of seasons
	(Tschakert 2007) (West, Roncoli, and Ouattara 2008)	Lack of rain Long-term decline in rainfall	Irregular rainfall Increase in rainfall variability	Periodic drought
Semi-arid zone	(Ouédraogo, Dembélé, and Somé 2010)	Decrease in rainfall	Changes in the onset and offset of seasons	Irregular rainfall
	(Tambo and Abdoulaye 2013)	Decrease in rainfall and changes in the timing of rain	Changes in the timing of rain	Decrease in rainfall

#### *Intention to migrate in case of rainfall changes*

In response to a drought, a drier climate, or a wetter climate, migration is rarely the first adaptation strategy currently implemented by the surveyed population, but the intention to migrate is an important one should the situation worsen (or rather be perceived to worsen). In case of drought, respondents currently give priority to selling their livestock, but several strategies are often considered together. Temporary migration has been cited as the first strategy in case of drought by 24 percent of respondents, and in total 29 percent of respondents intend to use temporary migration in response to a drought in the future. In case of a drier climate, the first two cited strategies are search for new crop varieties and livestock sales. About 11 percent of respondents indicated that they would resort to temporary migration and 30 percent to permanent migration in response to a future drier climate; and temporary and permanent migration would be the first strategy for 6 percent and 13 percent of households, respectively. The intention to migrate also exists but

is less important in case of a wetter climate, with only 2 percent and 4 percent of respondents saying they would migrate temporarily or permanently. Some 36 percent of respondents intend to migrate temporarily in a rainfall deficit situation (drought or drier climate). In total, taking into account temporary and permanent migration, more than 51 percent of respondents plan to migrate if rainfall conditions deteriorate in the future. However, some people who do not intend to migrate may not have a choice in the future and may have to use migration as a survival strategy. Conversely, the intention to migrate may not translate into actual movements: people who intend to migrate may find themselves unable to do so, lacking the necessary means (for example, financial, social, and human capital).

#### **4.1.3. Conclusion and Policy Implications**

Whereas researchers and stakeholders often consider the effects of climate change on the vulnerability and resilience of affected populations, this case study highlights the importance of taking into account populations' perceptions of climate change given that their perceptions can affect their adaptation responses. A perfectly rational decision to migrate in response to perfect information on the actual climate event is not actually in the populations' capacity to make, because it is their perceptions of change that drive their behavior (stay or move) rather than actual change. The conclusion of this study highlights the need for vulnerable populations to have better information to allow them to make better-informed policy choices.

### **5. Case studies**

In the following case studies, we attempt to measure the intersections between environmental changes, perceptions of those changes, and mobility outcomes.

#### **5.1. Environmental Mobility and Fishing Communities in Guet Ndar, Saint-Louis (Senegal)<sup>1</sup>**

##### **5.1.1. Context**

Senegal's coast, like that of many other coastal West African countries, is threatened by climate change impacts of coastal erosion, sea level rise, flooding, soil salinization, and increasing storm surges (Salem 2013). Concomitantly, the Senegalese coastal waters have witnessed changes in currents, stronger waves, depletion of fish stocks, and decreases in maritime biodiversity. These visible impacts of climate change have been compounded by man-made environmental degradation, including overfishing by national and foreign industrial vessels and local changes to infrastructure such as the opening of a breach in 2003 that displaced dozens of villages in the Langue de Barbarie along Senegal's northern coast (Tacoli 2011). These environmental changes threaten the livelihoods of the approximately 600,000 people directly or indirectly working in the Senegalese fishing industry (FAO 2008), increasing and diversifying existing mobility

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1. The research leading to these results has received funding from the European Union Seventh Framework Programme FP7/2007-2013 under grant agreement No. 603864.

patterns. Yet Senegalese fishermen's mobility responses and their effects on local resilience capacity have received little attention.

### **5.1.2. Methods**

To examine the migratory patterns associated with man-made environmental degradation and climate change impacts in West African fishing communities, a qualitative case study was undertaken in Guet Ndar,<sup>2</sup> an overcrowded fishing quarter in Saint-Louis, Senegal. Along with an extensive literature review and document analysis, the primary tools of investigation were qualitative, in-depth interviews and focus groups with fishermen (migrant and nonmigrant), women working in the local fishing industry, and leaders of fishing associations. Local and national stakeholders, experts, community leaders, and researchers were also consulted in Dakar and Saint-Louis. The qualitative data were collected over a five-week period during the summer of 2014. Participants were selected using a network-sampling strategy, and insofar as possible maximum variation, in which respondents reflected different occupations, ages, gender, and geographical locations (and thus the differences in perceived and actual environmental threats) within Guet Ndar.

### **5.1.3. Findings**

#### *Vulnerability*

In 2008, UN-Habitat designated the city of Saint-Louis as the most threatened by sea level rise in all of Africa. The fishing quarter of Guet Ndar in Saint-Louis is particularly vulnerable to environmental degradation. This vulnerability stems, first, from the quarter's location between the Senegal River on its eastern limits and the Atlantic Ocean to its west, leaving it with no territory to expand into as the sea advances. Piles of rubble and debris where homes once stood line the coast. Currently, those who live on the "front lines" of Guet Ndar are forced to build their own makeshift barriers to protect their homes from coastal erosion and sea level rise. In the south of Guet Ndar, women's working spaces for fish processing are now tightly cramped areas, wedged between the sea on one side and a cemetery on the other. Therefore, some women have resorted to performing their work beside their homes, or commuting daily to a nearby newly constructed space north of Guet Ndar near the Mauritanian border. Compounding local vulnerability, the quarter is one of the most densely populated districts in all of West Africa, with more than 25,000 inhabitants occupying an area 1 kilometer long and 300 meters wide according to regional statistics (CLUVA 2013; Ateliers 2010). The local impacts of climate change only exacerbate overcrowding, with coastal erosion forcing the growing population into an ever-smaller space. Furthermore, without an agricultural production program, almost all households rely on fishing in one form or another. The local population is also heavily reliant on fish for their own subsistence, being a hallmark of the daily local diet in traditional dishes such as Thiéboudienne. Guet Ndar's inhabitants are therefore especially vulnerable to the impacts of climate change and environmental degradation because they threaten their local livelihood strategies, their lands, and their food security. It is interesting, however, that only two respondents in the study attributed environmental change in Guet Ndar in any way to climate change. Respondents cited overfishing by foreign vessels and other unintended consequences of man-made changes to the

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2. Interviews were also conducted in rural villages in the south of the Languedoc de Barbarie and two urban neighborhoods to the north of Guet Ndar: Ndar Toute and Goxu Mbathie.

environment (for example,, the opening of a breach in 2003 to decrease flood risks in the city) as the primary causes of environmental degradation, and thus the key challenges facing Guet Ndarians alongside urban overcrowding.

