Chapter 3
Human Migration in the Face of Environmental Change: A Global Empirical Approach

Els Bekaert, Ilse Ruyssen, and Sara Salomone

3.1 Introduction

Climate change and migration take center stage in daily news reports and have shaped debates during many recent elections around the world. Climate change is affecting weather patterns, ecosystems and sea levels. As a consequence, an increasing number of people and countries on our planet is confronted with severe environmental problems. Broadly speaking, a distinction is made between fast or sudden onset hazards—in the literature also referred to as natural disasters—such as floods, storms or tropical cyclones; and slow or gradual onset hazards such as gradual changes in precipitation or (ocean) temperatures, desertification and sea level rise. Both types of environmental hazards directly impact people's lives and increasingly threaten the livelihoods of entire communities.

Changes in temperature and rainfall lead to droughts, heat waves, water scarcity and land degradation and have significant impacts on agricultural yields, as well as on fishing industries and food production more generally. Eventually this can result in rising famine, a greater frequency of infectious disease epidemics and substantial health effects, all of which are likely to cause decreasing labor productivity and

E. Bekaert (✉) · S. Salomone
Department of Economics, Ghent University, Gent, Belgium

UNU-CRIS, Bruges, Belgium
e-mail: ebekaert@cris.unu.edu

I. Ruyssen
CESSMIR, Department of Economics, Ghent University, Ghent, Belgium

United Nations University – Institute on Comparative Regional Integration Studies (UNU-CRIS), Bruges, Belgium
e-mail: ilse.ruyssen@ugent.be

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economic decay (IPCC 2014). Additionally, floods due to extreme rainfall or sea level rise and increased intensity and occurrence of storms might lead to major and recurrent destruction of lives, assets and livelihoods (Rigaud et al. 2018). Furthermore, global warming has large impacts on glaciers and ice sheets, which will keep declining and subsequently accelerate the rising of the sea level (Mousavi et al. 2011; Nicholls and Cazenave 2010). Especially for large coastal cities and low-lying rural areas the rising sea level is a major issue (Goldbach 2017).

When severe environmental events are recurrent and people lack the means to diversify their assets and livelihoods, moving away from the deteriorating environment might be the only alternative (Rigaud et al. 2018). In 1990, the Intergovernmental Panel on Climate Change (IPCC) first put forward human migration as the greatest impact of environmental change. Today, the Global Compact for Safe, Orderly and Regular Migration (GCM) clearly identifies environmental degradation, natural disasters and climate change as drivers of contemporary migration. In response, it stresses the need for more investments focused on strengthening evidence, data and research to address environmental migration challenges.

Migration in the face of environmental problems can take up many different forms including local migration (e.g. between rural areas), internal migration (e.g. from rural to urban areas) and cross-border migration (to neighboring countries or further away). Environmental migration can furthermore encompass voluntary movements, forced displacement as well as planned relocation. In this chapter, we follow the International Organization for Migration (IOM) definition of environmental migrants as "A person or group(s) of persons who, predominantly for reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are forced to leave their habitual residence, or choose to do so, either temporarily or permanently, and who move within or outside their country of origin or habitual residence" (2019).

According to the Internal Displacement Monitoring Centre (IDMC), an estimated 227.6 million people worldwide were displaced *within their country* because of sudden onset environmental hazards between 2008 and 2016. In 2017, the number of environmentally displaced within their country was estimated at 18.8 million people in 135 countries, primarily located in South and East Asia, the Caribbean and the Pacific. This number exceeds the 11.8 million internally displaced people due to conflict and violence by far (IDMC 2018). Scientists agree that climate change will force even more people to move in the future. A 2018 World Bank Group report, for instance, finds that climate change might push more than 140 million people in Sub-Saharan Africa, South Asia and Latin America to migrate within their countries by 2050 (Rigaud et al. 2018). Quantifications of *cross-border* movement in the context of disaster are more scarce and challenging. This is primarily due to the lack of harmonized data collection and accompanying methodological issues, as well as the difficulties in isolating the influence of environmental factors from other migration drivers such as economic, political and demographic factors. Similarly, data on the number of people displaced because of slow onset processes are mostly qualitative and fragmented, commonly based on case studies. General forecasts typically vary from 25 million to 1 billion environmental migrants by 2050, moving

either internally or internationally, with 200 million being the most widely cited estimate (UN 2015).

Well-planned migration can form a successful strategy to cope with environmental problems when there is no credible long-term pathway to viable livelihoods. Yet, given the development implications of migration for both sending and destination regions, it is important that governments are able to anticipate the scale of ensuing migration flows as well as the places people will move to or stay in (Rigaud et al. 2018). There are, however, inherent difficulties in predicting the size and dispersion of such flows. Empirical analyses are typically subject to binding data constraints, inducing a reliance on a coarse spatial and temporal aggregation of the data (e.g. Barrios et al. 2006; Dell et al. 2014; Beine and Parsons 2015; Desmet and Rossi-Hansberg 2015; Cattaneo and Peri 2016). As put forward by Piguet (2010), individual sample surveys often only document a single event (e.g. a hurricane) in which case it is hard to disentangle environmental change from other contextual effects. Macro studies, on the other hand, cannot account for the local character of such shocks, i.e. there is no evidence that people who emigrated from a country or area under environmental stress were actually subject to it.

This chapter contributes to the current understanding of environmental migration patterns across countries. We aim to overcome some of the data limitations often faced in existing studies by using an original micro dataset, the Gallup World Polls (GWP), to address the critical nexus between climate change and migration. Specifically, we will present stylized facts on the number of people affected by environmental problems as well as on individual migration propensities in a large set of (developing) countries. Subsequently, we conduct a cross-country individual-level analysis of the impact of severe environmental problems on people's short-term migration intentions. Given that environmental change may influence both incentives to migrate as well as migration costs, we expect that the relationship between environmental drivers and migration differs across countries depending on their exposure to environmental hazards and migration costs. To account for this, we estimate our model separately for different groups of countries, either by geographic region or by development level. Furthermore, we also allow the migration response to environmental hazards to vary with respondents' demographic and socio-economic characteristics.

The remainder of this chapter is organized as follows. Section 3.2 elaborates on the channels through which environmental factors influence migration. Section 3.3 provides an overview of the current stance of the literature on the climate-migration nexus. Section 3.4 describes the data used in the empirical analysis obtained from the GWP as well as some stylized facts on individual experiences with severe environmental problems and migration intentions. Section 3.5 outlines the theoretical and empirical framework, while Sect. 3.6 presents the evidence and main conclusions of the impact of severe environmental issues on people's migration intentions. Section 3.7 concludes with a summary and policy recommendations.

3.2 Channels of Transmission

Environmental problems can induce migration both directly and indirectly through their effect on the existing drivers of migration. According to Coniglio and Pesce (2015), climate variability can directly affect migration in two ways. First, an adverse climatic shock can reduce human survival in a certain environment, for example, because of unsustainable water supplies. Secondly, an adverse climatic event can also impact a person's future expectations of shocks, which could increase the incentive to migrate. Coniglio and Pesce (2015) find robust evidence of climate change directly inducing international migration and demonstrate that changes in precipitation foster migration from poor to rich countries.

Nonetheless, the literature shows that most of the impact of the environment on migration occurs through indirect effects, also known as transmission channels (Berlemann and Steinhardt 2017). A multitude of channels through which environmental factors spur or hamper migration have been identified. In what follows, we attempt to provide a comprehensive overview of the different mechanisms at play. The most important is the income channel, also referred to as the wage differential channel, the labor market channel or the economic channel in the literature. Environmental hazards directly decrease income in the affected area by disrupting business and reducing labor productivity. This is likely to widen the wage differential between the affected region and potential destinations, making it more attractive for individuals to migrate. The income channel is particularly decisive in regions that rely heavily on agriculture. In these regions, environmental issues directly impact agricultural productivity through crop failure or decreases in yield, which subsequently affect farmers' income and employment opportunities (see e.g. Cai et al. 2016).[1] The latter effects are likely to increase the incentive to migrate in middle and high income countries, but could reduce emigration in poor countries where liquidity constraints are more binding (see Cattaneo and Peri 2016).

This brings us to a second potential transmission mechanism, namely that of liquidity or credit constraints. Environmental problems may damage or destroy private assets such as real estate as well as capital goods and infrastructure, thereby raising migration costs and making credit constraints more binding (Beine et al. 2016). As such, affected individuals might lack the resources to bear the costs of migration (Naudé 2010; Waldinger 2015). Consequently, the extremely poor could get trapped into poverty in the most hazard-prone areas. Receiving remittances may, however, smooth the income channel and loosen liquidity constraints.

Third, detrimental environmental shocks tend to decrease the attractiveness of affected regions independently from income, making people more inclined to migrate. Given their impact on food production, environmental hazards are likely to affect human health. In regions where water resources become more scarce and food supply decreases, food prices are likely to rise. This may in turn induce famine

[1] In this context, the income channel has also been denoted the agricultural channel (see e.g. Cattaneo and Peri 2016).

and malnutrition, thereby increasing the incidence of disease and morbidity and even influencing the life of unborn children (Simeonova 2011; Marchiori et al. 2012; Beine et al. 2016, Berlemann and Steinhardt 2017). The increased threat to human life and health can be seen as negative amenities which may act as an additional push factor, on top of reduced income and employment opportunities, inciting people to leave.

