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RESEARCH PAPER

Domestic and international migration intentions in response to environmental stress: A global cross-country analysis

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Abstract

In light of increasing environmental stress and its likely implications for migration patterns, we conduct a cross-country individual-level analysis of the impact of self-reported exposure to environmental stress on people's migration intentions and their destination choice. We simultaneously model intentions to migrate domestically and internationally for 90 countries worldwide in 2010. We find that self-reported exposure to environmental stress increases the probability to intend to migrate both domestically and internationally in the coming year. In absolute terms, the largest impact is obtained for domestic migration, but controlling for the fact that this is the most common form of migration anyway, environmental stress particularly raises intraregional migration intentions. Overall, the effects on migration intentions to the different destinations are strongest in low- and middle-income countries in Africa and Latin America and the Caribbean, while in high-income countries, and in Europe particularly, environmental stress appears to spur only domestic migration intentions.

Key words: Destination choice; domestic migration; international migration; migration intentions; self-reported environmental stress

JEL classification: F22; O13; O15; R23

1. Introduction

An annual average of 21.5 million people have fled their homes because of sudden weather-related onset hazards—such as floods, storms or wildfires—since 2008 [IDMC (2016)]. Thousands of others are forcibly displaced by slow-onset hazards, such as droughts, desertification or sea-level rise. 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 over 140 million people in sub-Saharan Africa, South Asia, and Latin America to migrate within their countries by 2050 [Rigaud *et al.* (2018)]. Forecasts generally vary from 25 million to 1 billion

environmental migrants by 2050, moving either domestically or internationally [IOM (2009)].[1]

Clearly, well-planned migration can form a successful strategy to cope with climate change when there is no credible long-term pathway to viable livelihoods.[2] Yet, given its potential development implications for both sending and destination regions, it is important that governments are able to anticipate the scale of the 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 reliance on a (very) coarse spatial and temporal aggregation of the data [e.g., Barrios et al. (2006); Dell *et al.* (2014); Beine and Parsons (2015); Desmet *et al.* (2015); Cattaneo and Peri (2016)]. This paper contributes to our understanding of environmental migration patterns across countries.[3] Specifically, we draw on the unique Gallup World Polls (GWP henceforth) to conduct a cross-country individual-level analysis of the impact of self-reported environmental stress on people's migration intentions and destination choice.[4]

A rapidly growing body of literature in economics and other social sciences has looked into the impact of environmental factors on migration. Recent empirical analyses have been facilitated by the growing availability of data on environmental stress and human mobility needed to investigate the complex nexus between these two phenomena [Beine and Jeusette (2018)]. There is, however, no consensus on the effect of environmental factors on migration. A series of recent literature reviews report a significant diversity in terms of outcomes, going from (i) increased mobility over (ii) no effect at all to even (iii) a reduction in human mobility leaving people

[1]Already in 1990, the Intergovernmental Panel on Climate Change (IPCC) put forward human migration as the greatest impact of climate change. Early predictions of the number of climate refugees ranged between 10 and 25 million [Ionesco *et al.* (2016)]. In 1989 the United Nations Environment Programme (UNEP) predicted 50 million people to be displaced by 2010. Even larger numbers ranging between 150 and 300 million by 2050 were predicted by Myers (2002) and Aid ((2007). However, all these numbers are rough estimates rather than the result of reproducible scientific methods [Gemenne (2011)].

[2]Importantly, migration is only one of many potential adaptation measures to climate change. Cattaneo *et al.* (2019), for instance, highlight on-farm adaptation, reliance on informal credit and social protection policies as potential ways to adapt to climate change, while Delaporte and Maurel (2018) find changing the amount of land under production, changing the pattern of crop consumption, changing the field location or seeking off farm employment for rural households to be other adaptation measures for rural households in Bangladesh.

[3]We follow the International Organization for Migration (IOM) definition of an *environmental migrant*, which reads: "Environmental migrants are persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad." In this light, *climate migrants* can be considered a subset of environmental migrants who—e.g., according to the Global Governance House's definition—were forced to flee "due to sudden or gradual alterations in the natural environment related to at least one of three impacts of climate change: sea level rise, extreme weather events, and drought and water scarcity."

[4]Our indicator of self-reported environmental stress captures whether people have experienced severe environmental problems (e.g., pollution, floods, droughts, or long periods of extreme heat or cold) in their city or area during the 12 months preceding the date of the interview. It covers experience with a wide variety of both slow and sudden onset environmental hazards. More information is provided in section 3.2 below.

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unable to move, trapped in increasingly unviable areas [Piguet (2010); Millock (2015); Berlemann and Steinhardt (2017); Beine and Jeusette (2018); Cattaneo *et al.* (2019)].

Key in this lack of consensus is the large variety of adopted methodologies [Berlemann and Steinhardt (2017); Beine and Jeusette (2018)]. The estimated impact of climatic factors on migration is found to crucially depend on the type of data that is used (micro vs. macro), each of which come with their own limitations. Micro-level studies, which typically rely on country-specific individual-level survey data, often document only a single event (e.g., a hurricane, drought, flood) in which case it is hard to disentangle environmental stress from other contextual effects. Cross-country macro studies, alternatively, cannot account for the local character of environmental stress, i.e., nothing guarantees that people who emigrated from a country or area under environmental stress were actually subject to it.

Also, the type of migration that is considered makes a big difference. Empirical research provides rich evidence for the impact of environmental factors on domestic migration [see e.g., Barrios et al. (2006); Marchiori *et al.* (2012); Strobl and Valfort (2013); Robalino *et al.* (2015); Mastrorillo et al. (2016); Dallmann and Millock (2017)], but evidence on the relationship with international migration is surprisingly scarce despite the disproportional amount of attention it has received in the literature. Micro studies relying on individual sample surveys typically document no rise in international emigration in response to environmental stress [Piguet (2010)], while recent macro contributions using cross-country panels produce conflicting results. Cai *et al.* (2016), for instance, find that long-term warming induces out-migration only in agricultural-dependent countries, while Cattaneo and Peri (2016) conclude that it reduces migration in extremely poor countries, which are exactly the ones likely to depend strongly on agriculture. Beine and Parsons (2015) uncover no direct impact of long-run climatic factors on international migration whatsoever, only indirect effects operating through wages. Furthermore, as pointed out by Millock (2015), only a few macro studies separate the type of migration response by distinguishing local and international migration. Those who do, nonetheless, confirm that the migration response to environmental conditions is heterogeneous depending on the type of the move, with larger effects obtained for domestic than for international migration [see e.g., Gray (2009), or Gray and Bilsborrow (2013), for the case of Ecuador; or Gray and Mueller (2012b), for the case of Bangladesh; or Cattaneo and Peri (2016), who show that domestic migration is more common in low-income countries using data from 116 countries between 1960 and 2000].

Furthermore, findings vary with the migration measure (flows vs. stocks), the type of climatic factors (e.g., sudden vs. slow onset, or rainfall vs. temperature), the sample under consideration (geographical region, time period), as well as the estimation strategy. Yet, as the costs of migration and other sorts of adaptation considerably differ across regions and countries, we do not expect to find the same effects and patterns in all parts of the world. Beine and Jeusette (2018) indicate that the effect of climatic shocks on the propensity to move might depend on the level of development [see also Cattaneo and Peri (2016)], the type of economic activity [Cai *et al.* (2016)], available adaptation mechanisms and external options. Berlemann and Steinhardt (2017) also add that formal (e.g., labor market) and informal institutions (e.g., religion, marriage habits, etc.) can have important effects on the magnitude and pattern of environmental migration.

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Our study goes beyond the state of the art by exploiting an innovative source of individual-level data, the GWP, which provide information on people's stated migration intentions and their self-reported exposure to environmental stress for a large number of countries. This allows for a comprehensive micro-level analysis in which structural regional differences can be isolated from those related to the chosen research design [the ideal methodological setup put forward by Berlemann and Steinhardt (2017)]. Specifically, we draw on 76,484 observations obtained from surveys conducted in 90 countries in the year 2010 to analyse to what extent environmental factors affect people's stated migration intentions (i.e., whether they intend to move away within the next 12 months) and their destination choice (i.e., migrate domestically, intraregionally, or towards the The Organisation for Economic Co-operation and Development (OECD)).[5]

Our analysis improves on the existing literature in the following ways. First, the cross-country comparable individual-level GWP allow to bridge the gap between micro-level and macro-level studies, thereby avoiding the data limitations plaguing both approaches outlined above. Second, we model migration intentions rather than actual migration. Admittedly, the degree to which migration intentions actually signal a person's migration plans as opposed to pure wishful thinking forms a topic of ongoing discussion in the literature [van Dalen and Henkens (2008); Manchin *et al.* (2014)]. Importantly, the intentions to migrate, which our empirical analysis relies on, are stricter than pure migration considerations as used by e.g., Creighton (2013). Whereas the latter considers whether the respondent has thought about moving outside the locality or community where he or she lives in the future, the GWP use a stronger formulation which directly asks for the likely response under ideal conditions [Manchin and Orazbayev (2018); Ruyssen and Salomone (2018)] (see section 3.1 for more details). Moreover, migration intentions have been shown as good predictors of future actual migration [see e.g., Docquier et al. (2014); Ruyssen and Salomone (2018); Bertoli *et al.* (2019), forthcoming], but understanding the formation of these intentions is important in its own right as it permits an assessment of the migration propensities for a representative set of individuals in each of the countries studied which may hence contribute to our comprehension of migrant selection and possible future migration dynamics. Third, we consider both domestic and international migration behavior in the same model and explore which factors (household income, family composition, region of residence, etc.) determine the choice of destination. As indicated above, domestic and international migrations are usually examined separately and recent cross-country studies on the climate-migration nexus have focused mainly on the latter because comparable figures on domestic migrations are scarce and hard to construct [see Bell and Muhidin (2009), for a discussion]. Yet, as the number of domestic migrants worldwide is roughly three times that of international migrants [IOM (2015)], such an omission might be quite serious [Dustmann and Okatenko (2014)]. Making a distinction between domestic, intraregional, and OECD migration is, nonetheless,

[5]Domestic migration is defined as migration within a countrys' national borders, while international migration is decomposed into migration within subcontinents (denoted as "intraregional" in the paper) following the UN DESA Population Division classification of countries (used among others in the International Migrant Stock database), and migration towards OECD countries (to the extent that these are not part of the same subcontinental region). For a full list of (sub)continental regions and the countries falling within each of them, see Table A1.

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valuable for policy interventions. As put forward by Berlemann and Steinhardt (2017), climate-induced international migration could, among others, intensify the brain drain, while domestic migration might bring about social and ethnic conflicts. Understanding how climate change induces domestic and international migration flows is hence important for policymakers in sending countries, but it is equally relevant for policymakers in destination countries. As migration dynamics typically lie beyond the full control of national authorities, cooperation between countries to manage these flows and reduce global inequality is essential. Yet, the optimal policy response depends on expected migration dynamics: (i) in countries where internal migration is the most prevalent, sustaining urban development (SDG11) is key; (ii) in countries where short-distance international migration is frequent, regional integration is desirable; and (iii) in countries with high rates of long-distance migration, partnership with OECD countries is advisable.

Our estimation results indicate that self-reported exposure to environmental stress is associated with a higher probability of intending to migrate within the next 12 months both within and across national borders. We find a significant positive impact of self-reported environmental stress on migration intentions towards all three destination types (domestic, intraregional, and towards the OECD) though the effect is most pronounced for intending to migrate intraregionally. In fact, the increase in the probability of intending to migrate due to environmental stress is largest for domestic migration (in absolute terms), but correcting for the fact that this is by far the most common form of migration, this is a smaller change than that obtained for intraregional migration (in relative terms). Throughout the paper, we report relative effects as brought forth by relative risk ratios.

A more detailed picture arises when we rerun our benchmark specification on modified samples depending on individual and country characteristics. Our results indicate that domestic migration intentions in the face of environmental stress are higher for high skilled individuals living in urban areas with a higher household income per capita, while low skilled individuals living in rural areas with lower household income per capita are more inclined to respond to environmental stress by moving intraregionally. This is especially true for respondents residing in rural areas in developing regions Africa, Asia, and Latin America and the Caribbean, for whom intraregional migration consistently makes up the most likely migration response to environmental stress. This could be explained by the fact that individuals with low education in rural areas are likely to obtain their income from agriculture, which is probably the most vulnerable sector to the implications of global warming and environmental hazards in general. Given that environmental conditions in nearby areas are likely to be strongly correlated, the optimal coping strategy for these individuals concerns longer-distance (cross-border) migration to escape these harsh local conditions, though these movements typically occur within the same subcontinent. Intentions to migrate towards the OECD following environmental stress are, in contrast, particularly larger among the high skilled living in urban areas with a relatively high household income per capita. Furthermore, they do not seem to respond to environmental stress in Africa and Asia, but the likelihood to intend to migrate towards the OECD is significantly higher for those having experienced environmental stress in Latin America and the Caribbean. A breakdown by countries' development level, finally, reveals that in low- and middle-income countries, environmental stress primarily leads to more intraregional migration, while

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in high-income countries, and in Europe in particular, it seems to foster only domestic migration intentions.