### *Mobility patterns*

As local livelihoods become increasingly difficult to maintain, building on a long history of fishing migration throughout West Africa, many Guet Ndarian fishers respond by traveling northward to Mauritania (Sall and Morand 2008), where infrastructure and livelihood opportunities are markedly better. Although some fishermen fish irregularly just across the Senegalese-Mauritanian border or obtain one of 400 licenses granted annually to fishermen to bring catches back to Senegal, the danger of fishing irregularly stemming from conflicts with the Mauritanian coast guards historically and contemporarily led most respondents to obtain contracts with Mauritanian factories. Lacking a strong fishing tradition, factory representatives are sent to the quarter to recruit the highly experienced Guet Ndarian fishermen. The primary international destinations of Guet Ndarian fishermen are the Mauritanian cities of Nouakchott and Nouadhibou. Although retired respondents had fished outside of Guet Ndar in Mauritania, Guinea, and Guinea-Bissau, among others, the diminishment of local fish stocks because of climate change and overfishing has increased fishing migration to Mauritania and for longer durations. Whereas retired fishermen had travelled for short periods and seasonally in the past, currently active fishermen are spending 10 months or more outside of Guet Ndar. Moreover, those who stay in Guet Ndar and fish locally no longer abstain from fishing during maritime reproductive months because of the diminished returns the rest of the year and a lack of local infrastructure to preserve their catches, which in turn exacerbates maritime resource depletion.

Fishermen preferred to remain in Guet Ndar; however, fishing migration allowed men to support their families living in the community of origin. Money earned by fishermen in Mauritania is sent primarily through informal channels to relatives who stay behind in Guet Ndar. These remittances supplement household income and provide for basic necessities such as food, water, and shelter, demonstrating the importance of migration for improving household resilience in the community of origin by decreasing residents' reliance on the local economy. However, currency exchange rates weakened the potential of remittances and, additionally, differences among migrant fishermen led to varying levels of remittances. Irregular fishermen often have their equipment confiscated, and are jailed or fined by the Mauritanian coast guard, losing any earnings or assets in the process.<sup>3</sup> Poorer artisanal fishermen who take up contracts with Mauritanian factories must pay off the debts they accumulate when taking on loans for fishing equipment (boats, nets, motors, and the like), which decreases their remittances capacity. Only the more successful fishermen, who own their own, larger boats ( 25-meter pirogues) and therefore are able to generate larger catches, are able to send greater sums back to Guet Ndar. In an important development, the last group is able not only to provide their families with basic necessities, but also to relocate their families out of Guet Ndar and away from the encroaching sea. In a gradual process (sometimes taking more than a decade), remittances are used to construct homes in other coastal districts perceived to be safer from sea level rise and coastal erosion. Although local authorities have made gestures toward establishing

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3. Respondents who obtained a license to fish in Mauritania and return with their catches to Senegal also reported the same problems, citing corruption among Mauritanian coast guards.

residential developments for Guet Ndarians at danger of displacement, homes in these areas are often costly, and relocation remains out of reach for the households most vulnerable to climate change and environmental degradation, placing them at risk of becoming “trapped populations” (Foresight 2011).

#### **5.1.4. Conclusions and Policy Implications**

Driven by residential destruction, demographic pressures, and concomitant economic strife caused by maritime resource degradation, urban fishermen and their families are highly vulnerable to the current impacts of climate change, which will only exacerbate migratory pressures in the future. To protect these vulnerable coastal populations, local and national governments must intervene to mitigate and adapt to the effects of climate change but also to limit degradation caused by man-made environmental changes (for example, overfishing by foreign trawlers, unsustainable fishing practices, and breach openings). As it is, other than erection of makeshift barriers, departure is often seen as the only solution for those who are able to do so.

Environmental degradation is already significantly influencing both internal and international mobility patterns in Saint-Louis, Senegal. However, Guet Ndarian households’ vulnerability varies and so does their capacity for migration and building resilience. Active fishermen are able (if not always willing because of precarious conditions) to move up the coast to sustain their livelihoods, while those who are retired, elderly, or whose occupations are land-based are less able to migrate as an adaptation strategy and therefore rely on household members’ labor migration.

However, even though most fishermen are able to embark on international labor migration in one form or another, only the most successful fishermen are currently able to relocate their families within Senegal. The case of Guet Ndarians therefore demonstrates the importance of integrating livelihood strategies and socioeconomic status variations into vulnerability and resilience assessments and local, national, and intraregional adaptation plans. Policies and government initiatives must also make relocation available to the most vulnerable households, those in imminent danger of displacement, and those without the capital to move out of harm’s way. However, any efforts to relocate fishing families must be accompanied by infrastructure that recognizes their dependence on the sea, making commuting to work accessible, for example. Furthermore, policy interventions that seek to limit the need for international migration must ask how the local fishing sector can be developed to absorb excess labor supply and to address inadequate fish stocks, such as through investment in preservation and processing factories and the halting or mitigating of unsustainable fishing practices, both commonly cited solutions among Guet Ndarian respondents.

Finally, the connections between internal and international mobility patterns expose the importance of addressing environment-related population movements with integrated local, national, and regional solutions. As demonstrated by empirical investigation, these mobility responses are highly interrelated because international migration can facilitate internal relocation through remittances, and therefore cooperation among different levels of government and between countries is needed. Although Senegal and Mauritania recently increased the number of annual licenses granted for people to bring fish back across the Senegal-Mauritanian border from 300 to 400, further increases could improve the resilience capacity of local populations by stimulating the local economy, improving food security, and ameliorating precarious living and working conditions for migrant fishermen as well as local actors in the fishing sector. However,

ongoing conflicts between the Mauritanian coast guard and Senegalese fishermen must be addressed to facilitate migration as adaptation.