A fourth channel is that of violent conflict. Several studies have demonstrated that changes in climatic conditions increase the pressure on resources which can lead to violent conflict, which itself forms one of the root causes of migration and fleeing (Hsiang et al. 2011; Burke et al. 2015; Dell et al. 2014; Beine and Parsons 2015). Kelley et al. (2015), for example, demonstrate that a drought in the Fertile Crescent in Syria, which took place just before the Syrian uprising in 2011, was a contributory factor in the onset of the Syrian civil war (see also Maystadt et al. 2015, for the case of Sudan; or Maystadt and Eckers 2014, for the case of Somalia). Yet, the effect of changing climate conditions on conflict largely depends on a country's political, socio-economic and cultural characteristics (Kelley et al. 2015; Waldinger and Fankhauser 2015). It has been shown, for instance, that the risk of armed conflict is particularly high in low-income regions where changes in climate often affect economic conditions directly through agriculture (Burke et al. 2015) as well as in regions where fresh water resources are limited (Toset et al. 2000; Hauge and Ellingsen 2001). The risk of conflict can, however, be mitigated by the presence of good institutions (Gizelis and Wooden 2010; Beine and Parsons 2015; Berlemann and Steinhardt 2017). In any case, environmental hazards affect incomes, increase the scarcity of resources, thereby stimulating conflict and encouraging migration.

A fifth potential channel is the institutional channel. Environmental factors have been shown to affect the quality and stability of institutions (Acemoglu and Robinson 2012; Beine and Parsons 2015), which are known to play a role in the decision to migrate and the destination choice of ensuing migrants. Several studies provide evidence for an impact of different types of institutions including economic (rule of law, property rights), political (civil rights, democracy) and social institutions (gender inequality, social protection) (see Baudassé et al. (2018) for a recent review of the link between migration and institutions).

Finally, the urbanization channel—working partly through the agricultural channel—has been put forward as spurring migration in the face of environmental change. The environmental impact on migration is likely to be larger in rural areas, i.e. those relying relatively more on agricultural activities, and relatively smaller in urban areas, where the manufacturing sector is more important. Therefore, migration following weather anomalies is expected to take place from rural to urban areas. This inflow of workers in urban areas can in turn depress urban wages. As the gap between urban wages in the home and potential destination countries widens, people in urban areas might be more inclined to migrate abroad in search of higher wages (Beine and Parsons 2015).

The above overview shows that the relationship between the environment and migration is not clear-cut. The fact that environmental factors can influence migration through many different channels hampers accurate inference on the impact of

environmental hazards on migration. The literature typically does not identify the different channels at play. Many studies have considered only one or two of these channels, with most emphasis on the income and agricultural channels for which plenty of evidence has been reported [for an overview see Beine and Jeusette (2018)]. Also, the liquidity channel has deserved quite some attention often leading to compelling evidence of its presence (Naudé 2010; Waldinger and Fankhauser 2015; Beine et al. 2016).

3.3 Empirical Evidence on Environmental Migration

A large body of literature has empirically analyzed the relationship between climate change and human migration. There is, however, no consensus on the role of environmental factors as determinants of global migration (Piguet 2010; Millock 2015; Berlemann and Steinhardt 2017; Beine and Jeusette 2018). A large part of the empirical research has focused on the migration response to precipitation anomalies in Sub-Saharan Africa where many countries rely heavily on agricultural productivity, and most inhabitants already live on the brink of starvation (see e.g. Marchiori et al. 2012; Henry et al. 2004; Gray and Mueller 2012b; Strobl and Valfort 2015).

Yet, Asia is the continent experiencing more natural hazards than any other region. In 2015, 85% of people displaced by sudden onset disasters were in South and East Asia, primarily related to flooding in Southern India, the Cyclone Komen in Bangladesh, India and Myanmar as well as monsoon floods in Myanmar (IDMC 2016). In Latin America, the number of people affected by flooding in 2015 was estimated at 171,000 in Paraguay, followed by Brazil (59,000) and Venezuela (45,000) (IDMC 2016). On top of that, the continent experiences frequent forest fires and tropical storms devastating the coasts of Puerto Rico, the Dominican Republic, Nicaragua and Guatemala, all of which might spur human mobility, both within and across borders. Research on the effects of climate change on migration in Asia and Latin America is, nonetheless, scarce.

This section provides an overview of the current stance of the empirical literature on the migration response to environmental hazards. We distinguish between research focusing on internal and international migration, and between studies considering the impact of slow versus sudden onset hazards. The importance of accounting for the heterogeneity of climate shocks (in terms of size, type and sign of the shock) is explicitly highlighted in Coniglio and Pesce (2015). Overall, the literature provides more rich and conclusive evidence on the impact of environmental factors on internal migration as opposed to international migration. Internal migration patterns are assessed mostly on the basis of individual country case studies using survey data on the individual or household level. Generalizing the findings of such studies across countries is therefore not straightforward. The effect on international migration patterns is, however, mostly evaluated on the basis of cross-country macro studies, which rely on aggregated cross-country macro data (such as used in the research of Beine and Parsons 2015, 2017; Backhaus et al. 2015; Coniglio and

Pesce 2015; Cai et al. 2016; Cattaneo and Peri 2016). While such studies guarantee the comparability of estimated effects across countries, they rely on the assumption that all individuals within a country are equally exposed to and affected by an environmental hazard, without acknowledging the circumstances at the individual level (Piguet 2010).

3.3.1 Internal Migration

A large number of micro studies show that *slow onset hazards*, and rising temperatures in particular, form an important driver of internal migration. Using a large survey dataset collected in eight South-American countries, Thiede et al. (2016), for instance, show a growing internal migration pattern due to temperature variations (both positive and negative). Mueller et al. (2014) find a robust positive effect of severe heat in Pakistan, especially during the wheat season. Dillon et al. (2011) find increasing temperatures in Northern Nigeria to increase the probability that household members are sent away as a form of income insurance.

There is also ample evidence of internal migration being influenced by rainfall variations. Henry et al. (2004) find individuals living in dry regions in Burkina Faso to be more prone to migrate towards other rural areas than those from wetter regions. A rise in internal migration is also found by Gray and Mueller (2012b) for the case of rural Ethiopia, and by Dallmann and Millock (2017) for the case of India, especially in states which depend greatly on agriculture. Barrios et al. (2006) find a positive impact of decreasing rainfall on rural-urban migration in Sub-Saharan countries, but find no evidence for other developing countries. In contrast, Thiede et al. (2016) and Gray (2009) respectively find a negative effect for excessive and low precipitation levels in South America and the Southern Ecuadorian Andes. In general, the estimated impact for excess precipitation is ambiguous, varying from positive (Mastrorillo et al. 2016) to negative (Dallmann and Millock 2017).

When temperature and rainfall are studied together, temperature typically is found to produce the largest effects (Berlemann and Steinhardt 2017). Bohra-Mishra et al. (2014), for example, find temperature and precipitation to both have nonlinear effects on internal migration in Indonesia, although the effect of temperature was much stronger. Di Falco et al. (2012), on the other hand, found only a minimal reaction to changes in temperature and precipitation in the Nile Basin in Ethiopia; while Gray and Bilsborrow (2013) find no systematic effect of temperature and precipitation in rural Ecuador.

Most of the evidence on the effect of *sudden onset environmental hazards*, such as natural disasters, on internal migration originates from micro-level case studies which provide very mixed results. On the one hand, natural disasters lead to very short-term moves, sometimes in the form of evacuations after and even before the natural disaster takes place. This was, for instance, the case when over 100,000 evacuees moved to Houston as hurricane Katrina made landfall on the US in 2005 (McIntosh 2008), after the predicted eruption of the Kelud volcano in Indonesia in

2014 (Ionesco et al. 2017), and in the face of hurricane Irma in Florida in 2017 (Alvarez and Santora 2017). This type of migration is, however, mostly temporary with most people eventually returning to their area of origin. On the other hand, sudden onset hazards may drive individuals to move permanently to other regions or to cross international borders. In their comprehensive cross-country study, Beine and Parsons (2015) find natural disasters in developing countries to beget internal migration flows towards urban areas. Gröger and Zylberberg (2016) furthermore indicate the importance of rural-urban migration as a coping strategy in a case study of Vietnam in the aftermath of Typhoon Ketsana in 2009. Also, in the case of Vietnam, Dun (2011) shows that floods have significantly driven outmigration from the affected areas. Robalino et al. (2015) find floods and landslides to increase metropolitan populations in Costa Rica.

In contrast, floods in Bangladesh (Gray and Mueller 2012a), in Ghana and Indonesia (Goldbach 2017), and in Pakistan (Mueller et al. 2014), appear to have no or only modest effects on migration. One explanation for this lack of impact is related to the liquidity channel described in Sect. 3.2. Natural disasters destroy physical assets (housing and infrastructure) and financial assets (reduced income and increased living costs), and may thus impoverish the most vulnerable even further. Decreasing incomes and loss of assets might stimulate migration, but the poorest may not be able to cover the costs of migration. In addition, direct damage to roads and transportation networks may make short-term migration prohibitively costly (Millock 2015). Others have attributed the absence of a migration response to natural disasters to the increased demand for labor for reconstruction in the affected areas (see e.g. Gray and Mueller 2012b). Alternatively, Paul (2005) highlights post-disaster aid from outside the region as a plausible explanation for why no internal migration effect could be observed after the 2004 tornado in Bangladesh (see also Boustan et al. 2012, for the US case). It is shown that emergency aid can compensate in monetary terms for damage caused by disasters so that victims did not have an incentive to leave.