The rest of the paper is structured as follows. Section 2 describes the various strands of literature to which our paper is related. Section 3 discusses the data that we use in the empirical analysis and provides descriptive statistics on migration intentions as well as exposure to environmental stress. Section 4 provides the theoretical foundations for our empirical analysis. Section 5 describes the econometric analysis and estimation results. Section 6 concludes.

2. Related literature

A rapidly growing body of literature empirically analyses the relationship between environmental factors and human migration. Climate has been shown to interact and work on migration behavior through a variety of direct and indirect transmission channels, including through income [Beine and Parsons (2015); Coniglio and Pesce (2015); Cattaneo and Peri (2016)], crop production and subsequent food security [Gray and Mueller (2012b); Cai *et al.* (2016); Jacobson *et al.* (2019)], amenities [Marchiori *et al.* (2012)], urbanisation [Marchiori et al. (2012); Maurel and Tuccio (2016)] and violence [Abel *et al.* (2019)].[6] Recent empirical analyses have, in particular, been facilitated by the growing availability of data on climatic factors and human mobility needed to investigate the complex nexus between these two phenomena [Berlemann and Steinhardt (2017)]. Despite these efforts, there is, however, no clear consensus on the role played by environmental factors in determining global migration. This is reflected in a series of recent literature reviews reporting a significant diversity in terms of outcomes. A priori, the impact of climate factors on migration is indeed ambiguous: there is, for instance, strong evidence for a negative impact of climate change on income, particularly from agriculture, which increases incentives to migrate but also limits the ability to do so.

The diversity in outcomes is hence not surprising, given the widely varying research methodologies used and the many different contexts in which the climate-migration nexus has been studied. First, while all regions worldwide might be vulnerable to climate change, there is no reason to expect a uniform migration response to environmental stress across regions. 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 [see e.g., Henry et al. (2004); Marchiori *et al.* (2012); Gray and Mueller (2012a); Strobl and Valfort (2013); Kubik and Maurel (2016)]. Yet, Asia is the continent experiencing more natural hazards than any other region [IDMC (2016)]; and also in Latin America, the number of people affected by natural disasters, such as flooding, forest fires, and tropical storms, is not to be underestimated [Robalino et al. (2015); IDMC (2016)]. These events might all spur human mobility, both within and across borders, but research on the effects of climate change on migration in Asia and Latin America is much more scarce. The results for the African case can, however, not simply be generalised to other (developing) regions given its quite particular geographical, socioeconomic, and political context. Furthermore, Piguet *et al.* (2018), while analysing the geography of research on environmental migration, critically highlight

[6]For a comprehensive overview of channels through which environmental factors influence migration behavior, see Bekaert *et al.* (2020).

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a disproportional presence of research focus on the Global South. This is maybe not surprising as developing countries are also likely to suffer disproportionally [IPCC (2014)]. Yet, climate change is a universal challenge, such that Northern countries should not be overlooked in an analysis of the environment-migration nexus [Piguet *et al.* (2018)].

Second, comparison and generalisation of results are further hampered by differences in the chosen research methodology across studies. In general, a distinction can be made between case studies and cross-country studies, both of which come with specific advantages and disadvantages [Piguet (2010)]. Micro-level case studies mostly analyse the migration response to a specific shock (e.g., a drought, flood, cyclone, landslide, etc.) in one particular country. They typically do better than cross-country studies in accurately identifying the subpopulation that was effectively exposed to climate shock.

Many case studies provide evidence for environmental stress leading to direct, short-term, short-distance domestic migration, sometimes in the form of (planned) evacuations [Berlemann and Steinhardt (2017); Cattaneo *et al.* (2019)]. This was for example the case when Hurricane Katrina made landfall in the US 100,000 to 150,000 people were evacuated to Houston, Texas [McIntosh (2008)]. Furthermore, adverse environmental stress is often found to result in more permanent rural-urban migration movements (i.e., a so-called urbanisation channel). Gröger and Zylberberg (2016), for instance, find evidence for labor migration towards urban areas after a typhoon in Vietnam. Robalino *et al.* (2015) find evidence of such rural-urban movements in response to hydro-meteorological events (such as storms, floods, rainfall, strong winds, etc.) in Costa Rica, but only for less severe hydro-meteorological events, while more severe events resulting in loss of lives decrease migration towards urban areas. Also, Dillon *et al.* (2011) find increasing temperatures in Northern Nigeria to affect agricultural income, in turn, driving migration towards urban areas. But movements are not always directed towards urban areas. For example, Dallmann and Millock (2017) analyse the effect of climate variability on actual flows of domestic migration in India and find drought frequency to have the strongest impact on rural–rural interstate migration. A variety of other case-studies confirm environmental stress to negatively affect populations in rural areas, thereby increasing domestic mobility.[7] Also Bohra-Mishra *et al.* (2017) find the impact of temperature and typhoons in the Philippines stronger in rural areas. Zander *et al.* (2019), however, emphasise environmental stress (in the form of individual perceptions of heat stress) also having significant impacts on urban populations, thereby stressing the need for further research to not only focus on rural areas but to also consider urban–urban movements. Other case studies, however, find no or only modest effects of environmental stress on migration [see for instance Gray and Mueller (2012b); Mueller *et al.* (2014), for the case of flooding in rural Bangladesh and Pakistan, respectively]. Yet others find the impact to be negative. Koubi *et al.* (2016a), by using individual perceptions of different types of

[7]Gray and Mueller (2012a), for instance, find evidence for droughts (on the basis of both actual and self-reported data) to impact mobility in rural Ethiopian highlands; Mueller *et al.* (2014), by using both actual and self-reported data, find a robust impact of heat stress on long-term migration in rural Pakistan; Henry *et al.* (2004) find rainfall deficits leading to migration towards other rural areas in Burkina Faso, and Kubik and Maurel (2016) investigate the indirect agricultural channel through which weather shocks impact internal migration in rural Tanzania.

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environmental stressors, for instance, find droughts in Vietnam to significantly decrease the likelihood of migration [see also Gray and Bilsborrow (2013), for the case of rural Ecuador], while floods seem to increase this likelihood. Possible reasons for the lack of a significant positive effect put forward in the literature include the provision of post-disaster aid [Paul (2005); Boustan *et al.* (2012)], an increased demand for labor in reconstruction affected areas and the destruction of infrastructure which leads to impoverishment or increased migration costs [Millock (2015)].

In general, case studies focus primarily on domestic (rural–urban) migration movements, thereby ignoring cross-border migration [Cattaneo *et al.* (2019)].[8] Furthermore, the particular event that is being studied is usually very local and time-specific which hampers comparison of results across studies and possibilities to draw overall conclusions [Piguet (2010); Bertoli *et al.* (2019)]. An important advantage of these studies, however, is that they allow to explore individual heterogeneity in migration decisions depending on age, gender, level of education, wealth, etc. [Black *et al.* (2011b)]. Bohra-Mishra *et al.* (2017), for instance, find a stronger migration response to climatic factors in the Philippines for males, more educated and younger individuals. Also, Mueller *et al.* (2014) find a slightly higher response for men compared to women in rural Pakistan [see also Thiede et al. (2016); Baez *et al.*, (2017a, 2017b), for the case of South America].[9] Mastrorillo *et al.* (2016) find a stronger impact from environmental stress on domestic migration in South Africa for black and poorer migrants than for white and richer individuals.

Cross-country studies, on the other hand, typically consider a larger group of countries and time span, which allows to estimate the overall impact of climate change on migration for the countries under study (as well as to explore heterogeneous effects across groups of countries). Recent cross-country studies produce conflicting results on the macro-relationship between environmental stress and international migration. The findings vary from finding direct effects of environmental stress on international migration towards the European Union [Missirian and Schlenker (2017)] and towards the OECD [Drabo and Mbaye (2015); Coniglio and Pesce (2015); Wesselbaum and Aburn (2019)], to find little to no direct effect [Naudé (2010); Ruyssen and Rayp (2014); Beine and Parsons (2015); Cattaneo and Peri (2016); Gröschl and Steinwachs (2017)]; or finding evidence for indirect effects working for example through (agricultural) income [Beine and Parsons (2015); Coniglio and Pesce (2015); Cattaneo and Peri (2016)] or increased urbanisation [Marchiori et al. (2012); Maurel and Tuccio (2016)].

An important advantage of cross-country studies is that they allow to explore heterogeneity in the migration response across countries. The migration response to environmental stress has been shown to depend on countries' development level [Cattaneo and Peri (2016); Gröschl and Steinwachs (2017); Beine and Parsons (2017)] and their agricultural dependence or main type of economic activity [Marchiori et al. (2012); Cai *et al.* (2016); Falco *et al.* (2018)]. Cai *et al.* (2016), for instance, contrast the absence of any direct effect studied by Beine and Parsons (2015) and do find direct effects between temperature and international migration,

[8]Feng *et al.* (2010) do find variations in the environment to strain agricultural yields in Mexico, which seems to be driving international migration towards the USA.

[9]Note that although men are known to be more mobile, women are likely to be disproportionally affected by environmental stress, as they tend to be poorer, less educated, and have less ownership rights over resources (Chindarkar, 2012).

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but only in the most agriculture-dependent countries. In contrast, Cattaneo and Peri (2016) find only increased outmigration rates in middle-income countries, together with a reduction in the probability of migration in poor economies (whose economy typically heavily relies on agriculture) [see also Beine and Parsons (2017)].

Yet, these cross-country studies rely on the assumption that every resident of a country is affected by environmental factors in the same way, and they typically focus only on international migration, thereby ignoring domestic population movements.[10] Reliable comparisons of domestic migration across countries is, however, challenging due to the widespread variation in data collection practices of migration [Bell *et al.* (2015)]. Moreover, as pointed out by Findlay (2011), little attention has been paid to where migrants might move to in response to environmental stress. Nonetheless, accounting for both domestic and international movements in the same study and accounting for environmental migrant's destination choice would improve our understanding of the heterogeneity of migration responses [Cattaneo *et al.* (2019)]. Furthermore, both case studies and cross-country studies mostly look either into the impact of slow or sudden onset hazards. Studies that do account for both types of hazards report conflicting results. Mueller *et al.* (2014), for instance, find heat stress in Pakistan (on the basis of both actual and self-reported data) to raise migration, but cannot find evidence for an increased migration response to high rainfall, flooding or moisture. In contrast, Koubi *et al.* (2016a) find individual perceptions of sudden environmental stress (such as floods and typhoons) to increase the likelihood of migration in Vietnam, while longer-term environmental stress (such as drought or salinity) reduces the likelihood of moving.

In addition, a growing number of studies makes use of self-reported exposure to environmental stress, emphasising the importance of understanding individual perceptions to explain their likely change in behavior in the face of environmental change [Martin et al. (2014); Koubi *et al.* (2016a, 2016b); Parsons (2019); Zander *et al.* (2019)]. In that light, Koubi *et al.* (2016b) argue that "*perceptions of risk can act as a mediating factor between environmental stress and migration [Meze-Hausken (2008); Black et al. (2011a, 2011b); Hunteretal. (2015)]. The reason is that environmental perception is the means by which individuals seek to understand their environment in order to arrive at the most effective response to environmental hazards given their individual and household level circumstances.*" Also, Parsons (2019) explicitly states that a focus on how the climate is experienced brings meaning to mobility as no two people experience climate change in the same manner due to a variety of objective (i.e., economy, demography, etc.) and subjective realities (norms, emotions, and culture). Understanding individual environmental experience and perceptions can thus help explain migratory movements in response to these changes. Koubi *et al.* (2016b), for instance, examine whether and how individual perceptions of different types of environmental events (i.e., sudden and slow-onset) affect migration decisions in Vietnam and find that migrants perceive slow environmental events, such as droughts, as more extreme compared to non-migrants, while non-migrants perceive sudden and short-term environmental events (floods and hurricanes) as more extreme. Zander *et al.* (2019) investigate the influence of self-reported heat stress on migration intentions among urban populations in three

[10]A few exceptions considering both international and domestic migration concern the analyses by Gray (2009), Gray and Mueller (2012b), Gray and Bilsborrow (2013) and Cattaneo and Peri (2016).

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South-East Asian countries (Indonesia, Malaysia, and the Philippines). Their results indicate that individuals reporting hot temperatures (whether respondents ever felt stressed by heat) are more likely to intend to migrate, with women, older and richer individuals showing the strongest intentions to move.