### **5.2.1 Migratory Responses to Agricultural Degradation and Transformation in the Region of Saint-Louis (Senegal)<sup>4</sup>**

#### **5.2.2 Context**

Land remains the most fundamental productive asset in a country where more than 70 percent of the population depends directly and indirectly on agriculture for their livelihoods (Crabtree-Condor and Cassey 2012). Climate change impacts together with lack of socioeconomic assets pose considerable challenges to the resilience of Senegalese populations. These preexisting vulnerabilities are amplified by a growing number of large-scale land acquisitions through which approximately 17 percent of the country's arable land has been acquired by foreign and national investors since 2008 (Sy, Cissé, and Ba 2013).<sup>5</sup> Tensions between formal and customary land arrangements have significantly increased, with the interests of local communities often subordinated to those of recently arrived corporations. Despite a growing literature on the complex links between environment and migration, scant attention has been given to how environmental degradation, land rights, large-scale land acquisitions, and migration interact. In a region where both climate vulnerability and competition for land play a defining role in livelihood sustainability, how do these variables interrelate to give way to new migratory patterns? This case study addresses how the combination of environmental degradation and large-scale land transactions in the region of Saint-Louis in Senegal has affected the vulnerability and resilience of populations and modified both in and out migratory dynamics.

#### **5.2.3 Methods**

Data were gathered through an intensive review of the existing literature on the topic. Media reports, academic research, and findings from nongovernmental organizations (NGOs) were consulted. Rural populations' perceptions of the impacts of large-scale land acquisitions and information on their subsequent mobility patterns were collected in July 2014 through qualitative methods (semi-structured interviews and focus groups). For this purpose 45 people effected by nine different agribusinesses,<sup>6</sup> including village chiefs and religious authorities, were interviewed. Participants were selected through snowball sampling while making sure that the people selected were not only affected differently by each project (for example, directly or indirectly) but also presented different sociodemographic characteristics. Their opinions were complemented by 18 expert interviews with researchers, authorities, NGOs, journalists, and peasant organizations both in Dakar and Saint-Louis. Content analysis of the gathered data

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4. This fieldwork was funded by the Belgian National Fund for Scientific Research (FNRS) within a PhD research fellowship.

5. In the period 2000–07 there were six private investment deals concerning 168,964 hectares; between 2008 and 2011, 30 more deals involving 630,012 hectares were registered. The total land purchased in large-scale land acquisitions is now estimated at 844,970 hectares (Sy, Cissé, and Ba 2013).

6. Anonymization of the companies involved is required since further research in the same region will provide the explicit opinions of those companies to help counterbalance these findings. It is not the aim of this section to criminalize any particular company or to state that the population's perceptions alone reveal the complexity of the matter at hand.

allowed general shared perceptions on environmental vulnerability, impacts of large-scale land acquisitions, and migratory trends to be established.

#### **5.2.4 Findings**

Environmental problems are of great concern for local populations that notice a much later arrival of the rainy season and its shorter duration. Even though access to fresh water resources (Lac de Guiers and the Senegal River), which was facilitated by the construction of two dams in the late 1980s, has allowed some of them to reduce their dependence on rainfall through irrigation systems, family farming in the region still remains difficult because of the lack of access to credit, state subsidies, and adequate means (pesticides, fertilizers, machinery, and so forth). As a consequence of these factors, rural exodus has historically constituted an important livelihood diversification strategy.

However, the arrival of agribusinesses in the region initially spawned a return of locals that had migrated elsewhere in search of other job opportunities. The promises of employment and infrastructure gave hope to populations that initially viewed private investment as a way to improve their resilience to preexisting environmental and socioeconomic vulnerabilities while allowing them to stay in their communities of origin. However, out-migration followed shortly because of the population's disappointment with the companies' actions. Respondents unanimously reported scarce employment opportunities, with those available being unstable, offering very low wages, and not prioritizing local employment. As one village chief explained, "People are leaving because they cannot find a job in the area. This should be the other way around!" Furthermore, the promises of infrastructure development (such as schools, roads, dispensaries, hospitals) have rarely been kept. Locals, especially young men, thus continue to leave for Mauritania—especially Nouakchott—Dakar, and the city of Saint-Louis. Many of these migrants have difficulty finding employment in these already socially and environmentally vulnerable cities and often have to settle in slums, which can further reduce their resilience to future environmental shocks. Conversely, women that previously migrated to Mauritania as care workers have increasingly returned to the region to work for some of the agribusinesses. Although women also report difficult working conditions, they claim having accepted employment because it provides them with the opportunity to stay near their families.

Furthermore, vulnerability to socio-environmental changes has been further compounded by destructive environmental practices undertaken by the agribusinesses that have led to deforestation and the pollution of their basic productive assets. The pollution of water resources and contamination of grazing lands have added increasing constraints to already vulnerable livelihoods with considerable impacts on their productivity that could lead to increasing rural exodus in the future. Because mobility is inherent to their livelihoods, it is pastoralists that have suffered the most immediate effects. With the parceling of land and building of fences, they are now obliged to cross great distances to access grazing land and water for their herds. Their seasonal transhumant mobility has become increasingly permanent. Although longer distance and more permanent pastoralist mobility is the general trend, some pastoralists have become increasingly immobile, becoming "trapped" within project boundaries.

It is also important to note that agribusinesses have also attracted populations from the inner regions of Senegal (Fouta, Kaolack, Casamance, Fatick, Diourbel) who, given their sole dependence on rain-fed agriculture, are even more vulnerable to the impacts of climate change. For these populations, their lack of access to socioeconomic capital is compounded by a lack of access to water resources and increased rainfall

variability. Populations from these regions thus engage increasingly in seasonal agricultural labor migration to this region as a way to better diversify their livelihoods. Their relative lack of socioeconomic and environmental assets compounded by increased competition in urban areas for low-skilled jobs make sectoral mobility more difficult. With further projected climate change impacts on rainfall variability in the years to come, greater in-migration from particularly environmentally vulnerable areas can also be expected. Whether employment in such agribusinesses will continue to provide them with a livelihood diversification strategy remains to be seen since many of the agribusiness are increasingly technology rather than labor dependent.

### **5.2.5 Conclusions and Policy Implications**

To fully understand how mobility will be increasingly affected by climate change impacts, it is essential to acknowledge how the environment interacts with other factors, such as large-scale land acquisitions, that can further increase the vulnerability of populations while decreasing their resilience to future environmental and socioeconomic shocks. In a region where rainfall variability places considerable strains on livelihoods, environmental degradation resulting from harmful corporate practices and the loss of customary land all have the potential to increase rural exodus while continuously affecting pastoralists' daily mobility. Trying to artificially isolate the environmental variable from other major socioeconomic and political factors will not only hinder the understanding of migration but will also translate into inadequate protection mechanisms and development policies.