3.3.2 International Migration

The majority of empirical research on international migration in the context of climate change has focused on variations in temperature and/or precipitation. There is, however, little evidence on the impact of slow-onset environmental hazards on international migration. Studies relying on individual sample surveys typically document no rise in international emigration (Piguet 2010). However, recent contributions using cross-country panels produce conflicting results. Beine and Parsons (2015), for instance, find no direct impact of long-run deviations in temperature and precipitation on international migration, only indirect effects operating through wages (see also Ruyssen and Rayp 2014 for sub-Saharan African countries). Robust proof of both direct and indirect effects on international migration is provided by Coniglio and Pesce (2015), Backhaus et al. (2015) and Marchiori et al. (2012).

Coniglio and Pesce (2015) specifically highlight the direction of migration from poor developing regions towards rich OECD countries, while Marchiori et al. (2012) find weather anomalies to induce international migration both directly through the amenities channel, and indirectly through the urbanization channel in Sub-Saharan Africa. A large part of the cross-country literature, furthermore, highlights the importance of the agricultural channel. Cai et al. (2016) find that long-term warming induces out-migration only in agricultural-dependent countries. In contrast, Cattaneo and Peri (2016) conclude that it reduces migration in extremely poor countries, which are exactly the ones likely to depend strongly on the agricultural sector. In a follow-up paper, Beine and Parsons (2017) also provide evidence for liquidity constraints hampering emigration from poor countries.

Knowledge on the impact of natural disasters on international migration is even more scarce and fragmented. Most evidence comes from macro studies, which provide no conclusive evidence. Only a limited number of studies report a positive effect of natural disasters on international migration (see e.g. Reuveny and Moore 2009; Gray and Mueller 2012b; Drabo and Mbaye 2011, 2015; Coniglio and Pesce 2015). In contrast, Halliday (2006) shows that earthquakes in El Salvador reduced migration flows towards the United States, and this for both wealthy and poor households. He interprets this as a sign that liquidity constraints only form part of the explanation for a lack of migration. Most cross-country studies do, however, not find direct evidence for an impact of natural disasters on international migration (Naudé 2010; Gray and Mueller 2012a; Ruyssen and Rayp 2014; Beine and Parsons 2015; Cattaneo and Peri 2016; Gröschl and Steinwachs 2017).

Yet, as pointed out by Drabo and Mbaye (2015), the relationship largely depends on the geographical location of countries and the type of disaster considered. In addition, Beine and Parsons (2017) and Gröschl and Steinwachs (2017) both notice the importance of considering the heterogeneity across income levels at origin and distinguish between poor and middle-income countries. Gröschl and Steinwachs (2017) do not find evidence for an impact of natural hazards on medium- to long-term international migration using the full sample (all countries in the Global Bilateral Migration Database) but do report a positive effect in middle-income countries. The latter are not financially constrained like low-income countries and have high insurance penetration rates like high-income countries. Beine and Parsons (2015) show that natural disasters in poor countries even reduce migration, confirming the relevance of the liquidity constraint channel, while they spur migration to former colonies and common-border countries. Alternatively, Naudé (2010) shows that whereas natural disasters do not directly affect international migration in Sub-Saharan Africa, there is an indirect impact through civil conflicts, in line with the conflict channel.

In sum, this literature review reveals that the relationship between climate change and migration is highly context-specific. While numerous studies find evidence for increased internal and international migration to neighboring countries, plenty of others have shown that environmental change can also have a neutral or even negative effect on migration, especially for the poorest households. Overall, it seems that evidence on the impact of gradual environmental hazards is more robust

than that related to sudden climate events. Whether or not individuals will migrate and where they will end up (within or across national borders) depends on characteristics of the individual (financial status, occupation, risk aversion, etc.), the country (size, migration policies, institutional setting, demography, etc.), as well as the type and severity of climatic events, the alternative coping strategies and government assistance programs. In what follows, we take a comprehensive, multilevel approach by relying on individual survey data that are comparable across a large number of countries. Our analysis allows to distinguish different regions around the world, with a particular focus on developing countries in Africa, Latin America and the Caribbean and Asia. This is valuable as both climatic conditions and situations significantly differ across regions and countries.

3.4 Data and Descriptives

Our empirical analysis relies on the rich and unique Gallup World Polls (GWP), a comprehensive cross-country dataset collected through individual surveys conducted worldwide. Specifically, we draw on data from 114 countries where at least one Gallup World Poll has been conducted in the year 2010, the year for which all our variables of interest are available.[2] Gallup collects detailed individual and household characteristics of respondents, and tracks attitudes and behaviors concerning a wide variety of areas such as politics, economics, well-being and trends. The surveys conducted by Gallup typically have a sample of around 1000 randomly selected respondents per country. The data are collected either through face-to-face interviews or through phone calls in countries where at least 80% of the population has a telephone landline. In addition, an area frame design is used for face-to-face interviewing in Central and Eastern Europe, as well as in the developing world, including much of Latin America, former Soviet Union countries, nearly all of Asia, the Middle East, and Africa.[3] The sampling frame represents the entire civilian, non-institutionalized population aged 15 and over, covering the entire country including rural areas.[4]

Our sample contains 93,197 individuals with complete information on all the variables of interest used in the model, interviewed worldwide during the year 2010. In what follows, we explain in detail how the variables of interest (related to individual exposure to environmental problems and migration behavior) have been constructed.

[2]For a description of the methodology and codebook, see Gallup (2017).

[3]In some large countries such as China, India and Russia as well as in major cities or areas of special interest, over-samples are collected resulting in larger total numbers of respondents.

[4]That is with the exception of areas where the safety of the interviewing staff is threatened, scarcely populated islands in some countries, and areas that interviewers can reach only by foot, animal, or small boat.

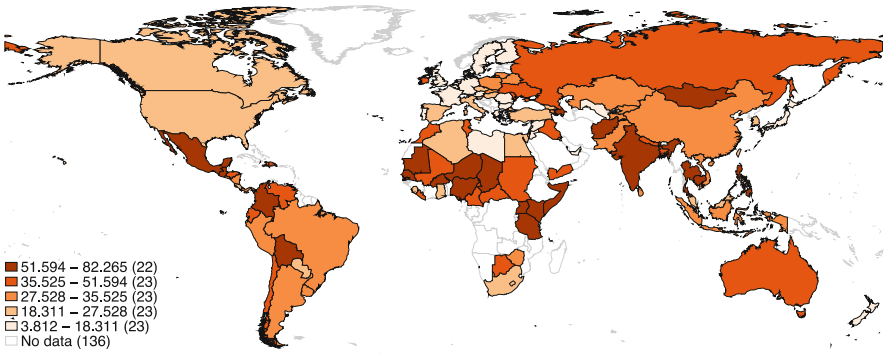

Fig. 3.1 Percentage of individuals experiencing severe environmental problems. Note: the map reports the percentage of individuals interviewed in 2010 who state having experienced severe environmental problems in their area in the past 12 months for each country. Source: Authors' elaboration on the Gallup World Polls

3.4.1 Severe Environmental Problems

The GWP allows to measure people's exposure to severe environmental problems. For the purpose of this chapter, we rely on the following question: (Q1) "In the past 12 months, have there been any severe environmental problems in your city or area, or not? For example, pollution, floods, droughts, or long periods of extreme heat or cold?". These data are available for all 114 countries in our sample for the year 2010. The question directly asks whether people have experienced any extreme environmental problems during the last 12 months, covering a wide range of both slow and sudden onset environmental hazards related to climate change.[5]

On average, about 34% of the respondents in our sample indicated having experienced severe environmental problems in the last 12 months. However, there are significant differences across countries. As illustrated in Fig. 3.1, the share of individuals indicating having experienced environmental hazards in the year preceding the interview ranges from around 4% to slightly over 80%. The lowest shares of perceived environmental problems are found in Libya (3.8%), the Netherlands (4.5%), Denmark (5.6%), Japan (5.9%; surveyed before the tsunami in 2010), Luxembourg (6.5%), Germany (7.9%), Finland (8.1%), Belgium (8.4%), and Sweden (9.7%), i.e. mostly European high income countries. The countries with the highest shares of self-reported environmental issues are Burkina Faso (82.3%), Chad

[5]It could be argued that the list of examples provided in the question refers not only to climate-related hazards. Indeed, given the presence of "pollution" in the list and the open end question, also other hazards for which the link with climate is less obvious could be considered by respondents. The question, nonetheless, can safely be interpreted as providing information on whether or not individuals have faced any environmental hazard which could be both a cause (e.g. pollution) or a consequence (e.g. drought, flood, extreme weather) of climate change.

Table 3.1 Pairwise correlations between Q1 and alternative measures of environmental hazards (in the GWP and EM-DAT)

Measure of environmental hazards	Pairwise correlation
Alternative GWP measures	
(Q2) Water access	0.079***
(Q3) Storm frequency	0.076***
(Q4) No water for crops	0.211***
(Q5) No water for livestock	0.208***
EM-DAT measures	
Cold wave	0.208**
Drought	0.337***
Fire	0.169*
Riverine flood	0.289***
Tropical cyclone	0.391*

Source: Authors' elaboration on the Gallup World Polls. *, ** and *** indicate significance at 10%, 5% and 1% respectively

(81.1%), Kenya (79.3%), Niger (75.5%), Mongolia (74.7%), Uganda (68.2%), Mauritania (67.4%), Cambodia (66.3%), Tanzania (62.7%), the Philippines (62%), and Guatemala (60.2%), i.e. predominately low-income countries located in Africa or Asia.