In addition, an expanding body of literature has empirically explored the drivers of migration intentions [see among others Jónsson (2008); Drinkwater and Ingram (2009); Becerra (2012); Creighton (2013); Carling and Collins (2018); Carling and Schewel (2018)], some of which in a cross-country framework, relying on the GWP. Dustmann and Okatenko (2014) for instance, look into the role of wealth constraints and the quality of local amenities in migration decisions in sub-Saharan Africa, Asia, and Latin America. Docquier *et al.* (2014), disentangle the role of macroeconomic determinants of migration intentions aggregated at the country level, as well as the probability that these intentions translate into actual migration. Dao *et al.* (2018) also make use of aggregated international migration intentions as well as realisation rates by education level to examine the microeconomic and macroeconomic drivers of the relationship between emigration rates and economic development. Moreover, Docquier *et al.* (2015), Docquier and Machado (2016) and Delogu *et al.* (2018) use the GWP data to proxy the number of potential migrants who could respond to removal of legal restrictions on migration. Manchin and Orazbayev (2018) and Bertoli and Ruyssen (2018) quantify the effect of migrant networks on migration intentions and on prospective migrants' destination choice, respectively. Ruyssen and Salomone (2018) track both women's migration desires as well as preparations they have already made to migrate within the next 12 months and disentangle how gender discrimination fosters or impedes female migration across countries. Docquier *et al.* (2020) investigate whether intended migrants from MENA countries self-select on cultural traits such as religiosity and gender attitudes. Friebel *et al.* (2018) study the elasticity of migration intentions to illegal moving costs, exploiting the demise of the Gaddafi regime in 2011, and the ensuing opening of the Libyan route to Europe as a quasi-natural experiment. Gubert and Senne (2016) consider information on individuals' plans to move within the next 12 months to explore the relative attractiveness of EU-countries as potential destinations. Finally, Bertoli *et al.* (2019) explore the role of weather shocks in six Western African countries at a relatively detailed level of spatial resolution. To the best of our knowledge, our paper is the first to look into the impact of self-reported exposure on environmental stress on intentions to migrate both domestically and internationally, that accounts also for regional variation in migration responses as well as diversity in the preferred destination across individuals.

3. Data and stylised facts

Our analysis rests on individual-level data from 90 countries where at least one Gallup World Poll has been conducted in the year 2010.[11] The surveys conducted by Gallup typically have a sample of around 1,000 randomly selected respondents per country, and 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 land-line.[12]

[11]For a description of the methodology and codebook, see Gallup (2016).

[12]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.

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The sampling frame represents the entire civilian, non-institutionalised population aged 15 and over covering the entire country including rural areas.[13] Our final sample contains 76,484 individuals at working age (i.e., between 15 and 60 years old) with valid 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 have been constructed.

3.1 Migration behavior

The GWP include several related questions on the intention to migrate. Following Manchin and Orazbayev (2018), we combine three consecutive questions to categorise respondents' short-run migration intentions: (Q1) "In the next 12 months, are you likely or unlikely to move away from the city or area where you live?"; (Q2) "Ideally, if you had the opportunity, would you like to move permanently to another country, or would you prefer to continue living in this country?"; and (Q3) "Are you planning to move permanently to another country in the next 12 months, or not?".[14]

The first question refers to a strong inclination to migrate within the next year regardless of destination. Both the phrase "likely to move" and the relatively short time window of 12 months within which any intended migration response is placed, make it likely that only individuals who have already developed concrete migration plans provide a positive answer to this question [Dustmann and Okatenko (2014)]. Also, the migration intentions depicted in the second question are stricter than mere migration considerations typically documented in other surveys [e.g., Creighton (2013); Dustmann and Okatenko (2014)] since they use a stronger formulation which directly asks for the likely response under ideal conditions [Manchin and Orazbayev (2018)]. The absence of a time frame, however, does not require any concrete migration plans to answer this question affirmatively, in contrast, to question (Q1), an element which has been proved important to guarantee accurate replies [see e.g., European European Commission (2010); Dustmann and Okatenko (2014)]. In order to identify people with strong intentions (concrete plans) to migrate in the short-run, we, therefore, combine questions (Q2) and (Q3).

In order to be able to compare these three questions, some further assumptions need to be made [see also Manchin and Orazbayev (2018)]. First, without imposing a constraint on the distance (domestic or international) or the length (temporary or permanent) of the move, question (Q1) elicits firmer intentions than question (Q2). The phrasing of question (Q1) is, nonetheless, much closer to that of question (Q3): both questions consider similar time periods during which the move should take place ("in the next 12 months") and ask for a relatively firm intention to migrate (there is no reference to ideal conditions or opportunities). A distinction that remains, however, is that question (Q3), just like question (Q2), asks for *permanent*

[13]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 [Gallup (2016)].

[14]The way in which this kind of questions is interpreted might vary across countries, as observed by Clemens and Pritchett (2016) who underline 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. For this reason, we only exploit within-country variation in the econometric analysis.

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migration plans only. This implies that for further comparisons, we need to assume that question (Q1) can be interpreted as asking about permanent moves too, which however does not seem implausible given the phrasing "likely to move *away*".[15,16]

Table 1 illustrates all possible combinations of replies to each of these three questions, the resulting migration status and the share of respondents in our sample that belongs to each category. A few things are worth mentioning. First, according to these figures, the share of people intending to move domestically in the next 12 months stands at 14.5% worldwide. Second, on average 2.4% of the respondents questioned worldwide in 2010 intended to migrate permanently abroad in the next 12 months, which is not too far from the overall actual flow of 3.2% documented in the year 2010 by the World Bank [World bank (2010)]. Third, the vast majority of the respondents, 83.1%, indicated not planning to move in the next 12 months.

These figures confirm the importance of national borders for migration. Domestic migration is likely to involve shorter travel distances and also cultural differences between the origin and destination location are probably more limited than in the case of international migration, implying lower monetary and psychological costs, which helps to explain the imbalance in migration intentions across domestic and international destinations. Importantly, as put forward by Beine and Parsons (2015), international migration does not always entail a move over long distances. They postulate that in regions with porous borders, such as Africa, it might be less costly to cross an international border than to migrate domestically over longer distances. Yet, on average, crossing an international border involves additional costs of obtaining passports and visas, so that in general this conjecture can be assumed to hold. The importance of borders was shown among others by Helliwell (1997), who finds that national borders play an even larger role in determining migration flows than they do to explain trade flows (a well-known fact in the trade literature). So even if individuals might want to move internationally (to an OECD country) in the face of environmental hazards, many of them lack the means to actually do so. Hence, if liquidity constraints are binding, individuals hit by environmental hazards may end up moving internally, a possibility which might be particularly relevant in developing countries where people are more likely to be financially constrained [Beine and Parsons (2015)].

Furthermore, for those respondents replying positively to question (Q3), there is the follow-up question (Q4) "To which country would you like to move?". The destination dimension allows us to identify prospective international migrants' preferred destination, which we will use to differentiate between intentions to migrate intraregionally, towards the OECD or elsewhere. We define intraregional migration as migration within the same subcontinent for which we rely on the country classification of the UN DESA Population Division (used among others in the International Migrant Stock database). Migration to the OECD concerns migration towards OECD countries outside the subcontinent in which the respondent resides.

[15]Note that the distinction between domestic and international migration is based on the destination where an individual plans to finally reside in 12 months time. This implies that we cannot exclude that an individual who we categorise as planning to migrate permanently abroad in the next 12 months will first move locally within his or her country.

[16]We are aware that current migrants might reply differently than natives to the questions posed above (they might for instance not consider returning to their home country as a permanent move abroad). Therefore, as a robustness check, we will rerun our benchmark model for natives only.

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Table 1. Categorisation of migration behavior (2010)

(Q1)	(Q2)	(Q3)	Migration status	Share (%)
Yes	Yes	Yes	Permanent international migrant in the next 12 m, among whom based on (Q4):	2.4
			- Intraregional	0.4
			- Towards OECD	1.5
			- Other country	0.4
		No	Domestic migrant in the next 12 m	14.5
	No	Not asked	Domestic migrant in the next 12 m	
No	Yes	Yes	Inconsistent	–
		No	Permanent international migrant beyond 12 m	–
	No	Not asked	Stayer	83.1

Notes: Authors' calculations based on the Gallup World Polls. *Share* denotes the share of respondents in our sample that belongs to each category. (Q1) "In the next 12 months, are you likely or unlikely to move away from the city or area where you live?"; (Q2) "Ideally, if you had the opportunity, would you like to move permanently to another country, or would you prefer to continue living in this country?"; (Q3) "Are you planning to move permanently to another country in the next 12 months, or not?"; and (Q4) "To which country would you like to move?".

Other destinations encompass non-OECD countries that are not part of the subcontinent in which the respondent resides. For a full list of (sub)continental regions and the countries falling within each of them, see Table A1.

A similar logic as above applies when distinguishing between intraregional vs. migration to OECD countries outside the respondent's subcontinent: for most countries (particularly those in developing regions), travel distance to OECD countries is much larger than to countries within the same subcontinental region, and also in terms of culture the latter countries probably are much more similar. Indeed, empirical evidence based on gravity-type studies shows that geographical distance between countries of origin and destination, as well as the presence of a common border, a common language and other shared characteristics of countries, form important determinants to explain bilateral migration flows [see Beine *et al.* (2016), for an overview].

The resulting number of observations in each category and the related shares are presented in Table 1. From the 2.3% of respondents intending to migrate permanently abroad in the next 12 months, about 1.5% has plans to move away towards the OECD and about 0.4% is planning to move intraregionally within the following 12 months. The relatively small share of intended intraregional migrants is the result of the rather small number of countries belonging to each subcontinent according to the UN DESA Population Division country classification. Larger figures would be obtained when regions would be defined more broadly (for instance at the continental level), but this would entail much larger travel distances and smaller cultural similarities within a region.

The share of respondents falling within each category varies considerably across regions and countries. Africa and Latin-America and the Caribbean proved to be the most mobile regions in our sample. Respectively 23.2% and 19.2% of respondents intend to migrate domestically in the next 12 months, compared to only 9.7% in

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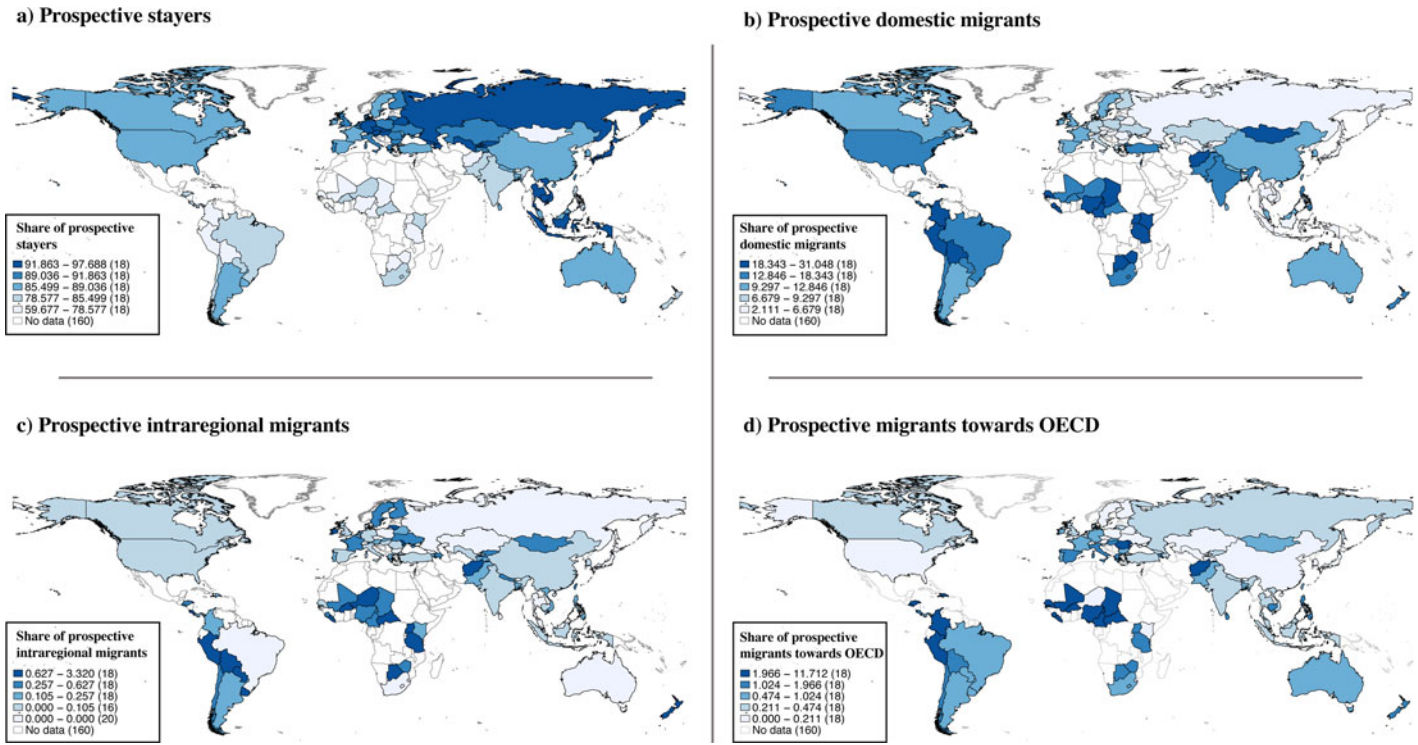

Figure 1. Share of respondents following their migration intentions by destination.
Notes: The maps report, for each country in our sample, the share of individuals interviewed in 2010 who intend to (a) stay in their current place of residence, (b) migrate domestically, (c) migrate intraregionally and (d) migrate towards the OECD within the next 12 months (based on the categorisation illustrated in Table 1). Darker colors are associated with a higher share of individuals in a country reporting to stay (panel a) or having plans to move (panels b, c and d), while lighter colors denote lower shares. Source: Authors' elaboration on the Gallup World Polls.