Findings show that the interaction between environmental vulnerability and large-scale land acquisitions can have both short-term and long-term impacts on population movements. The complex manner in which such variables interact across environmentally fragile areas shows that a more nuanced understanding is needed between the two extremes of a “win-win” scenario, in which rising employment opportunities would reduce rural exodus, and the dispossession and expulsion scenario, in which people would be automatically displaced. Although “agro-industrial development” in the delta is providing a diversification strategy for some rain-fed dependent farmers from other regions of Senegal, local populations would much rather benefit from state-subsidized irrigation schemes and secure access to fertile land. Continued large-scale land acquisitions that overlook customary rights and fail to develop environmentally sustainable practices or provide viable livelihood diversification strategies for environmentally and socioeconomically vulnerable populations will increase competition for natural resources while decreasing the resilience of rural communities and affect investment viability in the long term. Transparency in negotiations, respect for existing land rights, sharing of benefits, environmental sustainability, and adherence to national trade policies are the most frequently addressed challenges in global and national land-governance norms.<sup>7</sup> Yet, such principles still fail to question agro-industrial development per se (Borras and Franco 2014), as if supporting other possible development pathways, such as smallholder agriculture, would not be better suited to increasing the resilience capacities of already environmentally vulnerable rural populations and to preventing possible forced displacement or the “trapping” of pastoralists. The voluntary nature of such principles and their subsequent lack of national and local implementation remain considerable challenges

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7. FAO, IFAD, UNCTAD and the World Bank (PRAI) have developed sets of principles for responsible agricultural investment. The United Nations Economic Commission for Africa, the African Union, the African Development Bank, and the EU have also developed frameworks and guidelines.

that need to be urgently addressed. Finally, a better understanding of migration flows at a time when climate change will compound preexisting vulnerabilities is essential to developing the social provisions and infrastructure that will make receiving areas resilient to growing demographic and environmental pressures. To diminish the negative impacts that environmental degradation poses to traditional livelihoods, land governance policies and land use plans need to take future environmental degradation into account. The protection of housing, land, and property rights as well as appropriate natural resource governance will increasingly condition the vulnerability and resilience of populations to socio-environmental changes in general and to climate change in particular.

### **5.3 The Settlement Dynamics of Populations Vulnerable to Erosion in Cotonou's Coastal Zone (Benin)**

#### **5.3.1 Context**

In the 21st century, the effects of global warming could be particularly disastrous for coastal areas, among others those located on the Gulf of Guinea in West Africa. The coast of Cotonou, the economic capital of Benin, has recorded significant coastal erosion for several decades, mainly due to the obstruction of the littoral transit by the harbor built in 1962 and the decrease in sedimentary inputs from the west caused by diverse coastal protection structures. Moreover, sand quarries operated directly on the beach have amplified erosion. Like most other coastal nations, a high proportion of the population is located on the coast. The vulnerability is exacerbated by rapid demographic growth and inadequate resources for urban development. In the future, the process will very likely be amplified by sea level rise and more frequent storms as consequences of global warming (Ozer et al. 2013).

This study examines population dynamics in a section of the coastal zone of Cotonou that is exposed to rapid erosion. The aims were to determine the vulnerability of populations in the risk zone and to analyze the responses of the authorities to underline the needs in the context of climate change, since global warming is responsible for sea level rise that accelerates the shoreline erosion process.

#### **5.3.2 Methods**

To assess the eroded area in the six kilometers directly east of the harbor infrastructure and to observe the human settlement dynamics next to the sea, multitemporal analyses of very high-resolution satellite images from Google Earth (2002, 2011, and 2013) were carried out. The analyses were complemented with field missions in September 2012, September 2013, and July 2014. This field work consisted of discussions with institutional actors, local authorities, and researchers and of some 20 interviews with affected people.

#### **5.3.3 Findings**

##### *Coastal erosion and settlement dynamics*

Between 1963 and 1997, the coastline retreated by 400 meters at the east of the harbor of Cotonou (Codjia 1997). Diachronic analyses of satellite images show that the sea eroded approximately 75 hectares of land between 2002 and 2013. This area corresponds to a coastline retreat of 125 meters in 12 years (Figure 1). Coastal erosion is observed up to the Nigerian border, which is 27 kilometers east of Cotonou, with erosion of 30 meters in 10 years recorded at the border.

**Figure 1. Coastal Erosion around Cotonou, 2002–13**



In some zones, a progressive replacement of parceled or standing houses by makeshift houses between 2002 and 2011 can be observed. Furthermore, between 2011 and 2013 images reveal a rapid destruction of some of these newly constructed houses.

### *Migrants and trapped populations*

Results from fieldwork show that people with sufficient financial or social capital left the coastal zone when their houses were threatened by the sea. According to evidence, they relocated inland, usually to the peripheral areas of Cotonou. People remaining in the risk zone were mainly fishermen and precarious populations. Fishermen (or their parents) are native to the region of Grand-Popo (on the coast 90 kilometers to the west of Cotonou) and arrived in the coastal zone of Cotonou in the 1970s to enjoy better living conditions and more employment opportunities. However, since their arrival they have been successively displaced along the coastal zone because of the sea's encroachment. The resulting loss of assets and capital necessary for constructing a new home caused their vulnerability to increase with each move. There are two groups of precarious populations in the zone. On the one hand are people who lost their homes to the sea, causing them to fall into poverty. On the other hand, poor people moved into the risk zone because they had no money to pay rent elsewhere in the city. Both groups feared being displaced by the sea. Unlike fishermen who want to stay near the shoreline for their economic activities, the precarious populations want to leave the coastal area but lack the financial capital and social networks to do so. Results highlight the increasing vulnerability of populations as the sea continues to advance and a

concomitant decrease in their resilience capacities. The poorest people are forced to stay in the risk zone, becoming “trapped” populations (Foresight 2011). Without sufficient resources or other viable alternatives, their only adaptation strategy is to continually move within the risk zone.

#### *Authorities’ responses*

In the national strategy to implement the UN Framework Convention on Climate Change, Benin proposed two adaptation options: (1) stabilizing the coastline by building groynes (rigid hydraulic structures built out from an ocean shore that interrupt water flows and limits the movement of sediment, thereby reducing erosion), and (2) relocating activities, communications, transport, hotel infrastructure, and communities out of the risk zone. Under the pressure of local environmental NGOs, all marine sand quarries were closed in March 2009. Since May 2014, seven groynes have been built in the most exposed zone for a cost of 45.4 milliards FCFA, financed by several investors (essentially Middle Eastern states’ funds). At a scale of a groyne, positive effects are observed at the west of the structure but negative effects (fast erosion) appear at the east. However, where the seven groynes have been placed, the problem has been transferred to the neighboring municipality. The installation of such protection structures restores confidence to investors who are starting to build new standing houses in the zone protected by the groynes.