To explore what exactly this self-reported measure of environmental hazards captures, we correlate the share of individuals reporting to have experienced severe environmental problems with other variables in the GWP as well as with external indicators of environmental problems taken from the Emergency Events Database (EM-DAT).

There are several other relevant questions on climate change effects in the GWP which we can rely on to know more about what exactly is picked up by our variable of interest. Particularly relevant are the following questions:

(Q2) "Some people say the weather around the world is changing. Do you agree or disagree with the following statements. Water is getting harder to find."
(Q3) "[. . .] There is more extreme weather such as rain or windstorms now."
(Q4) "Please think about the last 12 months. In the area where you currently live, would you say there has been enough water for growing crops, or not?"
(Q5) "Again thinking of the last 12 months, in the area where you currently live, would you say there has been enough water for raising livestock, or not?"

The pairwise correlations with these alternative GWP questions (reported in Table 3.1) are all positive and highly significant. The strongest correlation is obtained with questions Q4 and Q5, which capture a lack of water availability for growing crops or raising livestock, respectively. It thus seems that our key variable of interest picks up exposure to drought, resulting in water scarcity particularly affecting agriculture and stock raising and, hence, the livelihoods of people working in these sectors.

Subsequently, we compare our variable of interest with indicators of the share of people affected by natural disasters taken from the EM-DAT,[6] kindly provided by the Centre for Research on the Epidemiology of Disasters (CRED). The database is made up of information from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies. It is constantly reviewed for inconsistencies and incompleteness. The environmental problems that we consider are climatological disasters (droughts, glacial lake outbursts, wildfires), geophysical disasters (earthquakes, dry mass movements, volcanic activity), meteorological disasters (extreme temperatures, fog, storms), and hydrological disasters (floods, landslides, wave actions). These events enter the dataset only when at least one of the following criteria is met: 10 or more people are reported killed, 100 or more people are reported affected, there has been a declaration of a state of emergency, and/or there has been a call for international assistance. For each of these environmental problems, we know the affected countries, the dates between which they occurred, the number of people who lost their life, and the total number of affected, i.e. the sum of people injured, people requiring immediate assistance during a period of emergency (requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance), and people left homeless after a disaster.

In order to match these data to those in the GWP, we compute the ratio of the total number of people affected by disaster subtype in each country during the years 2009-2010 over the country-specific population aged 15+ in 2010. These ratios are then correlated with the shares of people answering positively to question Q1. Table 3.1 reports only those disaster subtypes for which the pairwise correlation with the GWP shares are significant at least at the 10% significance level. It appears that the GWP question Q1 particularly picks up environmental shocks related to drought, riverine floods and cold waves and to a lesser extent also fires and tropical cyclones.

3.4.2 Migration Intentions

To capture individual migration propensities, we rely on the following GWP question: (Q6) "In the next 12 months, are you likely or unlikely to move away from the city or area where you live?". We refer to the individuals who express their intention to leave their area or country of residence as intending migrants. The duration of the intended move is left unspecified so that it might pick up not only permanent but also temporary (including seasonal or circular) migration episodes. In addition, it is not restricted to international migration, for which a wide variety of reasonable estimates are available, but also captures internal migration for which statistics are much more scarce and hard to construct from available data (see Bell and Muhidin 2009, for a discussion). Yet, as the number of internal migrants worldwide is roughly three

[6] See https://www.emdat.be

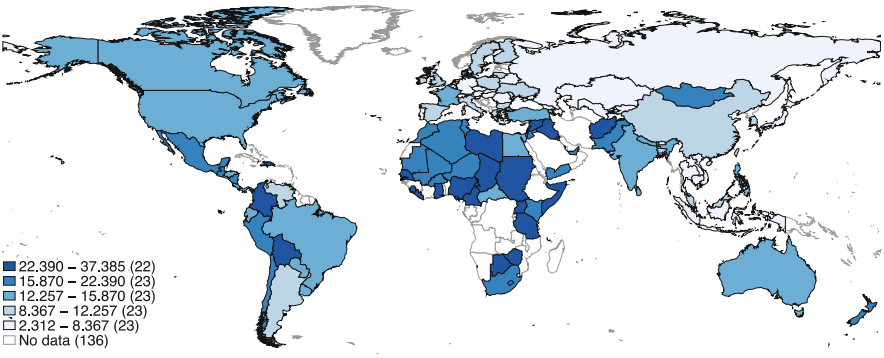

Fig. 3.2 Percentage of individuals intending to move within 12 months. Note: the map reports the share of individuals interviewed in 2010 who state an intention to move (irrespective of the destination) within 12 months for each country. Source: Authors' elaboration on Gallup World Polls

times that of international migrants (IOM 2015), such an omission might be quite serious (Dustmann and Okatenko 2014). Furthermore, the dataset documents migration intentions rather than actual migration,[7] which permits an assessment of the migration propensities for a representative set of individuals in each of the countries studied. While nothing guarantees that these migration intentions will materialize, migration intentions have been shown good predictors of future actual migration (see e.g. Bertoli and Ruyssen 2018; Docquier et al. 2014). Manski (1990) attributes the failure of migration intentions to translate into actual migration plans to the additional information received by the respondent after the intentions have been stated. The formation of these intentions is thus important in its own right and may contribute to our understanding of migrant selection and possible future migration dynamics (Dustmann and Okatenko 2014).

Figure 3.2 plots the percentage of people intending to move away from where they currently live in the next 12 months. Again, significant differences across countries arise. The lowest shares are reported in Singapore (2.3%), Kyrgyzstan (5.7%), Vietnam (5.7%), Azerbaijan (5.8%), and Belarus (6.2%). The highest shares of people intending to migrate are reported in Ghana (37%), Liberia (35.9%), Sudan (35%), Dominican Republic (33.5%), Botswana (33.1%), Cameroon (32.9%), and Nigeria (32.7%).

Subsequently, it is interesting to see whether countries where more inhabitants report having experienced severe environmental problems in the last 12 months are

[7]The way in which this kind of hypothetical question is interpreted might vary across countries, as observed by Clemens and Pritchett (2016) who underlines the risk of using contingent value surveys. Typically, respondents may interpret "opportunity" in light of the possibilities currently available to them (legal migration, irregular life-threatening trip, with or without funding, etc.), which vary across countries. To account for this, we will include country fixed effects in the econometric analysis.

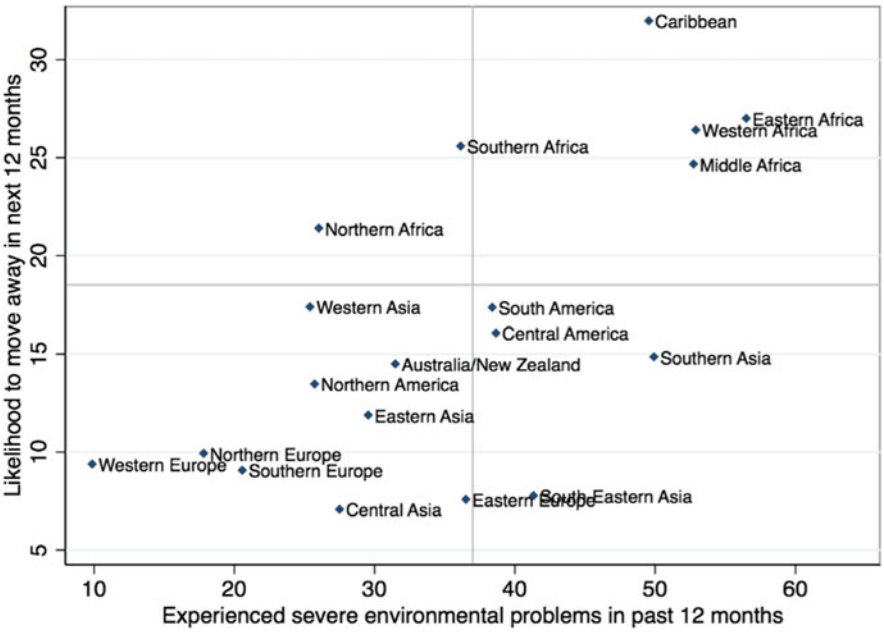

Fig. 3.3 Migration intentions and experienced environmental problems by region. Note: the figure plots the average share of respondents answering that they are likely to move away from where they currently live in the next 12 months against the share of respondents indicating that they have experienced severe environmental problems in their area in the past 12 months by region. Source: Authors' elaboration on Gallup World Polls

also those where more individuals indicate that they are likely to move away in the coming year. To test whether such a positive correlation exists, Fig. 3.3 presents a scatterplot of the two questions of interest (Q1 and Q6). Countries where both shares are relatively high (in the upper right corner) seem to be mostly located in Africa (Eastern Africa, Western Africa, and Middle Africa) and Latin American and (predominantly) Caribbean countries. Southern Asia is characterized by relatively high shares of experiences with environmental problems, but in general less individuals indicate to be likely to move away from the area where they currently live. In Europe, Northern America and Oceania (lower left corner) shares of reported environmental problems are relatively low and intentions to move away are quite modest.