Europe, 11.6% in Asia, and 15.5% and 15.2% in North America and Oceania. Also, within regions, there is a large degree of variation in stated migration intentions, as can be seen in Figure 1 displaying country-specific shares of respondents falling within each category. Within Africa, e.g., we find the highest shares of respondents intending to migrate domestically in Liberia (31.0%), Botswana (31.0%), and Nigeria (29.6%), while they are much lower in Burkina Faso (14.9%), Mali and South-Africa (17.2 and 17.3%) (panel b). As far as international migration intentions are concerned, Africa and Latin America and Caribbean report a higher average share compared to the full sample, 5.5% (3.1%) of African (Latin American) respondents intend to migrate internationally, but only 3.6% (2.4%) is intending to move towards the OECD (panel d), respectively. The highest shares of respondents intending to move towards the OECD can be found in Senegal (with 11.7%), Haiti (8.9%), Liberia (8.1%), Sierra Leone (6.0%), and El Salvador (5.4%). Within Africa, Burkina Faso has the lowest share of domestic intending migrants, but the highest share of respondents intending to migrate intraregionally (panel c) standing at 3.3%, followed by Niger with 2.5%, which is greatly above the African average of 0.9%. Europe, Russia, and Asia seem to be the least mobile regions in our sample. Overall, more than 88.3% of European respondents intend to stay in their country, 93.5% in Russia, and 87.2% in Asia (panel a). Within the latter, only 2.1% of the respondents in Singapore, 4.2% in Kyrgyzstan, 5.4% in Vietnam, and about 6.3% in Japan are intending to move domestically (panel b). These latter figures are in vast contrast with the average of 14.5% of domestic migrants in our total sample.

3.2 Environmental stress

Information on individual self-reported exposure to environmental stress *(Environmental stress)* is extracted from the following question (Q5) available in the GWP: "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?". This question directly asks whether people have experienced extreme environmental stress during the past 12 months, covering a wide variety of both slow and sudden onset environmental threats. It takes the value one if question Q5 is answered affirmatively and zero otherwise.[17,18] On average, 37.5% of the respondents in our sample indicate having experienced environmental

[17]Note that the list of examples provided in the question refers not only to climate-related stress. 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 stress which could be both a cause (e.g., pollution) or a consequence (e.g., drought, flood, extreme weather) of climate change.

[18]The GWP contain also other questions related to the implications of global warming including "Over the past five years, would you say that the annual average temperatures in your local area have gotten warmer, colder, or stayed about the same?"; "Over the past 5 years, would you say the rainfall in your local area increased a great deal, increased a little, stayed about the same, decreased a little, or decreased a great deal?"; and "In the area where you currently live, would you say there has been enough rainfall for growing crops for people or livestock?". These questions were, however, asked only in a subset of the countries in our sample, thereby significantly reducing sample size and generalisability of the results. Therefore, we do not report estimates on the basis of these variables (though estimation results are available upon request).

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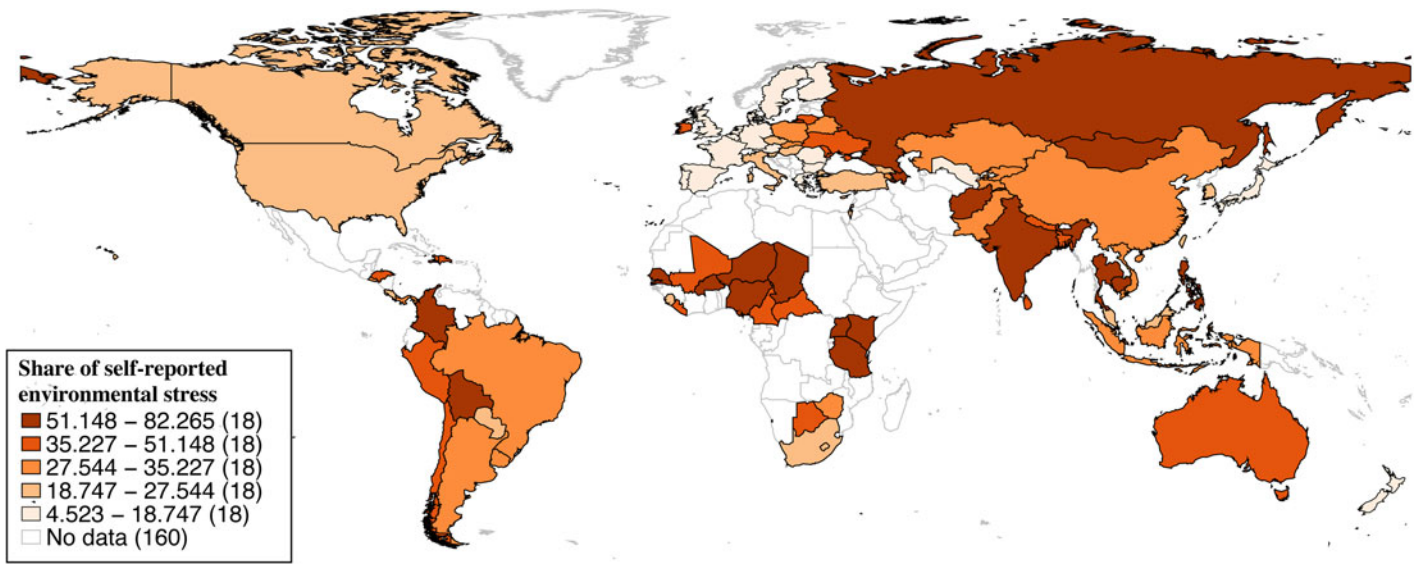

Figure 2. Share of respondents reporting environmental stress in their city or area in the past 12 months.
Notes: The map reports, for each country, the share of respondents reporting environmental stress in their city or area in the past 12 months. Darker colors are associated with a higher share of individuals in a country reporting environmental stress in the past 12 months in their city or area, while lighter colors denote lower shares. Source: Authors' elaboration on Gallup World Polls.

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stress in the last 12 months. Figure 2, plotting country-specific percentages of individuals reporting environmental stress in the past 12 months, indicates significant variety across countries and regions in our sample. The share of individuals having experienced environmental stress in the last year ranges from 4.5% to 6.5% in the Netherlands, Denmark, Japan, and Luxembourg to reaching over 80% in Burkina Faso and Chad (respectively, 82.3% and 81.1%), followed by Kenya (79.3%), Niger and Mongolia (both around 75%).

Bekaert *et al.* (2020) investigate what this measure of exposure to environmental stress exactly captures by computing pairwise correlations with other GWP individual climate indicators as well as external measures of environmental stress commonly used in the literature. Pairwise correlations with other individual indicators of environmental stress[19] from the GWP were all found to be positive and highly significant. The strongest correlation is obtained with indicators of a lack of water for growing crops and raising livestock. This seems to suggest that our key variable of interest primarily picks up exposure to water scarcity and its implications, stemming from drought.

In addition, the variable of interest is aggregated at country level (as the share of positive answers by country) and then correlated with objective indicators of the occurrence and intensity of natural disasters taken from the EM-DAT, provided by the Centre for Research on the Epidemiology of Disasters (CRED). The EM-DAT database contains disaster data disaggregated by disaster type (i.e., climatological, geophysical, meteorological, and hydrological disasters) collected from various sources. An event is classified as a disaster when at least one of the following criteria is met: ten or more people reported killed, 100 or more people reported affected, a declaration of a state of emergency or a call for international assistance. The correlations show that our question measuring exposure to environmental stress primarily picks up environmental stress related to drought, riverine floods, and cold waves, and to a lesser extent also fires and tropical cyclones.

Overall, it can be concluded that our GWP individual measure of environmental stress predominately picks up exposure to droughts and water scarcity which are said to "kill more people than any other single weather-related catastrophe" [United Nations Convention to Combat Desertification (2014)]. Correlations with external indicators are not perfect, though, reflecting various objective (related to the economy, demography, as well as individual characteristics) and subjective factors (norms, emotions, and culture) shaping people's self-reported experiences with environmental hazards [Parsons (2019)]. As argued by Parsons (2019), no two people experience climate change in the same manner such that a focus on how climate change is experienced brings meaning to mobility. Nonetheless, country-level variation in environmental stress—as would be picked up by objective indicators of the occurrence of environmental hazards—is largely controlled for through the inclusion of our country of origin fixed effects in our empirical specification.

[19]These are computed on the basis of the answers to the following questions: "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."; "[…] There is more extreme weather such as rain or wind storms now"; "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?"; and "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?"

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Table 2. Descriptive statistics following the migration categorisation

Variable	Overall	Stay	Domestic	Intraregional	OECD
Environmental stress	0.375	0.362	0.432	0.583	0.482
	(0.484)	(0.481)	(0.495)	(0.474)	(0.500)
Age	36.292	37.282	31.547	30.190	30.741
	(12.930)	(12.949)	(11.766)	(11.550)	(10.934)
Male	0.448	0.439	0.484	0.511	0.541
	(0.497)	(0.496)	(0.500)	(0.501)	(0.499)
Higher education	0.689	0.687	0.699	0.592	0.684
	(0.463)	(0.463)	(0.458)	(0.492)	(0.465)
Urban	0.394	0.390	0.406	0.332	0.530
	(0.489)	(0.488)	(0.491)	(0.472)	(0.499)
HH income pc (ln)	7.573	7.630	7.342	6.952	7.033
	(1.626)	(1.621)	(1.616)	(1.824)	(1.546)
Number of adults	3.281	3.237	3.419	3.710	4.043
	(2.040)	(2.025)	(2.022)	(2.413)	(2.515)
Number of children	1.427	1.369	1.632	2.381	2.171
	(1.919)	(1.852)	(2.074)	(2.996)	(2.746)
Network	0.301	0.281	0.357	0.674	0.661
	(0.459)	(0.450)	(0.479)	(0.470)	(0.474)
Observations	76,484	63,579	11,100	331	1,155

Notes: Authors' own calculations based on the Gallup World Polls. Standard deviations between brackets. *HH income pc (ln)* denotes the log of household income per capita.

3.3 Individual and household controls

Besides these key variables of interest, we also keep track of the additional individual- and household-level information contained in the GWP. Specifically, we record respondents' age *(Age)* and gender *(Male)* at the time of the interview, whether they are highly educated *(Higher education)* (i.e., have completed secondary education), whether they live in a rural or urban area *(Urban)* (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 distance-one connection abroad *(Network)* (i.e., relatives or friends who are living in another country whom they can count on to help them when needed). We also take into account the number of adults (aged 15 and above) in the household *(Number of adults)*, the number of children (below 15 years of age) in the household *(Number of children)* as well as the log of self-reported household income per capita *(HH income pc (ln))*. The econometric analysis is conducted on individuals at working age (i.e., between 15 and 60 years old).

Table 2 provides descriptive statistics for the variables used in our empirical analysis. As indicated above, 37.5% of respondents reports having experienced environmental stress in the past 12 months. The share of people answering positively to this question is considerably larger among those expressing an intention to migrate (particularly intraregionally). Furthermore, individuals in our sample are on average 36 years old, but those expressing an intention to migrate are considerably younger. The overall sample contains slightly more females, but men are more likely to state an intention to migrate (both domestically and internationally). Of the total, 68.9% of the individuals in our sample have completed secondary education; 39.4% of respondents live in an urban area. The average number of adults (aged 15 and over) and children (below 15) in the household respectively, stands at 3.3 and 1.4. Respondents in larger households are more likely to express intentions to move abroad, which probably signals the larger responsibilities and pressure on individuals having to support more dependents. Finally, 30% of respondents indicate having a network of family and friends living abroad, but this figure is more than twice as high among those who intend to migrate abroad.

4. Theoretical foundations

The model that we bring to the data to analyse the migration decision and the prospective migrant's destination choice is a random utility maximisation (RUM) model of migration. Consider an individual i, residing at time t in area r of country j; the choice set D of individual i includes his or her home area r (which we refer to as $k = 0$ without loss of generality), the rest of country, i.e., $R_j/\{r\}$ where R_j is the set of other areas in country j (we refer to this second alternative in the choice set as $k = 1$), the set $W/\{j\}$ of other countries within the same subcontinental region ($k = 2$), the set of OECD countries outside the subcontinental region where the respondent resides $O/\{j, W\}$ ($k = 3$), and the set of other countries in the world $E/\{j, W, O\}$ ($k = 4$). Thus, the choice set D includes five alternatives: staying at origin, moving domestically, migrating to an international destination within the same

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subcontinental region, migration towards an OECD country outside the subcontinental region, or migrating towards another international destination.