#### **5.3.4 Conclusion and Policy Implications**

Habitat regulations and land use planning that would address settlement in the risk zone are absent. Some laws and decrees have not been respected and others are inadequate and should be revised or updated. Additionally, local populations are often unaware of existing legal mechanisms and regulations. Although the Cotonou town council wants to solve the erosion problem while avoiding displacement of their residents, they have few resources within their reach. They place their hopes on the groynes but realize that their effectiveness will only be proven over time, and furthermore, that even then the problem will be transferred to the neighboring municipality. Meanwhile, local authorities have been trying to persuade fishermen to relocate away from the sea but without offering compensation or assistance. However, they turn a blind eye to informal settlements because they have no alternative to propose.

In addition to the need for local solutions, coastal erosion is not confined to this zone, therefore the development of international cooperation with other countries in the Gulf of Guinea is necessary. Benin, like the other 10 coastal countries of West Africa, has adopted a master plan for coastal development with the support of the West African Economic and Monetary Union but implementation of the recommendations must be consistent within the region. Consultation with affected populations is also needed (Teka and Vogt 2010).

## **6. Conclusions and Policy Recommendations**

Climate change's effects on West African mobility cannot be isolated to a single outcome. Environmental degradation, whether resulting from slow-onset changes or sudden shocks, affects populations' vulnerability and resilience capacity in complex ways. These complexities stem from, and result in, varied and cumulative vulnerability and resilience among and within West African populations. First, the presence of multiple environmental trends and shocks varies geographically. While desertification and droughts are of prime importance for some, floods, coastal erosion, and sea level rise are the main hazards for others.

Even within local populations affected by the same climatic threats, their vulnerability and likelihood to migrate are affected by their socioeconomic status (with those having some form of financial and social capital more able to adapt locally or through migration), their dependence on natural resources, and their demographic characteristics (age, gender, and so on). The complex links that emerge between environmental degradation, vulnerability, and migratory patterns are further exemplified through the added pressures of large-scale acquisitions of agricultural land. Fishing communities equally encounter compounded environmental and socioeconomic pressures with changes in maritime resources affecting livelihoods and coastal erosion and sea level rise threatening their places of residence. Together, cumulated vulnerabilities increasingly shape differentiated mobility outcomes and consequential capacities for resilience.

A comprehensive understanding of how environmental vulnerabilities compound preexisting vulnerabilities is essential to the formulation of useful responses. Given the differentiated vulnerabilities and capacities for resilience, there is no one-size-fits-all solution. Policy must be adapted and implemented according to particular populations and needs. Strategies will need to take into account geographical and climatic variations, but also differences in socioeconomic vulnerability to build resilience. However, regional cooperation is still needed. Although specific threats may be local, climate change stimulates internal and international migration that will affect all the countries of West Africa.

However, along with taking into account differences in vulnerability and subsequent migration decisions among and within local populations, policy makers must also consider vulnerability as it is perceived by those affected. Therefore, environmental mobility cannot be treated as a strictly rational behavior based on actual vulnerability, as if local populations' perceptions of environmental threats and changes necessarily correspond to meteorologically observed climatic trends or their causes. Furthermore, all of the components (environmental, political, economic, demographic, and so on) of perceived vulnerability among local populations must be analyzed because they together inform people's subsequent (im)mobility behaviors and intentions. Building resilience among local populations therefore requires that perceived and actual vulnerability be assessed, and local populations must be educated about current and expected changes to their natural environments to facilitate better-informed mobility decisions.

Just as the relationship between vulnerability and mobility outcomes varies among and within the presented case studies, so too does the impact of environmental mobility on individual, household, and community resilience. Again, it is important to consider how people's mobility decisions are based on their expectations of the outcomes of these movements. Although migration may be perceived to increase individual and household resilience to socio-environmental changes, it may in fact place them at further risk in the destination area. For example, the heavy erosion of the coast of Cotonou has caused the voluntary migration of those with capital and the displacement of fishermen, but also an in-migration of poor populations who despite the risk, cannot afford to live elsewhere. Their preexisting economic vulnerability is then compounded by environmental hazards in the migratory destination. Furthermore, regional rural-to-urban migration does not always provide better conditions for migrants, who may struggle to find employment in destination areas and often move into slums and makeshift housing in urban peripheries. These living conditions can exacerbate environmental risks and health hazards.

However, migration can also offer a significant tool with which local populations can increase their resilience to socio-environmental changes. With local livelihoods increasingly difficult to maintain, out-migration of youth from rural villages in the region of Saint-Louis decreases household reliance on agriculture, for example. At the same time, populations that depend solely on rain-fed agriculture in the interior of Senegal, who are particularly vulnerable to climate change, diversify their livelihoods by moving into these rural villages to work for agribusinesses. Similarly, on the West African coast, Guet Ndarian fishing migration to Mauritania generates remittances used to support households in the community of origin, and, for the most successful, remittances enable households to escape the threat of coastal erosion and sea level rise by building new homes in safer areas of Saint-Louis.

West African cities, already struggling with economic, demographic, and environmental pressures, will only see their vulnerability compounded with future climate change. Building infrastructure and establishing protection mechanisms for migrants and displaced persons is thus a necessary step in mitigating future risk. Although it is of the utmost importance that national adaptation plans in West Africa incorporate mobility (Warner et al. 2014), they also offer an encouraging platform for the strengthening or establishment of appropriate institutional arrangements to address increasing environmental vulnerability and to build populations' resilience to future shocks (UNFCCC 2014). In conclusion, regional authorities must work together to build the resilience of sending communities to climatic shocks, but they must also facilitate migration as an adaptation strategy by, for example, recognizing the development potential of remittances. In addition, to avoid adverse migration outcomes, they must prepare destination areas (especially coastal urban centers) to receive internal and international migrants, but they must also better inform those living and migrating to risk zones about the potential risks of (im)mobility in and out of these areas. These policy interventions may help decrease the potential for the creation of "trapped" populations (Foresight 2011), be they trapped in areas of origin, in transit, or in destination areas.