In Fig. 3.4, the same relationship is shown at the country level, which immediately reveals a significant heterogeneity across countries. While Asian countries are mostly situated in the lower quadrants, in some countries the share of experiences with severe environmental problems is strikingly higher than in others. In Singapore, for instance, this share amounts to 19.4% while in Cambodia it is as high as 66.3%. In both countries, the likelihood to move away in the next 12 months is relatively low (2.3% in Singapore and 6.6% in Cambodia). A different picture emerges, for

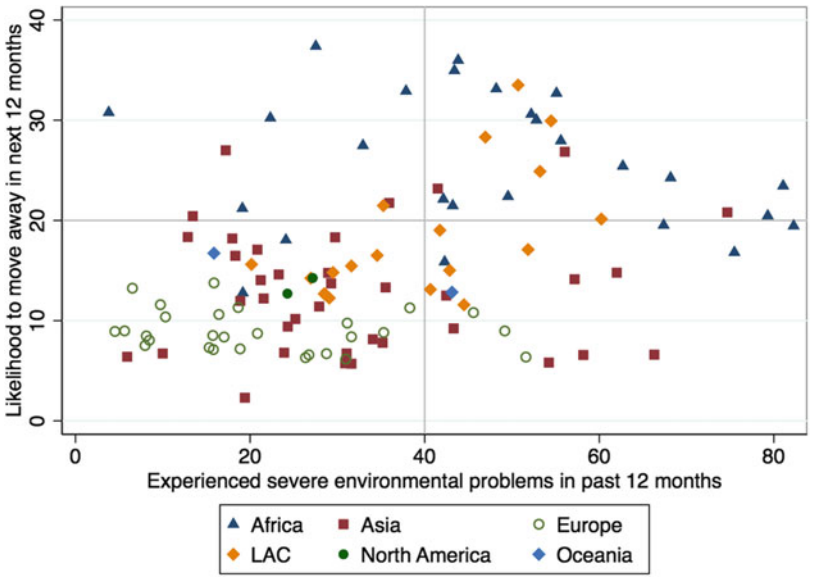

Fig. 3.4 Migration intentions and experienced environmental problems by country. Note: the figure plots for each country the average percentage of respondents answering that they are likely to move away from where they currently live in the next 12 months against the percentage of respondents indicating that they have experienced severe environmental problems in their area in the past 12 months in 2010. Source: Authors' elaboration on Gallup World Polls

instance, in Afghanistan where 56% of respondents experienced environmental problems in the last year and 27% are likely to move away in the next 12 months. Such discrepancies in the mobility response of inhabitants clearly exposed to environmental hazards could be due to financial capacity, differences in long-term climate conditions, culture, or adaptation capabilities (Bertoli et al. 2019).

An additional question included in the GWP specifically refers to the likelihood of people to migrate in the face of environmental problems, again, available for 114 countries: (Q7) "In the next five years, do you think you will need to move because of severe environmental problems?" This question focuses directly on environmental migration over a relatively longer timespan than Q6 (5 years rather than 1 year), again regardless of destination (hence covering both internal and international migration). Similarly to Q6, the duration of the intended move is unspecified, so that the question encompasses not only permanent but also temporary (as well as seasonal or circular) migration episodes. We refer to the individuals who express the intention to move away because of severe environmental problems as *intending environmental migrants*.

Figure 3.5 shows the percentage of people who will have to move in the next 5 years because of severe environmental problems. Again, we observe significant heterogeneity across countries. The lowest percentages of individuals which need to move are found in Poland (0.43%), Sweden (0.80%), Czech Republic (0.94%),

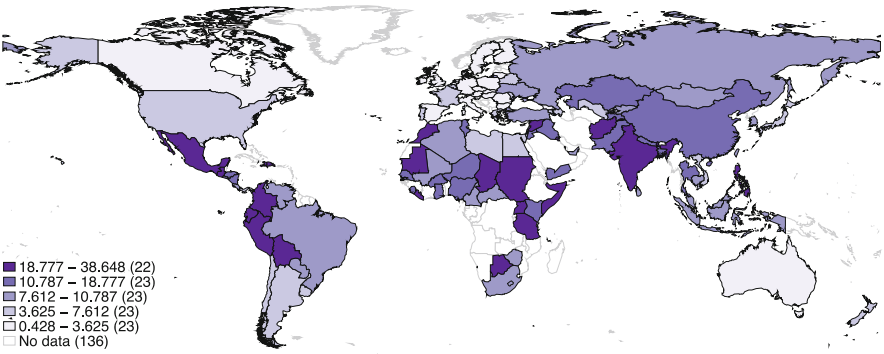

Fig. 3.5 Percentage of individuals who will have to move in the next 5 years because of severe environmental problems. Note: the map reports the share of individuals interviewed in 2010 who state they will have to move within in the next 5 years because of severe environmental problems for each country. Source: Authors' elaboration on Gallup World Polls

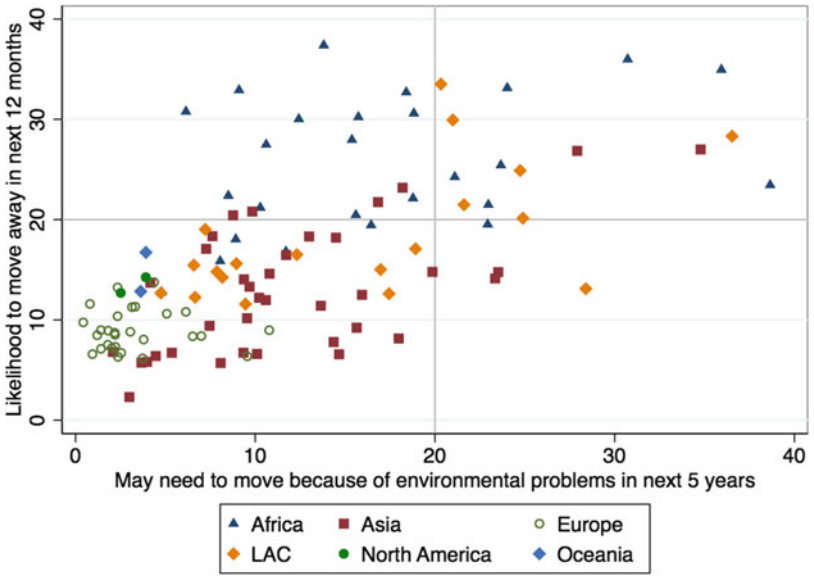

Fig. 3.6 Short-run migration intentions versus mid-term environmental migration intentions. Note: the figure plots for each country the percentage of people indicating that they are likely to move away in the next 12 months from their current location against the percentage of respondents who have experienced severe environmental problems in the past 12 months and that, because of this, they will need to move in the next 5 years. Source: Authors' elaboration on Gallup World Polls

Finland (1.2%), Denmark (1.4%), Austria (1.4%), Germany (1.8%), and the Netherlands (1.8%), i.e. European high income countries. The highest shares of individuals who will have to move away in the next 5 years are reported in Haiti (38.6%),

Sudan (36.5%), Syria (34.7%), Liberia (30.7%), Ecuador (28.4%), and Afghanistan (27.9%).

Subsequently, Fig. 3.6 plots for each country the percentage of people indicating that they are likely to move away in the next 12 months from their current location against the percentage of respondents stating they believe they will need to move in the next 5 years because of environmental problems. It is important to note that the latter question was asked only to people who confirmed having experienced severe environmental problems in the past 12 months, meaning that this indicator was calculated on a much smaller sample than the former question. It is nonetheless clear that both shares are positively correlated. Yet, the picture again shows significant heterogeneity across countries. Most of the countries displaying the lowest shares of individuals likely to move away are situated in Europe, Northern America and Oceania, and located in the lower left quadrant, indicating that these are also the countries with the lowest shares of potential environmental migrants in the next 5 years. Also Asian countries seem to display relatively low shares of (environmental) migration intentions. Most of the African countries are situated in the upper quadrants, suggesting that more of their inhabitants are likely to move away in the next 12 months. For seven of these countries, a lot of this migration could be related to environmental issues. For 13 African countries, located in the upper left quadrant, a significant amount of people in these countries is likely to move away in the next 12 months, but not necessarily because of environmental drivers. For Latin American countries, no clear pattern emerges, suggesting a great deal of heterogeneity in this continent. Finally, the lower right quadrant is the least populated. This seems to suggest that most respondents indicating that they will have to move because of environmental problems in the next 5 years already have plans to do so quite fast, i.e. in the next 12 months.

3.4.3 Additional Individual Information

Besides these key variables of interest, we keep track also of additional individual- and household-level information contained in the GWP. Specifically, we record respondents' age and gender at the time of the interview, whether they are highly educated or not (i.e. have completed 4 years of education beyond high school and/or received a 4-year college degree or not), whether they live in a rural or urban area (a rural area covers residence on a farm or in a small town or village while an urban area is defined as a large city or a suburb of a large city), and whether they have a relative or friend abroad whom they can count on for help when needed. We also include information on the number of adults (aged 15 and above) in the household and the number of children (below 15 years of age) in the household as well as self-reported household income per capita. Table 3.2 reports descriptive statistics for our variable of interest and the controls.