Let U_{ikt} denote the utility that individual i would derive if opting for alternative $k \in D$ at time t. We assume that this alternative-specific utility includes a deterministic component V_{ikt} and a stochastic component ϵ_{ikt}. If the stochastic component follows an independent and identically distributed Extreme Value Type 1 (EVT-1) distribution, then the probability p_{ikt} that $k \in D$ will be the utility-maximising alternative is given by:

$$p_{ikt} = \frac{e^{V_{ikt}}}{\sum_{l \in D} e^{V_{ilt}}} \tag{1}$$

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

$$\frac{p_{i1t}}{p_{i0t}} = e^{V_{i1t} - V_{i0t}} \tag{2}$$

The relative probability of migrating to destination $k = 2, 3, 4$ over staying at origin is given by:

$$\frac{p_{ikt}}{p_{i0t}} = e^{V_{ikt} - V_{i0t}} \tag{3}$$

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

$$\frac{p_{i1t} + p_{i2t} + p_{i3t} + p_{i4t}}{p_{i0t}} = \frac{e^{V_{i1t}} + e^{V_{i2t}} + e^{V_{i3t}} + e^{V_{i4t}}}{e^{V_{i0t}}} \tag{4}$$

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

We include in the estimation a vector of individual and household-level characteristics x_{it}. The elements included in the vector are: dummies for different age groups (i.e., 20–29, 30–39, 40–49, 50–60, with 15–19 representing the omitted category) *(Aged 20–29; Aged 30–39; Aged 40–49; Aged 50–60)*, a dummy for male individuals *(Male)*, a dummy for high-educated individuals (i.e., who have obtained a secondary education degree, equivalent to at least 9 years of education) *(Higher education)*, a dummy for individuals living in urban areas *(Urban)* (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 distance-one connection abroad *(Network)* (i.e., relatives or friends who are living in another country whom an individual can count on to help him or her when needed), the number of adults (aged 15 and above) in the household *(Number of adults)* and the number of children (below 15 years of age) in the household *(Number of children)* as well as the log of the self-reported household income per capita *(HH income pc (ln))*. We also include country of origin fixed effects to account for the

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fact that the migration behavior of people in the same country might be driven by common unobserved time-invariant factors.

This vector also includes a dummy for whether the individual has experienced any environmental stress in the past 12 months *(Environmental stress)*. If the coefficient $\hat{\beta}$ 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 $\hat{\beta}p_{ikt}(1-p_{ikt})$, with $k=1, 2, 3, 4$ depending on the choice of the dependent variable, while $\hat{\beta}$ 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 migration intentions is the following: if an individual considers moving to a neighboring area, then environmental factors at origin could be positively correlated with environmental factors at the destination, and this correlation confounds the effect of the estimated coefficient, possibly biasing it towards zero and reducing its statistical significance.[20] A further concern related to the data is that individuals might have moved between the occurrence of an extreme environmental shock and the date in which they are interviewed by Gallup. If individuals with the highest propensity to migrate abroad have already moved by the time of the survey, then we would be missing them entirely. If they moved domestically, they might still be included in the sample, but we would be incorrectly matching them to the wrong environmental conditions (the GWP do *not* provide information on the individual past migration history), i.e., those prevailing in the area to which they moved rather than in their home area.

5. Results

The following sections present multinomial logistic estimates of the impact of environmental stress on migration intentions and prospective migrants' destination choice. Staying in the current area of residence forms the base category on the basis of which relative probabilities are obtained. Each specification includes country of origin fixed effects. Standard errors are always clustered by countries of origin and robust to heteroskedasticity and serial correlation. The tables report exponentiated coefficients, which can be interpreted as relative risk ratios. The latter tells us how the relative probability of choosing destination k over staying changes if we increase a right-hand side variable by one unit, holding the other variables constant. Values greater than one indicate an increase in the likelihood of mobility, while coefficients smaller than one indicate that migration is less likely.[21]

5.1 Benchmark results

Table 3 (columns 1–3) presents multinomial logit estimates of the impact of the traditional controls and our variable of interest, i.e., having experienced

[20]Thus, when you have incentives to migrate, potential (domestic) destinations can look less attractive. This concern is much less pressing when we consider intentions to migrate abroad, as the attractiveness of foreign destinations should be largely unaffected by local environmental issues.

[21]We also report McFadden's pseudo R-squared. Because in regressions of categorical outcome variables, this statistic does not mean what R-square means in OLS regression (the proportion of variance for the response variable explained by the predictors), we suggest interpreting this statistic with great caution.

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Table 3. Impact of controls and self-reported environmental stress on migration intentions

	Controls			Environmental stress		
	Domestic	Intraregional	OECD	Domestic	Intraregional	OECD
Environmental stress				1.172***	1.776***	1.322***
				(2.70)	(4.41)	(3.55)
Aged 20–to 29	1.079**	1.199	1.376***	1.077**	1.189	1.372***
	(2.26)	(1.35)	(3.40)	(2.18)	(1.28)	(3.35)
Aged 30–39	0.703***	0.740*	0.858	0.701***	0.733*	0.851
	(−7.10)	(−1.66)	(−1.53)	(−7.08)	(−1.70)	(−1.60)
Aged 40–49	0.504***	0.408***	0.701***	0.502***	0.403***	0.694***
	(−9.76)	(−4.62)	(−2.92)	(−9.72)	(−4.69)	(−3.01)
Aged 50–60	0.368***	0.358***	0.411***	0.367***	0.355***	0.407***
	(−13.39)	(−3.85)	(−5.64)	(−13.34)	(−3.91)	(−5.71)
Male	1.133***	1.265*	1.364***	1.131***	1.257	1.359***
	(3.21)	(1.68)	(3.98)	(3.17)	(1.63)	(3.90)
Higher education	1.187***	0.920	1.239	1.184***	0.916	1.236
	(3.26)	(−0.54)	(1.61)	(3.22)	(−0.57)	(1.60)
Urban	1.081	1.064	1.975***	1.082	1.061	1.953***
	(1.53)	(0.44)	(7.25)	(1.53)	(0.44)	(7.33)
HH income pc (ln)	1.020	0.932	1.044	1.020	0.934	1.044
	(1.17)	(−1.01)	(1.08)	(1.15)	(−0.98)	(1.06)
Number of adults	0.988	0.959	1.025**	0.988	0.960	1.025**

	(−1.17)	(−1.00)	(2.34)	(−1.16)	(−0.97)	(2.39)
Number of children	0.989	1.034	1.003	1.012	1.030	1.001
	(−0.83)	(1.08)	(0.16)	(−0.93)	(0.95)	(0.05)
Network	1.344***	4.976***	4.096***	1.340***	4.927***	4.071***
	(8.85)	(9.98)	(12.37)	(8.75)	(9.79)	(12.25)
Pseudo R^2	0.104			0.105		
Observations	76,484			76,484		

Notes: The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and serial correlation and clustered across origins. *HH income pc (ln)* denotes the log of household income per capita.

environmental stress in the past 12 months (columns 4–6), on prospective migration behavior within the next 12 months. We differentiate between intentions to migrate domestically, intraregionally or towards the OECD.

In line with expectations, the likelihood to migrate is in general larger for younger and male individuals. This is also the case for respondents who have a friend or family member abroad whom they can count on if needed, especially for international migration (intraregional or towards the OECD) [in line with Bertoli and Ruyssen (2018); Manchin and Orazbayev (2018)]. Being highly educated (i.e., having completed at least secondary education) increases the relative likelihood of migrating domestically, while living in an urban area increases the relative likelihood of migration towards the OECD. Migration intentions towards the OECD also increase significantly with the number of adults present in a household. The latter might signal higher pressure on prospective migrants to cater to more dependents in the household, or lower budget constraints if more household members can contribute to cover the more costly migration towards the OECD. We obtain very similar results for these control variables when we introduce our variable of interest; and the impact of the controls is robust across different specifications. These controls are always included in the following regressions, but estimation coefficients will no longer be consistently reported to save space.

The last three columns of Table 3 highlight the results from our benchmark specification, which now includes also self-reported exposure to environmental stress in the past 12 months. Our estimates show that having experienced environmental stress (i.e., floods, droughts, or long periods of extreme heat or cold) during the year preceding the interview elevates migration intentions, and this towards each destination category (within the country, towards another country in the same subcontinental region and towards the OECD). The estimated relative risk ratio is highest for intraregional migration, which indicates that the difference in the relative probability of intending to move vs. stay for those having experienced environmental stress and those who have not is largest for intraregional migration.

It is interesting to compute also average marginal effects on the basis of these benchmark results (reported in Appendix Table A.2). These indicate that the probability of intending to migrate domestically is 1.7 percentage points higher for those who have experienced environmental stress in the past 12 months compared to those who have not (corresponding to a rise in the predicted probability from 13.84% to 15.55%), assuming all else equal. The probability of intending to move intraregionally or towards the OECD is, respectively, 0.2 and 0.3 percentage points larger for those stating having experienced environmental stress compared to those who state they did not (corresponding respectively to a rise in the predicted probability from 0.33% to 0.55% and from 1.37% to 1.70%), all else equal. Contrary to relative risk ratios, the marginal effect simply indicates by how many percentage points the risk of intending to migrate towards a certain destination increases or decreases (without a reference to a baseline). Yet, as indicated in Table 1, domestic migration is by far the most likely option for those expressing an intention to migrate in the next 12 months: 14.5% of respondents in our sample intends to migrate domestically in the next 12 months, far more than the 2.3% of respondents intending to migrate abroad in the next 12 months. Relative risk ratios have the advantage to control for this imbalance in migration intentions across the various destination categories (domestic, intraregional, and towards OECD countries). More precisely, RRR give an indication of the *relative* effect while marginal effects produce

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absolute effects. So, a 1.7 percentage point increase in domestic migration due to environmental stress is the highest absolute effect (just by virtue of being by far the most common form of migration, which makes this finding rather trivial), but compared to the migration that happens anyhow (the constant) this is a smaller change than that obtained for intraregional migration.

So in absolute terms, environmental stress particularly raises intentions to migrate domestically (which most people can indeed afford), confirming the assumption that migration costs increase with the distance migrated, and in line with the findings of other studies distinguishing between domestic and international migration in response to environmental conditions [see e.g., Gray (2009); Gray and Bilsborrow (2013); or Gray and Mueller (2012b)]. Yet, in relative terms, the highest impact is obtained for intraregional migration intentions. The latter seems to offer support for the point raised by Beine and Parsons (2015) with respect to international border crossing not always being the more costly option, especially in porous regions like Africa (which is also reflected in the relatively higher relative risk ratios reported for Africa in section 5.2.2) where the costs of crossing an international border might well be lower than domestic migration over longer distances. It could perhaps also indicate that intraregional migration offers a higher likelihood to escape particular forms of environmental stress hitting entire countries (for instance reduced precipitation or increased temperatures in arid or semi-arid countries) than domestic migration does, for those who can afford it. In terms of policy response, our results suggest that countries should primarily invest in sustaining urban development (given that in absolute numbers environmental stress will primarily increase domestic migration of which a large fraction probably involves movements from rural to urban areas) in combination with regional integration and cooperation (as in relative terms intraregional migration ensuing from environmental stress will become much more prevalent).

Nonetheless, these average marginal effects can be used to give some indication of the number of people who might additionally intend to migrate to the various destinations when exposed to environmental stress. To this end, we select from the UN World Population Prospects 2019 database the 2010 population aged 15–59 for the 90 countries in our sample, which is then multiplied with the various average marginal effects.[22] Our results suggest that environmental stress has spurred 62.51 million people to develop an intention to migrate domestically during the year after the interview, while it spurred respectively, 8.26 and 12.20 million people to develop an intention to migrate intraregionally and towards the OECD during the same period. Those are considerable numbers, and although our indicator of migration intentions captures firm intentions to migrate in the next 12 months rather than pure wishful thinking, not all intentions to migrate eventually materialised into actual migration.

Also, as argued by Cattaneo *et al.* (2019), these results should be viewed only as indications of ensuing migration rather than accurate predictions. The estimation results that we present are based on data for the year 2010. Over time, socioeconomic scenarios might change fast and drastically and people's migration decision "results from the interaction between climatic, economic, political, demographic, and social drivers" [Cattaneo *et al.* (2019), p. 5], introducing a great

[22]Note that our estimation sample also has respondents aged 60 but these do not appear in the age category 15–59 in the UN World Population Prospects 2019 database.

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deal of uncertainty in migration predictions. The figures obtained for the year 2010 can hence not be interpreted as average future annual effects. Nonetheless, despite these uncertainties, there is a high likelihood of increased migration occurring towards each destination in the face of environmental change [IPCC (2014)]. Our results clearly indicate that most environmentally-induced migration intentions concern domestic rather than international migration, thereby confirming previous findings in the literature on the differential impact by destination type and countering the public paradigm that exists around climate change giving rise to large scale permanent migration movements from poor vulnerable to rich countries in the next decades.

It is important to note that our benchmark results provide evidence for a *direct* effect of environmental stress on migration intentions, which is rather distinct from other cross-country studies in the literature documenting primarily indirect effects. Indeed, most cross-country studies relying on aggregate data have found indications for indirect effects rather than direct ones, but this is not the case in studies relying on individual-level data. Gray and Mueller (2012a), for instance, show that drought has important consequences for population mobility in rural highland Ethiopia, while Gray and Mueller (2012b) find a modest but positive direct effect of flooding on within-district mobility in Bangladesh, most visible at moderate intensities. Mastrorillo *et al.* (2016) find that an increase in positive temperature extremes as well as positive and negative excess rainfall at the origin act as a push effect increasing internal migration in South Africa. Furthermore, Dallmann and Millock (2017) find evidence for a direct effect of drought frequency on internal inter-state migration in India, even if they control for indirect channels (the impact on net state domestic product and the agricultural sector). Bohra-Mishra *et al.* (2017), finally, find evidence for both direct and indirect effects (through rice yields as a proxy for agricultural productivity) of a rise in temperature and increased typhoon activity on aggregate inter-provincial migration in the Philippines.