## References

- Adger, W. N., S. Dessai, M. Goulden, M. Hulme, I. Lorenzoni, D. R. Nelson, L. Otto Naess, J. Wolf, and A. Wreford. 2009. "Are There Social Limits to Adaptation to Climate Change?" *Climatic change* 93 (3–4): 335–54.
- Adger, W. N., P. M. Kelly, A. Winkels, L. Q. Huy, and C. Locke. 2002. "Migration, Remittances, Livelihood Trajectories, and Social Resilience." *AMBIO: A Journal of the Human Environment* 31 (4): 358–66.
- Ahouangan, M. B. D., B. Djaby, P. Ozer, Y. C. Hountondji, A. Thiry, and F. de Longueville. 2014. "Adaptation et résilience des populations rurales face aux catastrophes naturelles en Afrique subsaharienne. Cas des inondations de 2010 dans la commune de Zagnanado, Bénin." In *Eau, milieux et aménagement. Une recherche au service des territoires*, edited by A. Ballouche and A. N. Taïbi, 265–78. Angers, France: Presses de l'Université d'Angers.
- Akponikpè, I., P. B. Irénikatché, P. Johnston, and E. K. Agbossou. 2010. "Farmers' Perception of Climate Change and Adaptation Strategies in Sub-Saharan West-Africa." 2nd International Conference: Climate, Sustainability and Development in Semi-arid Regions, Ceara, Brazil, August.
- Ateliers (Les Ateliers Internationaux de Maîtrise d'oeuvre urbaine). 2010. "Saint-Louis 2030: New African Metropolis." Ateliers, St. Louis, Senegal. [http://www.ateliers.org/IMG/pdf/2\\_\\_dossier\\_analyse\\_eng.pdf](http://www.ateliers.org/IMG/pdf/2__dossier_analyse_eng.pdf).
- Bates, D. C. 2002. "Environmental Refugees? Classifying Human Migrations Caused by Environmental Change." *Population and Environment* 23 (5): 465–77.
- Black, R., W. N. Adger, N. W. Arnell, S. Dercon, A. Geddes, and D. Thomas. 2011 "The Effect of Environmental Change on Human Migration." *Global Environmental Change* 21 (Supplement 1): S3–S11.
- Black, R., N. W. Arnell, W. N. Adger, D. Thomas, and A. Geddes. 2013. "Migration, Immobility and Displacement Outcomes Following Extreme Events." *Environmental Science and Policy* 27 (Supplement 1): S32–S43.
- Borras, S., and J. Franco. 2014. "From Threat to Opportunity? Problems with the Idea of a 'Code of Conduct' for Land-Grabbing." *Yale Human Rights and Development Journal* 13 (2): 507–23.
- Cissé, P., M. Zorom, B. Barbier, and A. Maiga. 2011. "Les migrations, une stratégie d'adaptation à la variabilité climatique en zones sahéliennes." *RGLL* 8: 184–96.
- CLUVA (Climate Change and Vulnerability of African Cities). 2013. "Saint-Louis, Senegal." [http://www.cluva.eu/CLUVA\\_publications/CLUVA\\_Climate-change-and-vulnerability-of-African-cities-Saint-Louis.pdf](http://www.cluva.eu/CLUVA_publications/CLUVA_Climate-change-and-vulnerability-of-African-cities-Saint-Louis.pdf).
- Codjia, C. L. 1997. "Application de la télédétection à l'étude des changements urbains et des transformations du littoral à Cotonou (Bénin)." *Universités francophones. Actualité scientifique*: 299–306.

Coniglio, N., and G. Pesce. 2010. "Climate Variability, Extreme Weather Events and International Migration." COMCAD Arbeitspapiere-Working Papers No 92. Paper presented at the ESF-UniBi-ZiF research conference on "Environmental Change and Migration: From Vulnerabilities to Capabilities," Bad Salzuflen, Germany, December 5–9. [http://www.unibi.de/tdrc/ag\\_comcad/downloads/Coniglio-Pesce\\_Climate-Variability-Extreme-Weather-Events-International-Migration.pdf](http://www.unibi.de/tdrc/ag_comcad/downloads/Coniglio-Pesce_Climate-Variability-Extreme-Weather-Events-International-Migration.pdf).

Crabtree-Condor, I., and L. Cassey. 2012. "Lay of the Land. Improving Governance to Stop Land Grabs." Action Aid, Johannesburg, South Africa. [http://www.actionaid.org/sites/files/actionaid/lay\\_of\\_the\\_land\\_-\\_improving\\_land\\_governance\\_to\\_stop\\_land\\_grabs\\_low\\_res.pdf](http://www.actionaid.org/sites/files/actionaid/lay_of_the_land_-_improving_land_governance_to_stop_land_grabs_low_res.pdf).

Crétat, J., E. K. Vizy, and K. H. Cook. 2014. "How Well Are Daily Intense Rainfall Events Captured by Current Climate Models over Africa?" *Climate Dynamics* 42 (9–10): 2691–711.

CRED (Centre for Research on the Epidemiology of Disasters). 2015. "The International Disaster Database." <http://www.emdat.be/>.

DARA. 2013. "Indice de réduction des risques (RRI) en Afrique de l'Ouest. Analyse des conditions et des capacités de réduction des risques de catastrophes. Le Cap-Vert, la Gambie, le Ghana, la Guinée, le Niger et le Sénégal." <http://daraint.org/risk-reduction-index/>.

De Longueville, F., Y. C. Hountondji, I. Kindo, F. Gemenne, and P. Ozer. 2016. "Long-Term Analysis of Rainfall and Temperature Data in Burkina Faso (1950–2013)." *International Journal of Climatology*. DOI: 10.1002/joc.4640.

Descroix, L., Ibrahim Bouzou Moussa, Pierre Genthon, Daniel Sighomnou, Gil Mahé, Ibrahim Mamadou, Jean-Pierre Vandervaere, et al. 2013. "Impact of Drought and Land-Use Changes on Surface-Water Quality and Quantity: The Sahelian Paradox." In *Current Perspectives in Contaminant Hydrology and Water Resources Sustainability*, edited by P. Bradley, 243–71. Rijeka, Croatia: INTECH.

Diessner, C. 2012. "It Will Rain If God Wills It: Local Perceptions of Climate Change in the Futa Tooro of Northern Senegal." Master's thesis, University of Missouri, Columbia.

Dieye, A. M., and D. P. Roy. 2012. "A Study of Rural Senegalese Attitudes and Perceptions of Their Behavior to Changes in the Climate." *Environmental Management* 50 (5): 929–41.

Easterling, D. R., J. L. Evans, P. Ya Groisman, T. R. Karl, K. E. Kunkel, and P. Ambenje. 2000. "Observed Variability and Trends in Extreme Climate Events: A Brief Review." *Bulletin of the American Meteorological Society* 81 (3): 417–25.

FAO (Food and Agriculture Organization of the United Nations). 2008. "Vue générale du secteur des pêches national: La République du Sénégal." [ftp://ftp.fao.org/Fi/DOCUMENT/fcp/fr/FI\\_CP\\_SN.pdf](ftp://ftp.fao.org/Fi/DOCUMENT/fcp/fr/FI_CP_SN.pdf).

———. 2014. "FAOSTAT." <http://faostat.fao.org>, accessed May 17, 2014.