Table 3.2 Descriptive statistics

Variable	Mean	Std. Dev	Min	Max
Environmental problems	0.357	0.479	0.000	1.000
Age	42.286	17.696	15.000	97.000
Male	0.447	0.497	0.000	1.000
Highly educated	0.156	0.363	0.000	1.000
Urban	0.400	0.490	0.000	1.000
Ln of hhincpc	7.719	1.638	0.804	14.509
Nr adults	3.102	1.833	1.000	40.000
Nr children	1.258	1.871	0.000	37.000
Network	0.301	0.459	0.000	1.000

Notes: The table reports for each variable its mean value (column 2), standard deviation (column 3), minimum (column 4) and maximum value (column 5). There are 93,197 observations for each variable

3.5 Theoretical Framework and Empirical Specification

This section presents the theoretical framework and the empirical specification that we will estimate. The model that we use to analyze the migration decision is a Random Utility Maximization (RUM) model of migration. The migration decision is based upon the comparison of the lifetime utilities of staying in the current location and of migrating to a potential destination. Consider an individual i, residing in region r of country j; the choice set D of individual i includes her/his home region r (which we refer to as $k = 0$ without loss of generality), the rest of country j, i.e., $R_j/\{r\}$ where R_j is the set of regions of country j (we refer to this second alternative in the choice set as $k = 1$), and the set $W/\{j\}$ of other countries of the world ($k = 2$). Thus, the choice set D includes three alternatives: staying at origin, moving internally, and migrating to an international destination. Let U_{ik} denote the utility that individual i would derive if opting for alternative $k \in D$. We assume that this alternative-specific utility includes a deterministic component V_{ik} and a stochastic component ϵ_{ik}. If the stochastic component follows an independent and identically distributed EVT-1 distribution, then the probability p_{ik} that $k \in D$ will be the utility-maximizing alternative is given by:

$$p_{ik} = \frac{e^{V_{ik}}}{\sum_{l \in D} e^{V_{il}}} \tag{3.1}$$

The relative probability of migrating domestically over staying at origin is given by:

$$\frac{p_{i1}}{p_{i0}} = e^{V_{i1} - V_{i0}} \tag{3.2}$$

The relative probability of migrating to the foreign destination $k = 2$ over staying at origin is given by:

$$\frac{p_{i2}}{p_{i0}} = e^{V_{i2} - V_{i0}} \tag{3.3}$$

The relative probability of intending to move (irrespective of the destination) over staying at origin is given by:

$$\frac{p_{i1} + p_{i2}}{p_{i0}} = \frac{e^{V_{i2}} + e^{V_{i1}}}{e^{V_{i0}}} \tag{3.4}$$

Relative choice probabilities are solely determined by the difference in the levels of utility associated to each pair of alternatives (and not by the levels themselves). This, in turn, entails that we can normalize the utility associated to the baseline option (staying) to zero. Thus, the estimated coefficients for all the regressors give us the differential effect of each variable on the attractiveness of moving versus staying.

Let mig_{ir} represent a dummy variable taking the value one if individual i residing in region r expresses the intention to move within 12 months (regardless of destination), the probability to migrate is then given by:

$$\Pr(mig_{ir} = 1) = \frac{e^{V_{ir}}}{1 + e^{V_{ir}}} \tag{3.5}$$

Denoting the country-of-origin index by j, the reduced-form expression for the utility differential between migrating and staying writes as:

$$V_{irj} = \alpha_j + \gamma X_{irj} + \beta EP_{irj} \tag{3.6}$$

where X_{irj} denotes a vector of individual and household-level characteristics including: dummies for different age groups (i.e. 20–29, 30–39, 40–49, 50–98, with 15–19 representing the reference category), a dummy for male individuals, a dummy for highly educated individuals (i.e. who have completed 4 years of education beyond high school and/or received a 4-year college degree), a dummy for individuals living in urban areas (i.e. a large city or a suburb of a large city as opposed to residence on a farm or in a small town or village), and a dummy for having a relative or friend abroad whom one can count on for help when needed, the number of adults (aged 15 and above) in the household and the number of children (below 15 years of age) in the household as well as the self-reported household income per capita. We also include country of origin fixed effects, α_j, to account for the fact that the migration behavior of people in the same country might be driven by common unobserved time-invariant factors.

Our specification of the deterministic component of the utility associated with migrating also includes a dummy EP_{irj} for whether the individual has experienced any severe environmental problems in the past 12 months. If the coefficient $\widehat{\beta}$

associated with this dummy is positive, then this means that severe environmental issues make the origin location relatively less attractive than the intended destination. The marginal effect on the probability of intending to move is given by $\beta_{p_{ik}}(1 - p_{ik})$, with $k = 1,2$, while $\widehat{\beta}$ itself represents the partial derivative of the logarithm of the relative choice probability with respect to our variable of interest.

A possible concern in the regression on the intention to migrate is the following: if an individual considers moving to a neighboring region, then environmental factors at origin could be positively correlated with environmental factors at destination. Following, this correlation confounds the effect of the estimated coefficient, possibly biasing it towards zero and reducing its statistical significance.[8]

In Sect. 3.2, we elaborated on the potential role played by credit constraints. Some individuals, for whom migration forms the optimal choice, might not be able to afford migration costs, so that they are constrained to stay in their current location. In order to explicitly account for credit constraints, Dustmann and Okatenko (2014) introduce a budget constraint into the model. Migration is assumed to come at a cost, C, which needs to be paid up-front and could be financed from current wealth or by borrowing. Furthermore, it is assumed that the amount of capital that the individual can raise to cover the costs of migration, f, increases her/his overall wealth in the current location, w_i, and does not depend on potential future wealth due to credit constraints. This gives the following budget constraint:

$$f(w_O, \zeta_1) \geq C(\zeta_2) \tag{3.7}$$

where ζ_1 denotes individual circumstances influencing the relationship between wealth and the amount of capital that is available to the individual (such as family networks, etc.). ζ_2 captures individual variations in the costs of migration stemming from characteristics of the individual (e.g. age, education level or preferences), of the intended move (such as the distance that needs to be covered or travelling time), of the origin (e.g. emigration procedures), and the destination (e.g. the cost of living, cost to acquire visa) (Dustmann and Okatenko 2014). We can then determine the threshold value for wealth above which the individual is able to cover the migration cost as $w_O \geq T(\zeta_1, C(\zeta_2)) = T(\zeta_1, \zeta_2)$. Individuals whose wealth is below the threshold T will not be able to finance migration and will hence decide to stay even if they desire to migrate. In other words, individuals will decide to migrate if $U_{ik} > U_{i0}$ with $k = 1,2$, subject to the constraint $w_O \geq T$. Accounting for credit constraints hence increases the total number of stayers, which not only includes those who believe their lifetime utility is maximized in their current location, but also those who think they are better off elsewhere but cannot finance the migration (Dustmann and Okatenko 2014). The reduced-form expression for the utility

[8]Thus, when you have incentives to migrate, potential (internal) destinations can look less attractive.

differential between migrating and staying, accounting for potential credit constraints, can then be written as:

$$V_{irj} = \alpha_j + \gamma X_{irj} + \lambda w_{irj} - \rho w_{irj}^2 + \beta EP_{irj} \tag{3.8}$$

To evaluate the impact of severe environmental hazards on migration intentions, we estimate linear probability models with country of origin dummies.[9] Standard errors are robust to heteroscedasticity and are clustered across origins. The overall F-test always rejects the hypothesis that all parameters are jointly zero.

3.6 Empirical Evidence

Table 3.3 presents linear probability estimates of the impact of environmental problems and traditional controls on the intention to migrate in the next 12 months. The first column reports estimated coefficients for the model including only personal and household characteristics. In line with expectations, migration intentions peak for individuals aged between 20 and 29, and decrease as people get older. The likelihood to move away is relatively higher for men, for highly educated people (holding a tertiary education degree), and to a lesser extent also for those living in urban areas (large city or suburb of a large city). Household income per capita is found to have a marginally positive effect, but the strongest positive impact is obtained for networks: respondents, who have a family member or friend abroad whom they can count on when needed, are significantly more inclined to migrate than those without such a network (see also Bertoli and Ruyssen 2018).

In the second and third columns of Table 3.3, we respectively include a dummy for having experienced severe environmental problems in the last 12 months and an interaction term of the exposure to environmental problems and living in an urban area (which we consider our benchmark model). Overall, we find that individuals who recently experienced severe environmental problems are more likely to migrate in the next 12 months. The results for the individual and household controls are similar to those reported in the first column. The marginal effect of our variable of interest on migration intentions at the mean is positive and highly significant. Having recently experienced severe environmental problems increases the probability that an individual intends to migrate on average by 2.1 percentage points.

The interaction term also reveals that environmental hazards particularly drive away people residing in urban areas (though only at the 10% level). This could be

[9]The Gallup World Polls provide information on the region in which individuals were interviewed. Yet, for some countries, these are (partly) missing. Including regional dummies would thus result in a significant drop in the sample size which is why we do not systematically do so. Re-estimating our benchmark model including regional fixed effects, nonetheless provides very similar results (available upon request).