Similarly, to Dallmann and Millock (2017), we find evidence for a direct effect of environmental stress on migration intentions even if we control for a possible indirect effect through income. Indeed, household income per capita—which we include as a control variable—might have been affected by environmental stress experienced in the past 12 months. Interestingly, leaving out this variable from our benchmark specification [following e.g., Cattaneo and Peri (2016); Bertoli *et al.* (2019)] results in slightly larger relative risk ratios (see Appendix Table A.3, columns 4–6) compared to those obtained in our benchmark regression (columns 1–3), which could indeed be interpreted as an indication that environmental stress not only affects migration intentions directly but also indirectly through the income channel. In the remainder of the analysis, we continue to focus on the direct impact of environmental stress (abstracting from any potential indirect effects) and keep the variable household income per capita as a control.

Furthermore, we also explore how the inclusion of an indicator of the observed occurrence of environmental hazards (on the basis of EM-DAT) either replacing or complementing our self-reported variable of environmental stress alters the results. The full description of the procedure and results can be found in Appendix B. It is important to note that the country of origin fixed effects already pick up most of the effect of observed country-level environmental stress. Identification of a potential effect of such variables is hence severely restricted as it stems only from variation over time in the month in which the survey took place, and hence the exact 12

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months over which these actual measures of environmental stress were calculated. We can, nonetheless, safely conclude that the inclusion of these observed indicators of environmental stress does not affect our main result: the estimated coefficients for self-reported environmental stress all remain positive and highly significant, and are fairly similar to those obtained in the benchmark regression. This confirms the relevance of our indicator of self-reported environmental stress in determining migration intentions (for further details, see Appendix B).

5.2 Exploring heterogeneous migration responses

As highlighted in section 2, migration responses to environmental stress are likely to vary with country and individual characteristics. In what follows, we explore heterogeneous migration responses to environmental stress by rerunning our benchmark regressions on subsamples of respondents or countries.

5.2.1 Modified samples based on individual characteristics

Table 5 reports the results from rerunning our benchmark specification on subsamples of respondents along various individual traits. First, our sample includes not only natives but also previously arrived immigrants residing in the country, which could introduce measurement error. Some of the foreign respondents might be temporary migrants, who plan to return to their country of origin, or transit migrants who plan to move to another country in the (near) future. Former migrants might be more likely to migrate again and could hence exhibit different migration behavior than natives. To mitigate this concern, we limit our sample to natives only (column 1) and find very similar results to those obtained on the full sample.

Second, to allow for a heterogeneous migration response to environmental change by education level, we distinguish between high skilled (i.e., those having completed secondary education) (column 2) and low skilled individuals (i.e., those who only completed elementary education or less) (column 3). For high skilled individuals, the relative risk ratio of intending to migrate intraregionally following environmental stress is slightly larger than in the overall sample. High skilled respondents are thus relatively more likely to intend to migrate intraregionally in the face of environmental stress, while the estimated effects for domestic and OECD migration intentions are quite similar to the those obtained on the entire sample.[23] When restricting the sample to individuals who completed only primary education or less, there is a stronger tendency for intraregional migration than in the overall sample, while environmental stress does not increase the probability that primary educated individuals opt for domestic migration over staying.[24]

[23]Note that when we re-estimate our multinomial logit model on subsamples of observations (defined, for instance, on the basis of the level of education), we obtain a partition of the sample of often markedly different size. This, in turn, entails that (simply because of statistical power) the odds of finding a significant effect of environmental stress on, say, low skilled individuals, are smaller than the odds of finding a significant effect for high skilled individuals or for the entire sample. This matters also for subsamples on the basis of other individual or country characteristics.

[24]Note that the lack of a significant effect for the low skilled cannot be explained by a lower reporting of exposure to environmental stress. In fact, low skilled respondents are relatively more likely to indicate having experienced environmental stress than high skilled respondents, and this is even more outspoken for low skilled individuals in rural areas. Respondents from poor households are also much more likely to answer positively to this question (nearly 50% does so).

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The same holds for respondents living in rural areas (column 4) as well as when we select only low skilled individuals in rural areas (column 5). We expect individuals in rural areas (and especially the low skilled) to be more vulnerable to experiencing environmental stress (as they are more likely to depend on agricultural income), and this may have an impact on their intentions to move away. Somewhat surprisingly, (low skilled) individuals in rural areas are not more likely to migrate domestically in the face of environmental stress.[25] An explanation could be that nearby locations are likely to face similar environmental conditions, in which case migration towards such destinations is unattractive, and only migration towards more far-away destinations is worthwhile. The latter seems to be confirmed by the relative risk ratio for intraregional migration, which is larger than in the full sample. For respondents in urban areas (column 6), on the other hand, the probability of migrating over staying is always significantly larger among those having experienced environmental stress in the past 12 months; and more so than in the overall sample in terms of domestic and OECD migration.

Furthermore, when we restrict the sample only to female respondents (column 7), the size and significance of the effects are smaller than those in the overall sample. However self-reported exposure to environmental stress in the last 12 months appears as a robust determinant of migration intentions also for women.

Finally, we follow the literature and account for liquidity constraints potentially influencing migration intentions. Considering only the upper 20% richest respondents per country (in terms of household income per capita) (column 8) magnifies the effect of environmental problems on intentions to migrate across all types of destinations (though the level of significance seems to drop for international migration, potentially related to the sharp drop in sample size). In contrast, for the bottom 20% poorest respondents (column 9), self-reported exposure to environmental stress on domestic migration intentions is only significant at the 10% threshold, but the effect increases in size for intraregional migration intentions. Limiting the sample to low skilled respondents from poor households then confirms the previous findings for the (low skilled) individuals living in rural areas for whom we found only a significant increase in intraregional migration intentions following environmental stress.[26]

5.2.2 Modified samples based on development level and geographic region

The recent literature stresses the need for cross-country analyses of the environment-migration nexus that account for heterogeneity in migration responses across countries (as these allow to rule out differences in results stemming from methodological choices). In this section, we rerun our benchmark estimation on

[25]This result is explored more deeply in the following section.

[26]We are aware that self-reported household income—as in any survey—might be subject to measurement error. As an alternative, we also considered an indicator of household wealth à la Dustmann and Okatenko (2014). The latter is constructed as the first principal component computed through an origin-specific polychoric principal component analysis on four of the seven questions used by Dustmann and Okatenko (2014) that are available for all countries in our sample. The questions relate to (i) the ownership of a TV set, (ii) access to the Internet, to whether in the previous 12 months the respondent did not have enough money (iii) to buy food or (iv) to provide adequate shelter of housing to her family. Interacting our variable of interest with this wealth index, however, does not provide any additional insights, though our main results are unaffected by its inclusion.

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various subsamples of countries based on their development level (using the country income categorisation of the World Bank) and their geographic location.

Table 6 presents the results for the impact of self-reported exposure to environmental stress on migration intentions across four-country income groups, i.e., low-income countries (column 1), lower middle-income countries (column 2), upper middle-income countries (column 3) and high-income countries (column 4). The strongest relative risk ratio is found for intraregional migration intentions in upper middle-income countries: individuals reporting environmental stress in the past 12 months are 2.6 times more likely to intend to migrate intraregionally relative to staying than those who did not experience environmental stress in the past year. This effect is also strong in low-income countries; though in both low and upper middle-income countries environmental stress also positively influences the relative likelihood to migrate domestically and towards the OECD. For lower middle-income countries, we do not find very significant effects. Interestingly, in high-income countries, environmental stress seems to result only in higher intentions to migrate domestically, while it does not seem to spur people to migrate internationally. This could reflect the larger variety of alternative coping strategies available in rich countries, as well as the relatively lower exposure to the implications of global warming experienced so far (in comparison to developing countries which rely more heavily on agriculture and have disproportionally experienced extreme weather events). In any case, our findings confirm that the effect of environmental shocks on the propensity to move depends on a country's level of development as postulated by Beine and Jeusette (2018).

Table 4 shows the variation in results across different geographic regions. Our results present significant evidence for both Africa and Latin America and the Caribbean appearing as the most mobile regions. Especially the coefficient of intraregional migration intentions is substantially higher than in the full sample in both Africa and Latin America and the Caribbean; while the coefficient for migration intentions towards the OECD is considerably higher for Latin America and the Caribbean. In Europe, people are more likely to move within their own country, i.e., domestically, after experiencing environmental stress. In contrast, we do not find an impact of environmental stress on migration intentions in Asia and North-America and Oceania.[27] Also Afifi *et al.* (2016) did not find a clear link between rainfall variability and migration decisions in Thailand. An in-depth follow-up study revealed that this might have to do with the fact that many of the households (up to 50% in one of the study villages) received financial remittances which are mainly used to buy food and invest in their farms for agricultural diversification and to intensify production. The authors argue that qualitative interviews with the villagers have pointed out that "financial remittances of migrants are enabling them to enhance their scope of action in the context of economic and environmental risks and to strengthen their coping and adaptive capacities." Afifi *et al.* (2016, p. 259). Other reasons for the lack of a significant effect put forward in the literature include the provision of post-disaster aid [Paul (2005); Boustan *et al.* (2012)], an increased demand for labor in reconstruction affected areas and the destruction of infrastructure which leads to impoverishment or increased migration costs [Millock (2015)]. It is, however, hard to imagine that Asian individuals in general would not

[27]For the latter, this might have to do with the relatively low number of observations compared to that in the other subsamples.

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Table 4. Impact of self-reported environmental stress by geographic region

	Africa	LAC	Asia	Europe	North America/Oceania
Domestic					
Environmental stress	1.245**	1.286***	1.045	1.216***	1.097
	(2.38)	(3.28)	(0.32)	(4.19)	(1.11)
Intraregional					
Environmental stress	2.302***	2.835***	1.512	1.058	0.833
	(4.84)	(3.98)	(1.61)	(0.15)	(−0.31)
OECD					
Environmental stress	1.347***	1.655***	1.044	1.387	1.006
	(3.00)	(2.79)	(0.21)	(1.48)	(0.05)
Pseudo R^2	0.084	0.071	0.077	0.098	0.083
Observations	14,966	10,169	28,210	20,667	2,472

Notes: The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and serial correlation and clustered across origins.

Table 5. Impact of self-reported environmental stress by individual characteristics

	Natives	HS	LS	Rural	Rural LS	Urban	Female	Rich	Poor	Poor LS
Domestic										
Environmental stress	1.176***	1.172***	1.166	1.131	1.099	1.277***	1.135**	1.217***	1.194*	1.174
	(2.66)	(3.92)	(1.32)	(1.42)	(0.69)	(5.08)	(1.99)	(3.18)	(1.86)	(1.36)
Intraregional										
Environmental stress	1.703***	1.752***	1.831***	1.906***	1.873***	1.558**	1.438**	1.690*	2.107***	1.968***
	(3.86)	(3.26)	(3.54)	(3.93)	(3.21)	(2.04)	(2.18)	(1.74)	(3.28)	(3.02)
OECD										
Environmental stress	1.323***	1.305***	1.360**	1.200	1.271	1.507***	1.218*	1.476**	1.342**	1.385
	(3.45)	(2.88)	(2.12)	(1.23)	(1.03)	(3.60)	(1.71)	(2.07)	(2.03)	(1.37)
Pseudo R^2	0.107	0.111	0.114	0.111	0.112	0.116	0.111	0.108	0.114	0.115
Observations	73,381	52,693	23,791	46,345	18,093	30,139	34,270	18,142	16,623	10,403

Notes: The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *HS* and *LS* denote high and low skilled respondents, respectively. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and serial correlation and clustered across origins.

Table 6. Impact of self-reported environmental stress by development level

	L	LM	UM	H
Domestic				
Environmental stress	1.203*	1.092	1.147**	1.292***
	(1.86)	(0.58)	(2.31)	(4.48)
Intraregional				
Environmental stress	2.118***	1.248	2.642***	1.288
	(4.26)	(0.56)	(6.52)	(0.79)
OECD				
Environmental stress	1.281*	1.272*	1.539**	1.263
	(1.87)	(1.71)	(2.56)	(0.92)
Pseudo R^2	0.099	0.099	0.105	0.088
Observations	14,476	19,946	20,252	20,927

Notes: The table reports exponentiated coefficients for regressions on subsamples of countries by development level with *L*, *LM*, *UM*, and *H* denoting respectively low-income countries, lower middle-income countries, upper middle-income countries and high-income countries. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and serial correlation and clustered across origins.

at all resort to migration in response to environmental stress. Yet, to explore this further, we break down the Asian sample into subcontinental subsamples (see appendix Table A4). This reveals considerable differences across Asian subregions, with people in Eastern Asia and to a lesser extent in Western Asia being significantly more inclined to migrating domestically in the face of environmental stress. Also, in Western Asia, we pick up a small significant effect for domestic migration intentions, which is even much larger for intraregional migration intentions.