Ferris, E., and C. Stark. 2012. "Internal Displacement in West Africa: A Snapshot." Brookings LSE–Project on Internal Displacement.

Findley, S. E. 1994. "Does Drought Increase Migration? A Study of Migration from Rural Mali during the 1983–1985 Drought." *International Migration Review* 28 (3) :539–53.

Foley, S. F., Detlef Gronenborna, Meinrat O. Andreae, Joachim W. Kadereita, Jan Espera, Denis Scholza, Ulrich Pöschla, et al. 2013. "The Palaeoanthropocene–The Beginnings of Anthropogenic Environmental Change." *Anthropocene* 3 (November): 83–8.

Foresight. 2011. *Migration and Global Environmental Change. Final Project Report*. London: The Government Office for Science.

Gemenne, F. 2011a. "Climate-Induced Population Displacements in a 4 C+ World." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 369 (1934): 182–95.

———. 2011b. "Why the Numbers Don't Add Up: A Review of Estimates and Predictions of People Displaced by Environmental Changes." *Global Environmental Change* 21 (Suppl 1): S41–S49.

———, J. Blocher, F. De Longueville, N. Perrin, S. Vigil, C. Zickgraf, and P. Ozer. 2014. "Catastrophes, Changement climatique et Déplacements forcés: Dynamiques régionales de mobilité humaine en Afrique de l'Ouest." Nansen Initiative.

Henry, S., V. Piché, D. Ouédraogo, and E. F. Lambin. 2004. "Descriptive Analysis of the Individual Migratory Pathways According to Environmental Typologies." *Population and Environment* 25 (5): 397–422.

Hewawasam, I. 2002. *Managing the Marine and Coastal Environment of Sub-Saharan Africa: Strategic Directions for Sustainable Development*. Washington, DC: World Bank.

IOM (International Organization for Migration). 2014. "West and Central Africa."

IPCC (Intergovernmental Panel on Climate Change). 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Edited by C. B. Field, V. Barros, T. F. Stocker, D. Qin, D. J. Dokken, K. L. Ebi, M. D. Mastrandrea, et al. Cambridge, U.K., and New York: Cambridge University Press.

———. 2014. "Climate Change 2014: Impacts, Adaptation and Vulnerability." <http://ipcc-wg2.gov/AR5/>, accessed May 6, 2014.

Jalloh, A., G. C. Nelson, T. S. Thomas, R. B. Zougmore, and H. Roy-Macauley, eds. 2013. *West African Agriculture and Climate Change: A Comprehensive Analysis*. Washington, DC: International Food Policy Research Institute. <http://www.ifpri.org/publication/west-african-agriculture-and-climate-change>.

Juana, J. S., Z. Kahaka, and F. N. Okurut. 2013. "Farmers' Perceptions and Adaptations to Climate Change in Sub-Saharan Africa: A Synthesis of Empirical Studies and Implications for Public Policy in African Agriculture." *Journal of Agricultural Science* 5 (4): 121–35.

Lebel, T., and A. Ali. 2009. "Recent Trends in the Central and Western Sahel Rainfall Regime (1990–2007)." *Journal of Hydrology* 375 (1–2): 52–64. doi:10.1016/j.jhydrol.2008.11.030.

McLeman, Robert A., and Lori M. Hunter. 2010. "Migration in the Context of Vulnerability and Adaptation to Climate Change: Insights from Analogues." *Wiley Interdisciplinary Reviews: Climate Change* 1 (3): 450–61.

Meehl, G. A., T. Karl, D. R. Easterling, S. Changnon, R. Pielke Jr, D. Changnon, J. Evans, P. Ya Groisman, T. R. Knutson, and K. E. Kunkel. 2000. "An Introduction to Trends in Extreme Weather and Climate Events: Observations, Socioeconomic Impacts, Terrestrial Ecological Impacts, and Model Projections." *Bulletin of the American Meteorological Society* 81 (3): 413–16.

Mertz, O., S. D'haen, A. Maiga, I. Bouzou Moussa, B. Barbier, A. Diouf, D. Diallo, E. Dapola Da, and D. Dabi. 2012. "Climate Variability and Environmental Stress in the Sudan-Sahel Zone of West Africa." *Ambio* 41 (4): 380–92.

Mertz, O., C. Mbow, A. Reenberg, and A. Diouf. 2009. "Farmers' Perceptions of Climate Change and Agricultural Adaptation Strategies in Rural Sahel." *Environmental Management* 43 (5): 804–16.

Mortreux, C., and J. Barnett. 2009. "Climate Change, Migration and Adaptation in Funafuti, Tuvalu." *Global Environmental Change* 19 (1): 105–12.

Mouhamed, L., S. B Traore, A. Alhassane, and B. Sarr. 2013. "Evolution of Some Observed Climate Extremes in the West African Sahel." *Weather and Climate Extremes* 1: 19–25.

Müller, C., K. Waha, A. Bondeau, and J. Heinke. 2014. "Hotspots of Climate Change Impacts in Sub-Saharan Africa and Implications for Adaptation and Development." *Global Change Biology* 20 (8) : 2505–17.

Ndiaye, M., and N. Robin. 2010. "Les migrations internationales en Afrique de l'Ouest." *Hommes & Migrations* (4): 48–61.

New, M., B. Hewitson, D. B. Stephenson, A. Tsigas, A. Kruger, A. Manhique, B. Gomez, et al. 2006. "Evidence of Trends in Daily Climate Extremes over Southern and West Africa." *Journal of Geophysical Research* 111: D14102. doi:10.1029/2005JD006289.

Nicholls, R. J., S. Hanson, Celine Herweijer, Nicola Patmore, Stéphane Hallegatte, Jan Corfee-Morlot, Jean Château, and Robert Muir-Wood. 2008. "Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates." OECD Environment Working Papers No. 1, OECD Publishing, Paris.

Nielsen, J. Ø., and A. Reenberg. 2010. "Cultural Barriers to Climate Change Adaptation: A Case Study from Northern Burkina Faso." *Global Environmental Change* 20 (1): 142–52.

Ouédraogo, M., Y. Dembélé, and L. Somé. 2010. "Perceptions et stratégies d'adaptation aux changements des précipitations: cas des paysans du Burkina Faso." *Science et changements planétaires/Sécheresse* 21 (2): 87–96.

Ould Sidi Cheikh, M. A., P. Ozer, and A. Ozer. 2007. "Risques d'inondation dans la ville de Nouakchott (Mauritanie)." *Geo-Eco-Trop* 31: 19–42.