Table 3.3 Impact of traditional controls and severe environmental problems on migration intentions

	Traditional controls	Environmental problems	Benchmark
Environmental problems		0.021***	0.016*
		(2.99)	(1.87)
Env probl × urban			0.013*
			(1.80)
Aged 20–29	0.015***	0.015***	0.015***
	(2.90)	(2.84)	(2.85)
Aged 30–39	−0.052***	−0.053***	−0.053***
	(−7.33)	(−7.32)	(−7.33)
Aged 40–49	−0.089***	−0.090***	−0.090***
	(−9.82)	(−9.78)	(−9.79)
Aged 50+	−0.127***	−0.127***	−0.127***
	(−13.00)	(−12.98)	(−12.97)
Male	0.014***	0.014***	0.014***
	(3.41)	(3.37)	(3.39)
Highly educated	0.018***	0.017***	0.017***
	(4.20)	(4.16)	(4.17)
Urban	0.014**	0.014**	0.009
	(2.44)	(2.46)	(1.54)
Ln of hhincpc	0.004*	0.004*	0.004*
	(1.80)	(1.79)	(1.76)
Nr adults	−0.001	−0.001	−0.001
	(−0.69)	(−0.69)	(−0.73)
Nr children	−0.002	−0.003	−0.003
	(−1.40)	(−1.49)	(−1.47)
Network	0.046***	0.045***	0.045***
	(11.71)	(11.64)	(11.63)
R-squared	0.078	0.079	0.079
Observations	93,188	93,188	93,188

Note: All specifications include country of origin dummies. Standard errors are robust to heteroscedasticity and clustered across origins. t statistics in parentheses. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

interpreted as signaling that the main transmission channel for environmental migration in the overall sample is not necessarily the agricultural productivity channel, which has been most stressed in the literature. Instead, this finding seems to support the relevance of the urbanization channel (more rural-urban migration associated with environmental change pushing people from urban areas abroad in search of higher wages), but it is just as well in line with the credit constraint channel, which stipulates that people in rural areas (who are likely to be hit harder by environmental hazards) are more likely to be pushed further into poverty and hence less likely to respond by migrating in the near future (as they cannot afford the migration costs).

Table 3.4 Impact of environmental problems on migration intentions by geographic region

	Africa	Asia	LAC	Europe	NAM	Oceania
Environ problems	0.037*	−0.008	0.041***	0.028***	0.056**	−0.001
	(2.04)	(−0.55)	(4.18)	(5.01)	(41.79)	(−0.05)
Env probl × urban	0.031	0.032***	0.001	−0.024**	−0.067	0.045
	(1.16)	(3.80)	(0.07)	(−2.50)	(−5.14)	(1.56)
Aged 20–29	0.002	0.019**	0.014	0.024*	0.003	−0.017
	(0.21)	(2.34)	(1.14)	(1.71)	(0.08)	(−0.20)
Aged 30–39	−0.072***	−0.025***	−0.053***	−0.067***	−0.093	−0.102
	(−3.97)	(−2.92)	(−4.76)	(−4.93)	(−2.07)	(−4.53)
Aged 40–49	−0.131***	−0.042***	−0.086***	−0.117***	−0.187*	−0.161
	(−5.61)	(−4.60)	(−5.77)	(−8.42)	(−7.51)	(−3.72)
Aged 50+	−0.216***	−0.071***	−0.138***	−0.148***	−0.220*	−0.201*
	(−8.67)	(−7.88)	(−5.98)	(−8.68)	(−10.09)	(−6.85)
Male	0.048**	0.012*	−0.001	0.005	0.024	0.025
	(2.94)	(2.03)	(−0.15)	(0.94)	(4.04)	(3.08)
Highly educated	−0.026	0.026***	0.021**	0.025***	−0.009	0.023
	(−1.54)	(3.25)	(2.43)	(4.99)	(−1.18)	(0.61)
Urban	0.024	0.004	0.013	0.004	0.040	−0.003
	(0.93)	(0.31)	(1.19)	(0.60)	(1.29)	(−0.21)
Ln of hhincpc	0.004	0.007*	0.009***	−0.006*	−0.026**	0.004
	(0.84)	(1.93)	(3.27)	(−1.99)	(−28.91)	(0.19)
Nr adults	−0.002	0.001	−0.006*	−0.002**	0.002	0.003
	(−1.00)	(0.74)	(−1.99)	(−2.19)	(1.67)	(0.36)
Nr children	0.001	−0.005*	0.004	−0.013***	−0.014	−0.007
	(0.39)	(−1.88)	(1.12)	(−3.64)	(−1.08)	(−0.44)
Network	0.075***	0.030***	0.042***	0.045***	0.005	−0.015*
	(6.49)	(5.19)	(4.42)	(9.57)	(0.18)	(−6.54)
R-squared	0.066	0.040	0.063	0.060	0.065	0.042
Observations	15,948	32,490	12,205	28,898	1953	1694

Note: All specifications include country of origin dummies. *LAC* Latin American and Caribbean, *NAM* North America. Standard errors are robust to heteroscedasticity and clustered across origins. *t* statistics in parentheses. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

To account for potential heterogeneity in the migration response to environmental hazards based on the characteristics of the respective geographic region, we split the sample of countries by continent[10] (see also Dustmann and Okatenko 2014). As can be seen in Table 3.4, the relative importance of the different factors driving migration intentions strongly differs across geographic regions. Overall, we find that the significant positive impact of severe environmental problems on migration intentions reported in Table 3.3 is mainly driven by countries in Africa, Latin America,

[10]An overview of the countries in our sample by geographical region can be found in Appendix Table 3.7.

Europe and North America, while no significant effect is obtained for Asia and Oceania. It should be noted, however, that for North America and Oceania, the sample is considerably smaller than for the other regions which may (partly) explain the lack of significant effects for most variables. The estimated coefficients on the interaction term between recent exposure to severe environmental problems and urban areas are positive and highly significant in Asia, and negatively significant at 5% in Europe. These findings suggest that, while overall, we cannot confirm that migration intentions in Asia respond to environmental hazards, the likelihood to move in the face of severe environmental problems does appear higher for respondents residing in urban areas. In Europe, the estimated positive impact of environmental problems on migration intentions is much stronger for people residing in rural areas.

While Table 3.4 clearly shows a differential migration response to environmental factors depending on the geographic region, it does not distinguish rich from poor countries. We therefore classify countries based on their income per capita level, following the World Bank Country Classification, to allow for a heterogeneous migration response depending on a country's development level (in line with e.g. Cattaneo and Peri 2016). This classification distinguishes between low income (LI), lower middle income (LMI), upper middle income (UMI), high income non-OECD (HnOECD), and high income OECD (HOECD) countries.

Rerunning our benchmark estimation on these subsamples, reported in Table 3.5, reveals a particularly strong positive effect of recent exposure to severe environmental problems on migration intentions in high income OECD countries. The effect, however, seems to decrease with countries' development level: the effect is still positive, but significant only at 5% for high income non-OECD countries and only at 10% for upper middle income countries. It is insignificant for lower and lower middle income countries. For the latter, we do find a positive significant effect for the interaction term with the urban dummy, suggesting that exposure to severe environmental problems in lower middle-income countries increases the likelihood to migrate but only for people residing in urban areas. Although we have to be careful again in interpreting these results, given that splitting the sample considerably reduces the sample size across country groupings. Yet, the findings seem to confirm that people's intention to migrate in the face of severe environmental hazards depends positively on the country's income per capita (in line with Cattaneo and Peri 2016).

In order to test to what extent these discrepancies can be interpreted as evidence of credit constraints in the poorest countries, we extend our benchmark specification in the following ways. First, we include an interaction term of people's exposure to severe environmental problems and the log of the household income per capita. Table 3.6 (column 1) shows, however, that the migration response to environmental problems does not vary with per capita household income. As an alternative, we augment our benchmark specification with an individual wealth index as constructed by Dustmann and Okatenko (2014) as well as the square of this term. Specifically, the wealth index is the first principal component computed through an origin-specific polychoric principal component analysis on four of the seven questions

Table 3.5 Impact of environmental problems on migration intentions by development level

	LI	LMI	UMI	HnOECD	HOECD
Environ problems	0.027	0.000	0.017*	0.017**	0.030***
	(1.53)	(0.01)	(2.01)	(2.67)	(3.93)
Env probl × urban	0.014	0.033**	0.004	0.002	0.001
	(0.45)	(2.23)	(0.37)	(0.31)	(0.07)
Aged 20–29	0.008	0.008	0.008	0.011	0.057***
	(0.96)	(1.01)	(0.56)	(0.41)	(4.28)
Aged 30–39	−0.054***	−0.053***	−0.054***	−0.043	−0.054***
	(−3.02)	(−3.98)	(−4.12)	(−1.55)	(−4.24)
Aged 40–49	−0.084***	−0.083***	−0.089***	−0.079***	−0.106***
	(−3.56)	(−4.16)	(−6.36)	(−4.03)	(−6.85)
Aged 50+	−0.137***	−0.124***	−0.129***	−0.102***	−0.141***
	(−4.82)	(−6.07)	(−5.87)	(−3.80)	(−9.07)
Male	0.034**	0.028***	−0.000	−0.004	0.010*
	(2.31)	(3.49)	(−0.04)	(−0.51)	(1.76)
Highly educated	0.020	0.021**	0.023*	0.018*	0.019***
	(0.95)	(2.47)	(2.00)	(2.28)	(3.38)
Urban	0.057**	−0.003	0.001	−0.017	0.014**
	(2.56)	(−0.14)	(0.15)	(−1.45)	(2.66)
Ln of hhincpc	0.009*	0.004	0.011***	0.000	−0.007**
	(1.82)	(1.23)	(3.02)	(0.05)	(−2.17)
Nr adults	−0.001	−0.001	0.002	0.001	−0.002**
	(−0.77)	(−0.18)	(0.68)	(0.46)	(−2.43)
Nr children	0.001	−0.005	0.005	−0.007	−0.013***
	(0.19)	(−1.34)	(1.61)	(−0.96)	(−4.10)
Network	0.064***	0.057***	0.046***	0.041**	0.036***
	(6.22)	(5.92)	(4.85)	(3.45)	(7.35)
R-squared	0.081	0.076	0.086	0.046	0.059
Observations	16,266	22,177	19,503	9016	25,486

Note: All specifications include country of origin dummies. We follow the World Bank Country Classification, which distinguishes between low income (LI), lower middle income (LMI), upper middle income (UMI), high-income non-OECD (HnOECD), and high income OECD (HOECD) countries. Standard errors are robust to heteroscedasticity and clustered across origins. *t* statistics in parentheses. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

used by Dustmann and Okatenko (2014) that are available for all countries in our sample in 2010. The questions relate to (1) the ownership of a TV set, (2) access to the Internet, to whether in the previous 12 months the respondent did not have enough money (3) to buy food or (4) to provide adequate shelter of housing to her family.