To explore these results further, we can again compute average marginal effects. The findings (reported in Table A2) confirm that in absolute terms, environmental stress has the highest impact on intentions to migrate domestically across all regions, as we found in the benchmark regression (on the entire sample). Interestingly, migration intentions towards each destination are larger than average in Africa and Latin America and the Caribbean even in the absence of environmental stress (as observed from the predicted probabilities, not reported), and also the rise in migration intentions in response to environmental stress is relatively higher (about twice as large). The predicted probability to intend to migrate domestically in Africa (Latin America and the Caribbean), for instance, among those who do not report to have experienced environmental stress in the past year stands at 21.6% (17.9%) but rises to 24.8% (21.2%) among those who did experience environmental stress in the past year (in comparison to a rise from 13.8% to 15.6% in the entire sample). Similar findings are obtained for intraregional migration intentions and those towards the OECD. In Europe, on the other hand, both predicted probabilities to migrate and the impact on those from environmental stress are lower than in the entire sample. Changes in predicted probabilities in Asia and North America and Oceania are insignificant.

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Table 7. Impact of self-reported environmental stress for low skilled in rural areas of developing countries

	Africa			Asia			LAC		
	LS	Rural	Rural LS	Primary	Rural	Rural LS	LS	Rural	Rural LS
Domestic									
Environmental stress	1.276*	1.201*	1.295*	0.983	0.917	0.866	1.396***	1.320***	1.282**
	(1.76)	(1.74)	(1.70)	(−0.07)	(−0.47)	(−0.58)	(4.86)	(4.48)	(2.46)
Intraregional									
Environmental stress	1.981***	2.165***	1.733**	1.690	1.748*	2.202**	1.946	3.118**	1.917
	(3.31)	(3.02)	(2.52)	(1.37)	(1.83)	(2.19)	(1.03)	(1.98)	(0.65)
OECD									
Environmental stress	1.404*	1.092	1.221	0.630	1.052	0.968	1.838***	1.744*	2.298***
	(1.70)	(0.44)	(0.65)	(−1.01)	(0.14)	(−0.09)	(3.58)	(1.88)	(2.74)
Pseudo R^2	0.103	0.084	0.100	0.078	0.076	0.086	0.105	0.101	0.111
Observations	7,733	11,581	6,573	10,488	17,267	8,078	3,553	4,250	2,053

Notes: The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and serial correlation and clustered across origins.

We can then again apply these changes in the predicted probabilities to the 2010 population aged 15–59 from the countries in these different regions in our sample. These calculations suggest that in the year 2010, environmental stress has spurred 4.03 million people aged 15–59 from the African countries in our sample to develop an intention to migrate domestically in the coming year, while it spurred respectively 0.53 and 0.79 million people aged 15–59 from the African countries in our sample to develop an intention to migrate intraregionally and towards the OECD in the next 12 months. For Latin America and the Caribbean, these numbers stand respectively, at 4.20; 0.56 and 0.82 million; and for Europe they respectively reach 7.47; 0.97, and 1.46 million. As noted above, caution is required when interpreting such figures given that migration decisions are made in varying socioeconomic contexts which introduces a great deal of uncertainty, and nothing guarantees that these migration intentions (although more firm than pure wishful thinking) effectively translate into actual migration.

Finally, we further explore the rather puzzling result obtained in Table 5 regarding the lack of a domestic migration response to environmental stress among those with only primary education and/or living in rural areas. The average marginal effects obtained from our benchmark regression on the whole sample indicate that environmental stress primarily leads to higher intentions to migrate domestically, and we were expecting to see a more pronounced effect among the low skilled living in rural areas as these are more likely to depend on agricultural income which is disproportionally affected by the implications of climate change. Considering all countries together (as we do in the benchmark regression), our results do not seem to confirm this hypothesis. Yet, we can test whether it at least holds in developing regions by re-estimating columns 3–5 of Table 5 by geographical region in Table 7.

Indeed, at least in Africa and Latin America and the Caribbean, having experienced environmental stress in the past year increases the likelihood to intend to migrate domestically vs. staying, though the effect is statistically stronger in Latin America and the Caribbean. Also, while we did not find a significant impact from environmental stress on migration intentions in Asia as a whole, we do see a higher likelihood to intend to migrate intraregionally among the rural Asian population, and especially among the low skilled. Also, the likelihood to migrate intraregionally over staying in Latin America and the Caribbean is considerably larger when we focus only on the rural population. This is true also for intentions to migrate from Latin America and the Caribbean to the OECD, and even more so for the low skilled.

6. Conclusion

Environmental change directly leads to widespread impacts on human and natural systems, with long term climate variability and change involving increasing temperature, changing precipitation and the occurrence of extreme weather events (such as floods, cyclones, heat waves, droughts). As spelt out in the latest IPCC assessment report, the implications of the changing climate are likely to affect migration patterns around the world [IPCC (2014)]. Migration is only one among many possible coping strategies to climate change, but it can form an effective way to build resilience [Castles *et al.* (2013)]. Already a great amount of studies looks into the link between environmental stress and human mobility, however, a general consensus is not yet reached.

This study contributes to the existing literature by exploring how self-reported environmental stress drives people's migration intentions, thereby taking into

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account prospective migrants' preferred destination. Relying on the unique GWP, we conduct a comprehensive individual-level analysis across countries, thereby bridging the gap between micro-level and macro-level approaches. Specifically, we draw on survey information for 76,484 individuals collected by Gallup in 90 countries around the world to analyse to what extent self-reported exposure to environmental stress affects people's stated intentions to migrate within the next 12 months, thereby differentiating between intentions to migrate domestically, intraregionally and towards the OECD. We model the migration decision and the prospective migrant's destination choice using a random utility maximisation (RUM) model of migration, which results in an empirical multinomial logit model of migration intentions.

Our results demonstrate that having experienced environmental stress (in the form of floods, droughts, or long periods of extreme heat or cold) elevates migration intentions towards all three destination types (i.e., domestic, intraregional, and towards the OECD). The increase in the probability of intending to migrate due to environmental stress is largest for domestic migration (in absolute terms), but this is rather trivial as domestic migration is by far the most common form of migration. Correcting for the imbalance in migration that already occurs, this is a smaller change than that obtained for intraregional migration (in relative terms). Throughout the paper, we, therefore, report relative rather than absolute effects.

We further show a heterogenous migration response to environmental stress when rerunning our benchmark specification on subsamples of respondents depending on individual as well as country characteristics. We find that domestic migration intentions are higher among high skilled individuals living in urban areas with a higher household income per capita, while those with a lower household income level per capita, with lower education and living in rural areas are more likely to respond to environmental stress by moving intraregionally. This effect is even more outspoken for rural areas in Africa, Asia, and Latin America, and the Caribbean, where intraregional migration is the most likely response to environmental stress. In Europe, and in high-income countries in general, environmental stress results in higher intentions to move domestically while we do not find an impact on international migration. Our findings also suggest that intentions to migrate towards the OECD following environmental stress are particularly large among the high skilled living in urban areas with a relatively high household income per capita, and particularly in Latin America and the Caribbean.

Our results shed new light on the nexus between environmental factors and migration, and the differential migration responses depending on individual characteristics and contexts. Our findings support the notion that environmental stress will likely incite people to migrate more locally, either within the country or within the same subcontinental region, especially in rural, less developed regions, and hence help to counter the public paradigm that exists around climate change giving rise to large scale permanent migration movements from poor vulnerable to rich countries in the next decades. The places where environmental migrants are likely to end up are often already heavily populated and poorly equipped with policies and regulations to deal with people moving from climate affected areas, as laid out in the recent influential World Bank Groundswell report (Rigaud et al., 2018) . Our results suggest that countries should address this by primarily investing in sustaining urban development (given that in absolute numbers environmental stress will primarily increase domestic migration of which a large fraction probably involves movements from rural to urban areas) in combination with regional

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integration and cooperation (as in relative terms intraregional migration ensuing from environmental stress will become much more prevalent).

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/dem.2020.28

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Appendix

A. Appendix tables

Table A1. Country classification by (sub)continental region

(Sub)continent	Obs.	(Sub)continent	Obs.	(Sub) continent	Obs.
Africa		**Asia**		**Europe**	
Eastern Africa		*Central Asia*		*Eastern Europe*	
Kenya	940	Kazakhstan	679	Belarus	655
`Tanzania	949	Kyrgyzstan	741	Bulgaria	560
Uganda	935	Tajikistan	810	Czech Republic	709
Zimbabwe	909	Uzbekistan	856	Hungary	646
Middle Africa		*Eastern Asia*		Moldova	717
Cameroon	1,120	China	2,682	Poland	700
Central African Republic	918	Japan	625	Romania	577
Chad	949	Mongolia	824	Russia	2,729
Southern Africa		South Korea	622	Slovakia	671
Botswana	941	Taiwan	816	Ukraine	711
South Africa	867	*South-Eastern Asia*		*Northern Europe*	
Western Africa		Cambodia	874	Denmark	653
Burkina Faso	917	Indonesia	946	Finland	527
Liberia	935	Malaysia	852	Ireland	729
Mali	903	Philippines	797	Lithuania	619
Niger	946	Singapore	848	Sweden	798
Nigeria	941	Thailand	865	United Kingdom	594

(*Continued*)

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Table A1. (*Continued.*)

(Sub)continent	Obs.	(Sub)continent	Obs.	(Sub) continent	Obs.
Senegal	932	Vietnam	787	*Southern Europe*	
Sierra Leone	864	*Southern Asia*		Greece	676
		Afghanistan	811	Italy	686
Latin America & Caribbean		Bangladesh	883	Malta	607
Central America		India	4.995	Portugal	698
Costa Rica	797	Nepal	798	Slovenia	592
El Salvador	826	Pakistan	800	Spain	781
Honduras	801	Sri Lanka	881	*Western Europe*	
Panama	748	*Western Asia*		Austria	677
South America		Armenia	720	Belgium	725
Argentina	709	Azerbaijan	769	France	650
Bolivia	829	Cyprus	676	Germany	626
Brazil	791	Georgia	676	Luxembourg	710
Chile	711	Israel	769	Netherlands	644
Colombia	770	Turkey	808		
Paraguay	787				
Peru	759	**Northern America**		**Oceania**	
Uruguay	581	*Northern America*		*Oceania*	
Caribbean		Canada	702	Australia	654
Dominican Republic	783	USA	609	New Zealand	507
Haiti	277				

Notes: The table shows the countries used in our empirical analysis by continent (in bold) and subcontinental region (in italic) along with the number of observations for each country (denoted by "Obs."). The country classification corresponds to the one used in the International Migrant Stock Database by the UN DESA Population Division.

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Table A2. Impact of self-reported environmental stress—Marginal effects

	Benchmark	Africa	LAC	Asia	Europe	N-Am/Oceania
Domestic						
Environmental stress	1.713**	3.215**	3.356***	0.410	1.632***	1.131
	(2.53)	(2.09)	(2.99)	(0.31)	(4.02)	(1.17)
Intraregional						
Environmental stress	0.226***	0.636***	0.543***	0.070	0.005	−0.057
	(3.49)	(3.69)	(3.43)	(1.35)	(0.04)	(−0.45)
OECD						
Environmental stress	0.334***	0.717**	1.017**	0.017	0.271	−0.011
	(2.65)	(2.10)	(2.16)	(0.15)	(1.18)	(−0.18)
Observations	76,484	14,966	10,169	28,210	20,667	2,472

Notes: The table reports average marginal effects. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and serial correlation and clustered across origins.

Table A3. Indirect impact of self-reported environmental stress through income

	Benchmark			Without HH income pc (ln)		
	Domestic	Intraregional	OECD	Domestic	Intraregional	OECD
Environmental stress	1.172***	1.776***	1.322***	1.173***	1.790***	1.323***
	(2.70)	(4.41)	(3.55)	(2.78)	(4.52)	(3.58)
Aged 20–29	1.077**	1.189	1.372***	1.081**	1.209	1.379***
	(2.18)	(1.28)	(3.35)	(2.29)	(1.42)	(3.44)
Aged 30–39	0.701***	0.733*	0.851	0.704***	0.730*	0.865
	(−7.08)	(−1.70)	(−1.60)	(−7.05)	(−1.74)	(−1.45)
Aged 40–49	0.502***	0.403***	0.694***	0.505***	0.399***	0.706***
	(−9.72)	(−4.69)	(−3.01)	(−9.66)	(−4.72)	(−2.90)
Aged 50–98	0.367***	0.355***	0.407***	0.371***	0.351***	0.414***
	(−13.34)	(−3.91)	(−5.71)	(−13.31)	(−3.93)	(−5.48)
Male	1.131***	1.257	1.359***	1.132***	1.265*	1.367***
	(3.17)	(1.63)	(3.90)	(3.22)	(1.67)	(4.09)
Higher education	1.184***	0.916	1.236	1.196***	0.883	1.269*
	(3.22)	(−0.57)	(1.60)	(3.35)	(−0.84)	(1.73)
Urban	1.082	1.061	1.953***	1.088*	1.031	1.993***
	(1.53)	(0.44)	(7.33)	(1.67)	(0.22)	(7.26)
HH income pc (ln)	1.020	0.934	1.044			
	(1.15)	(−0.98)	(1.06)			

(*Continued*)

Table A3. (*Continued.*)

	Benchmark			Without HH income pc (ln)		
	Domestic	Intraregional	OECD	Domestic	Intraregional	OECD
Number of adults	0.988	0.960	1.025**	0.986	0.967	1.023**
	(−1.16)	(−0.97)	(2.39)	(−1.43)	(−0.81)	(2.21)
Number of children	0.988	1.030	1.001	0.985	1.038	0.994
	(−0.93)	(0.95)	(0.05)	(−1.17)	(1.27)	(−0.29)
Network	1.340***	4.927***	4.071***	1.345***	4.867***	4.092***
	(8.75)	(9.79)	(12.25)	(8.88)	(9.35)	(12.06)
Pseudo R^2	0.105			0.105		
Observations	76,484			77,068		

Notes: *HH income pc (ln)* denotes the log of household income per capita. The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and serial correlation and clustered across origins.