Ozer, P., Y. C. Hountondji, F. de Longueville, M. V. Bessan, and A. Thiry. 2013. "Impact de l'érosion littorale dans les villes côtières africaines: de la procrastination des pouvoirs publics à la migration forcée des plus précaires. Cas de Cotonou, Bénin." <http://hdl.handle.net/2268/156894>.

Ozer, P., Y. C. Hountondji, A. J. Niang, S. Karimoune, O. Laminou Manzo, and M. Salmon. 2010. "Désertification au Sahel: historique et perspectives." *Bulletin de la Société Géographique de Liège* 54: 69–84.

Ozer, P., and D. Perrin. 2014. "Eau et changement climatique. Tendances et perceptions en Afrique de l'Ouest." In *Eau, milieux et aménagement. Une recherche au service des territoires*, edited by A. Ballouche and A. N. Taïbi, 227–45. Angers, France: Presses de l'Université d'Angers.

Perch-Nielsen, S. L., M. B. Bättig, D. Imboden. 2008. "Exploring the Link between Climate Change and Migration." *Climatic Change* 91: 375–93.

Renaud, F. G., O. Dun, K. Warner, and J. Bogardi. 2011. "A Decision Framework for Environmentally Induced Migration." *International Migration* 49: e5–e29.

Salem, M.-C. Cormier. 2013. "L'aménagement du littoral: un enjeu crucial pour les pêcheries artisanales." *Artisans de la mer: une histoire de la pêche maritime sénégalaise <ird-00827404>*:136-145.

Sall, A., and P. Morand. 2008. "Pêche artisanale et émigration des jeunes africains par voie piroguière." *Politique africaine* 109 (1): 32–41.

Sow, P., S. A. Adaawen, and J. Scheffran. 2014. "Migration, Social Demands and Environmental Change amongst the Frafra of Northern Ghana and the Biali in Northern Benin." *Sustainability* 6 (1) : 375–98.

Stringer, L. C., M. Akhtar-Scuster, M. J. Marques, F. Amiraslani, S. Qaatrini, and E. M Abraham. 2011. "Combating Land Degradation and Desertification and Enhancing Food Security: Towards Integrated Solutions." *Annals of Arid Zones* 50 (34): 1–23.

Sy, C., E. H. Cissé, and S. Ba. 2013. "Etude participative sur les acquisitions massives de terres agricoles en Afrique de l'Ouest et leur impact sur l'agriculture familiale et la sécurité alimentaire des populations locales: Etat des lieux- Cas du Sénégal." COPAGEN, Inter Pares & REDTAC.

Tacoli, C. 2009. "Crisis or Adaptation? Migration and Climate Change in a Context of High Mobility." *Environment and Urbanization* 21 (9): 513–25.

Tambo, J. Akpene, and T. Abdoulaye. 2013. "Smallholder Farmers' Perceptions of and Adaptations to Climate Change in the Nigerian Savanna." *Regional Environmental Change* 13 (2): 375–88.

Teka, O., and J. Vogt. 2010. "Social Perception of Natural Risks by Local Residents in Developing Countries—The Example of the Coastal Area of Benin." *Social Science Journal* 47 (1): 215–24.

Tschakert, P. 2007. "Views from the Vulnerable: Understanding Climatic and Other Stressors in the Sahel." *Global Environmental Change* 17 (3): 381–96.

UEMOA (Union Economique et Monétaire Ouest Africaine). 2010. "Etude régionale pour le suivi du trait de côte et l'élaboration d'un schéma directeur du littoral de l'Afrique de l'Ouest." [http://cmsdata.iucn.org/downloads/flyer\\_sdlaofr.pdf](http://cmsdata.iucn.org/downloads/flyer_sdlaofr.pdf).

UN DESA (United Nations Department of Economic and Social Affairs). 2009. *Human Development Report 2009—Overcoming Barriers: Human Mobility and Development*. United Nations Development Program: New York. [http://hdr.undp.org/sites/default/files/reports/269/hdr\\_2009\\_en\\_complete.pdf](http://hdr.undp.org/sites/default/files/reports/269/hdr_2009_en_complete.pdf).

UNESCO (United Nations Educational, Scientific and Cultural Organization). 2012. "Adaptation aux changements climatiques et côtiers en Afrique de l'Ouest." <http://unesdoc.unesco.org/images/0021/002179/217953f.pdf>.

UNFCCC (United Nations Framework Convention on Climate Change). 2014. *Institutional Arrangements for National Adaptation Planning and Implementation. 2014 Thematic Report*. Bonn: United Nations Climate Change Secretariat. [http://unfccc.int/files/adaptation/application/pdf/adaption\\_committee\\_publication\\_-\\_web\\_high.pdf](http://unfccc.int/files/adaptation/application/pdf/adaption_committee_publication_-_web_high.pdf).

UN Habitat. 2010. *The State of African Cities 2010: Governance, Inequality and Urban Land Markets*. Nairobi: United Nations Human Settlements Programme.

Van Der Geest, K. 2011. "North-South Migration in Ghana: What Role for the Environment?" *International Migration* 49 (s1): e69–e94.

Warner, K., and T. Afifi. 2014. "Enhancing Adaptation Options and Managing Human Mobility: The United Nations Framework Convention on Climate Change." *Social Research: An International Quarterly* 81: 299–326.

Warner, K., W. Kälin, S. Martin, Y. Nassef, S. Lee, S. Melde, H. Entwisle Chapuisat, M. Frank, and T. Afifi. 2014. "Integrating Human Mobility Issues within National Adaptation Plans." UNU-EHS Publication Series. Policy Brief 9, June 2014. <http://www.ehs.unu.edu/file/get/11786.pdf>.

West, C. Thor, C. Roncoli, and F. Ouattara. 2008. "Local Perceptions and Regional Climate Trends on the Central Plateau of Burkina Faso." *Land Degradation and Development* 19 (3): 289–304.

World Bank. 2010. *World Development Report 2010: Development and Climate Change*. Washington, DC: World Bank. <http://siteresources.worldbank.org/INTWDR2010/Resources/5287678-1226014527953/WDR10-Full-Text.pdf>.

———. 2011. *Migration and Remittances Factbook 2011*. Washington, DC: World Bank. <http://data.worldbank.org/data-catalog/migration-and-remittances>.

Wouterse, F., and J. E. Taylor. 2008. "Migration and Income Diversification: Evidence from Burkina Faso." *World Development* 36 (4): 625–40.

Yonetani, M., and T. Morris. 2013. *Global Estimates 2012: People Displaced by Disasters*. Geneva: Internal Displacement Monitoring Centre.