In line with Dustmann and Okatenko (2014), we find that migration intentions respond to individual wealth by alleviating budget constraints: the estimated coefficient on the wealth index is positive and strongly significant, while its squared term is not. Note that in the specifications where we account for the household wealth,

Table 3.6 Impact of environmental problems and credit constraints on migration intentions

	Income pc inter	Wealth	Wealth inter	Wealth and urban
Environmental problems	0.027	0.014*	0.012	0.016*
	(0.79)	(1.68)	(1.54)	(1.95)
Environ probl × urban	0.015**	0.014*	0.017**	0.015**
	(2.14)	(1.86)	(2.37)	(2.18)
Aged 20–29	0.015***	0.015***	0.016***	0.015***
	(2.85)	(2.99)	(3.05)	(3.02)
Aged 30–39	−0.053***	−0.054***	−0.054***	−0.054***
	(−7.33)	(−7.48)	(−7.45)	(−7.47)
Aged 40–49	−0.090***	−0.092***	−0.092***	−0.092***
	(−9.79)	(−9.98)	(−9.96)	(−9.97)
Aged 50+	−0.127***	−0.131***	−0.130***	−0.131***
	(−12.95)	(−13.25)	(−13.24)	(−13.27)
Male	0.014***	0.016***	0.016***	0.016***
	(3.38)	(3.79)	(3.77)	(3.81)
Highly educated	0.017***	0.022***	0.021***	0.022***
	(4.18)	(5.11)	(4.94)	(5.26)
Urban	0.009	0.013**	0.011*	0.011*
	(1.58)	(2.04)	(1.88)	(1.86)
Ln of hhincpc	0.004*	0.008***	0.008***	0.007***
	(1.70)	(3.79)	(3.74)	(3.65)
Nr adults	−0.001	0.000	0.000	0.000
	(−0.73)	(0.35)	(0.29)	(0.26)
Nr children	−0.003	−0.002	−0.003	−0.002
	(−1.53)	(−1.44)	(−1.48)	(−1.42)
Network	0.045***	0.048***	0.048***	0.048***
	(11.67)	(12.07)	(12.08)	(12.17)
Env probl × ln hhincpc	−0.002			
	(−0.41)			
Wealth		0.021***	0.017***	0.017***
		(7.56)	(5.43)	(5.43)
Wealth^2		−0.002		
		(−0.99)		
Env probl × wealth			0.007	−0.003
			(1.35)	(−0.41)
Env probl × wealth × urban				0.029***
				(3.21)
Observations	93,188	90,833	90,833	90,833
R-squared	0.079	0.079	0.079	0.080

Note: All specifications include country of origin dummies. Standard errors are robust to heteroscedasticity and clustered across origins. t statistics in parentheses. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

also the log of the household per capita plays a bigger role. It is, however, even more interesting to see whether the migration response to severe environmental problems also depends on the household's wealth. To this end, we interact the dummy for having experienced severe environmental problems in the past 12 months with the wealth indicator (column 3) and the combination of the wealth indicator and the urban dummy (column 4). The results reveal no significant impact of the interaction term, but we do find a very strong significant impact of the last interaction term, while the other results are largely preserved. It thus seems that intentions to migrate in the face of severe environmental problems are stronger for people in urban areas who are part of wealthier households. This is in line with the fact that international migration – which is more costly than internal migration—typically originates in urban rather than rural areas (see e.g. FAO 2017).

3.7 Conclusion

Migration and climate change are two topics increasingly shaping our everyday lives as well as public debates. Despite enormous progress in the literature, it remains unclear to what extent environmental factors actually shape migration around the world. Numerous case studies have been conducted to identify the impact of natural disasters more generally. In addition, recent cross-country studies have attempted to empirically estimate the role played by environmental drivers in (bilateral) migration to the OECD or worldwide. Both types of studies, however, come with their own limitations, particularly related to the country-specific or very coarse cross-country data that they rely on.

In this chapter, we provided a comprehensive overview of the potential transmission channels underlying the climate-migration nexus. While most of the literature has focused on the agricultural channel, the importance of other channels is further (implicitly) documented in this literature review. We distinguish between studies which have focused on internal versus international migration in the face of climate change, as well as between studies looking at the impact of slow onset versus sudden onset hazards. We conclude that while there is particularly strong evidence for an impact of environmental hazards on internal movements, this is much less the case for international migration.

Subsequently, we provided a first attempt to bridge the gap between the two types of studies (micro versus macro) and the two types of migration (internal versus international). Specifically, we rely on the very rich and unique Gallup World Polls survey dataset, which, among others, collects information on individual migration intentions and people's exposure to severe environmental problems as well as a whole series of personal and household characteristics in a large number of countries. This dataset allowed us to empirically estimate the influence of recent exposure to environmental hazards on people's stated short-term migration intentions, and to test for a differential migration response in rural versus urban areas, in different geographic regions, and across countries with a different levels of development. We

also test to what extent the migration response to environmental hazards depends on household wealth.

Overall, we find that people exposed to environmental hazards are more likely to migrate away in the next 12 months. This effect is found to be stronger for people residing in urban areas, which could be interpreted as evidence for the urbanization channel being at play (people from rural areas are more inclined to migrate abroad following increased rural-urban migration associated with environmental hazards), although it might just as well signal the relevance of the credit constraint channel (people in rural households are probably hit harder and might therefore not be able to cover the costs of migration in the short run). The migration response to environmental problems is, however, heterogeneous across different groups of countries and locations of residents. Severe environmental problems are associated with a higher probability of intending to move in Africa, Latin America, Europe and North America, while in Asia the effect is only significant for residents of urban areas. Furthermore, the migration response to environmental hazards depends positively on the country's income per capita and is higher for residents of urban areas. Our results finally indicate that the migration response of people in urban areas is crucially determined by household wealth.

The preliminary analysis presented in this chapter shows how the literature would gain from empirical analyses applying an integrated approach, i.e. combining both micro and macro level information, and considering both internal and international migration responses to environmental change. By combining information on both country and individual/household characteristics, one can better identify the subpopulation that is actually affected by environmental hazards, and compare results across countries. Furthermore, this integrated approach allows to explore heterogeneity in the migration response across countries and groups of people.

Our analysis suggests that individuals exposed to severe environmental problems are more likely to move in the next 12 months. This could be seen as a first indication that we may expect an increase in human mobility in the face of environmental change. Of course, in order to provide more reliable results, more precise indicators tracking exposure to specific environmental hazards is required. It would also be interesting to distinguish between the internal and international migration response to these different environmental hazards. Such an analysis is beyond the scope of the present study but forms an interesting pathway to further assess and advance the existing evidence on the complex nexus between environmental change and migration.

Appendix

Table 3.7 Countries in our estimation sample by geographical region

Asia	**Freq.**	**Europe**	**Freq.**
Afghanistan	839	Austria	977
Armenia	904	Belarus	872
Azerbaijan	876	Belgium	935
Bangladesh	972	Bulgaria	904
Cambodia	981	Czech Republic	901
China	3082	Denmark	977
Cyprus	981	Finland	986
Georgia	896	France	970
India	5425	Germany	988
Indonesia	1022	Greece	937
Israel	919	Hungary	973
Japan	967	Ireland	971
Kazakhstan	815	Italy	938
Kyrgyzstan	914	Lithuania	859
Malaysia	926	Luxembourg	951
Mongolia	913	Malta	912
Nepal	895	Moldova	905
Pakistan	841	Netherlands	974
Philippines	920	Poland	938
Singapore	961	Portugal	933
South Korea	925	Romania	890
Sri Lanka	996	Russia	3528
Taiwan	932	Slovakia	917
Tajikistan	901	Slovenia	978
Thailand	958	Spain	968
Turkey	872	Sweden	974
Uzbekistan	964	Ukraine	901
Vietnam	893	United Kingdom	941
Total	32,490	Total	28,898
Africa	**Freq.**	**LAC**	**Freq.**
Botswana	993	Argentina	944
Burkina Faso	981	Bolivia	929
Cameroon	1194	Brazil	982
Central African Rep.	981	Chile	924
Chad	980	Colombia	937
Kenya	969	Costa Rica	924
Liberia	986	Dominican Republic	939
Mali	990	El Salvador	916
Niger	998	Haiti	291

(continued)

Table 3.7 (continued)

Nigeria	995	Honduras	856
Senegal	997	Panama	857
Sierra Leone	953	Paraguay	950
South Africa	986	Peru	885
Tanzania	994	Uruguay	871
Uganda	976	Total	12,205
Zimbabwe	975		
Total	15,948		
Northern America	**Freq.**	**Oceania**	**Freq.**
Canada	982	Australia	978
United States	971	New Zealand	716
Total	1953	Total	1694

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