Table A4. Impact of self-reported environmental stress by subcontinent—Asia

	Central Asia	Eastern Asia	South-Eastern Asia	Southern Asia	Western Asia
Domestic					
Environmental stress	1.075	1.404***	1.117	0.842	1.347*
	.	(9.52)	(0.97)	(−1.03)	(1.95)
Intraregional					
Environmental stress	0.607	0.993	2.068	1.804	4.230*
	.	(−0.01)	(1.10)	(1.64)	(1.88)
OECD					
Environmental stress	0.481	0.870	1.161	0.896	1.333
	.	(−0.32)	(0.54)	(−0.29)	(0.51)
Pseudo R^2	0.081	0.080	0.094	0.061	0.089
Observations	3,086	5,569	5,969	9,168	4,418

Notes: The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and clustered across origins.

Table A5. Impact of self-reported environmental stress by subcontinent—LAC

	Caribbean	Central America	South America
Domestic			
Environmental stress	1.464	1.412***	1.177
	.	(2.97)	(1.54)
Intraregional			
Environmental stress	2×10^{138}	3.651**	2.418***
	.	(2.33)	(3.21)
OECD			
Environmental stress	1.976	1.791	1.404
	.	(1.39)	(1.28)
Pseudo R^2	0.084	0.063	0.061
Observations	1,060	3,172	5,937

Notes: The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and clustered across origins.

Table A6. Impact of self-reported environmental stress by subcontinent—Africa

	Eastern Africa	Middle Africa	Northern Africa	Southern Africa
Domestic				
Environmental stress	1.054	1.016	0.895	1.653***
	(0.49)	(0.71)	(−0.80)	(3.76)
Intraregional				
Environmental stress	4.729**	1.651***	2.109***	2.300***
	(2.18)	(3.30)	(15.46)	(2.87)
OECD				
Environmental stress	0.854	1.155	2.081*	1.545***
	(−0.55)	(0.46)	(1.70)	(4.15)
Pseudo R^2	0.076	0.102	0.078	0.094
Observations	3,733	2,987	1,808	6,438

Notes: The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and clustered across origins.

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Table A7. Impact of self-reported environmental stress by subcontinent—Global North

	East Europe	North Europe	South Europe	West Europe	North America	Oceania
Domestic						
Environmental stress	1.184***	1.448***	1.075	1.219*	0.983	1.184
	(3.05)	(2.87)	(0.90)	(1.68)	.	.
Intraregional						
Environmental stress	0.597	1.746***	0.000***	1.344	0.000	1.247
	(−0.61)	(3.05)	(−21.07)	(0.37)	.	.
OECD						
Environmental stress	1.652*	1.386	1.069	0.955	1.237	1.059
	(1.79)	(0.52)	(0.13)	(−0.05)	.	.
Pseudo R^2	0.115	0.104	0.090	0.105	0.097	0.083
Observations	8,675	3,920	4,040	4,032	1,311	1,161

Notes: The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and clustered across origins.

B. Sensitivity analyses

In this section, we provide additional sensitivity analyses using observed levels of environmental factors rather than/on top of self-reported environmental stress. As argued in section 2, we believe that migration decisions are primarily affected by people's personal experience with environmental problems in their local area, as captured in self-reported information on environmental problems, rather than by environmental hazards as objectively identified using scientific evidence which does not capture personal experiences [see also Koubi et al. (2016a, 2016b); Dessai *et al.* (2004)]. Also, while actual indicators of environmental hazards might be more objective, results are known to vary widely with the type of measure that is used [see e.g., Berlemann and Steinhardt (2017); Beine and Jeusette (2018); Bertoli *et al.* (2019)]. Nonetheless, it is interesting to explore how the inclusion of an indicator of the actual occurrence of environmental hazards either replacing or complementing our self-reported variable of environmental stress alters the results.

Before turning to these additional regressions, a few points are worth mentioning. First of all, it is important to note that the country of origin fixed effects already pick up most of the effect of actual country-level environmental stress. Identification of a potential effect of such variables is hence severely restricted. If all surveys would have been completed in 1-month time, we would have just one value for these environmental variables per country, in which case they would be completely absorbed by the country fixed effects so that their effect could not be estimated. Yet, in most countries, interviews were conducted during a period spanning 1–3 months, such that we do have some time variation in these variables.[28] That means the effect of these variables can be estimated, but caution is required in its interpretation given that the only source of identification concerns variation over time in the month in which the survey took place, and hence the exact 12 months over which these actual measures of environmental stress were calculated. A second important point is that identification of the effect of environmental stress on the basis of actual indicators relies on the assumption that everybody within the country is equally affected by environmental hazards reported in these variables, an assumption which does not hold at all in practice and is considered an important limitation of the macro approach to investigate the impact of climate factors on migration [see Piguet (2010), for a discussion]. Environmental hazards are typically local in nature so that nothing guarantees that all residents of a country have actually been exposed to the particular hazards hitting the country.

Keeping this in mind, we rely on EM-DAT to construct a number of indicators capturing the occurrence of (a specific type of) environmental hazards[29] during the 12 months preceding the month in which the Gallup interview took place.[30] The latter information is provided in the GWP and allows us to construct a variable based on observed environmental stress spanning the same time period as our variable of interest based on self-reported information. These data hence allow to explore the impact of a wide variety of environmental hazards, as does our self-reported variable of environmental stress.

Table B1 reports exponentiated coefficients from a regression first replacing our variable of interest (self-reported environmental stress) by a dummy variable capturing the occurrence of environmental hazards in the country during the 12 months preceding the month of the Gallup interview (columns 4–6). This gives similar qualitative results as those obtained in our benchmark regression (see columns

[28]In fact, interviews were conducted in just 1 month in 30 out of the 90 countries in our sample, they took 2 months in 52 countries and 3 months in just 6 countries. In Russia, interviews exceptionally took 6 months because oversamples were taken.

[29]We narrowed down the EM-DAT database to natural disasters only, which correspond to the following environmental hazards: drought, earthquake, extreme temperature, flood, landslide, dry mass movement, storm, volcanic activity, and wildfire. Notice that—unlike in the literature—the category "natural disasters" in EM-DAT is not limited to *sudden onset* hazards like floods, storms or landslides and also encompasses *slow onset* hazards like droughts and extreme temperature. When focussing on the impact of specific types of environmental hazards, we consider only the ones that came out significantly related to our self-reported environmental variable, namely drought, flood, storm, wildfire, and extreme temperature.

[30]We also experimented with a variable indicating the frequency by which environmental hazards took place (a cumulative variable) during the 12 months preceding the month in which the Gallup interview took place, yet there was not enough variation in this variable to draw any sound conclusions.

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Table B1. Impact of actual environmental hazards

	Benchmark			Actual environmental hazards		
	Domestic	Intraregional	OECD	Domestic	Intraregional	OECD
Environmental stress						
Self-reported	1.172***	1.776***	1.322***			
	(2.70)	(4.41)	(3.55)			
Actual hazards				0.798***	2.670***	2.111**
				(−3.38)	(5.26)	(2.27)
Aged 20–29	1.077**	1.189	1.372***	1.079**	1.200	1.377***
	(2.18)	(1.28)	(3.35)	(2.26)	(1.36)	(3.40)
Aged 30–39	0.701***	0.733*	0.851	0.703***	0.741*	0.858
	(−7.08)	(−1.70)	(−1.60)	(−7.10)	(−1.65)	(−1.53)
Aged 40–49	0.502***	0.403***	0.694***	0.503***	0.408***	0.701***
	(−9.72)	(−4.69)	(−3.01)	(−9.76)	(−4.61)	(−2.91)
Aged 50–98	0.367***	0.355***	0.407***	0.368***	0.358***	0.411***
	(−13.34)	(−3.91)	(−5.71)	(−13.39)	(−3.85)	(−5.64)
Male	1.131***	1.257	1.359***	1.133***	1.265*	1.364***
	(3.17)	(1.63)	(3.90)	(3.21)	(1.68)	(3.98)
Higher education	1.184***	0.916	1.236	1.187***	0.920	1.239
	(3.22)	(−0.57)	(1.60)	(3.26)	(−0.54)	(1.62)

(*Continued*)

Table B1. (*Continued.*)

	Benchmark			Actual environmental hazards		
	Domestic	Intraregional	OECD	Domestic	Intraregional	OECD
Urban	1.082	1.061	1.953***	1.081	1.063	1.975***
	(1.53)	(0.44)	(7.33)	(1.53)	(0.44)	(7.24)
HH income pc (ln)	1.020	0.934	1.044	1.020	0.932	1.044
	(1.15)	(−0.98)	(1.06)	(1.17)	(−1.01)	(1.08)
Number of adults	0.988	0.960	1.025**	0.988	0.959	1.025**
	(−1.16)	(−0.97)	(2.39)	(−1.17)	(−1.00)	(2.34)
Number of children	0.988	1.030	1.001	0.989	1.034	1.003
	(−0.93)	(0.95)	(0.05)	(−0.83)	(1.08)	(0.16)
Network	1.340***	4.927***	4.071***	1.344***	4.974***	4.096***
	(8.75)	(9.79)	(12.25)	(8.84)	(9.98)	(12.37)
Pseudo R^2	0.105			0.104		
Observations	76,484			76,484		

Notes: *HH income pc (ln)* denotes the log of household income per capita. The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and serial correlation and clustered across origins.

Table B2. Impact of self-reported and actual indicators of environmental stress

	Combi of self-reported and actual			Different types of hazards		
	Domestic	Intraregional	OECD	Domestic	Intraregional	OECD
Environmental stress						
Self-reported	1.172***	1.775***	1.322***	1.174***	1.777***	1.327***
	(2.70)	(4.41)	(3.55)	(2.72)	(4.41)	(3.58)
Actual hazards	0.796***	2.588***	2.081**			
	(−3.12)	(4.86)	(2.18)			
Drought				4.112e6***	0.187***	6.544e7***
				(358.40)	(−8.03)	(18.82)
Extreme temperature				1.410***	1.493	1.214
				(3.78)	(0.58)	(0.70)
Flood				0.692***	2.203***	1.531***
				(−46.11)	(51.05)	(38.53)
Storm				0.868***	5.515e08***	3.546e08***
				(−25.21)	(20.00)	(20.60)
Wildfire				0.819***	0.780*	0.251***
				(−3.10)	(−1.70)	(−3.65)
Aged 20–29	1.077**	1.190	1.372***	1.077**	1.191	1.372***
	(2.18)	(1.29)	(3.35)	(2.20)	(1.30)	(3.35)
Aged 30–39	0.701***	0.733*	0.852	0.701***	0.733*	0.852
	(−7.08)	(−1.70)	(−1.60)	(−7.08)	(−1.70)	(−1.60)

(*Continued*)

Table B2. (*Continued.*)

	Combi of self-reported and actual			Different types of hazards		
	Domestic	Intraregional	OECD	Domestic	Intraregional	OECD
Aged 40–49	0.502***	0.403***	0.695***	0.502***	0.403***	0.694***
	(−9.72)	(−4.68)	(−3.01)	(−9.71)	(−4.68)	(−3.01)
Aged 50–98	0.367***	0.355***	0.407***	0.367***	0.355***	0.408***
	(−13.34)	(−3.91)	(−5.71)	(−13.34)	(−3.91)	(−5.70)
Male	1.132***	1.257	1.359***	1.132***	1.257	1.358***
	(3.17)	(1.63)	(3.90)	(3.17)	(1.63)	(3.89)
Higher education	1.184***	0.916	1.236	1.183***	0.915	1.236
	(3.22)	(−0.57)	(1.60)	(3.21)	(−0.57)	(1.60)
Urban	1.082	1.061	1.953***	1.082	1.062	1.952***
	(1.53)	(0.44)	(7.33)	(1.54)	(0.44)	(7.32)
HH income pc (ln)	1.020	0.934	1.044	1.020	0.934	1.044
	(1.15)	(−0.98)	(1.06)	(1.15)	(−0.98)	(1.07)
Number of adults	0.988	0.960	1.025**	0.988	0.960	1.025**
	(−1.17)	(−0.97)	(2.39)	(−1.16)	(−0.97)	(2.40)
Number of children	0.988	1.030	1.001	0.988	1.030	1.001
	(−0.93)	(0.95)	(0.05)	(−0.94)	(0.94)	(0.05)
Network	1.340***	4.925***	4.071***	1.340***	4.925***	4.069***
	(8.75)	(9.79)	(12.25)	(8.77)	(9.79)	(12.25)
Pseudo R^2	0.105			0.105		
Observations	76,484			76,484		

Notes: The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *HH income pc (ln)* denotes the log of household income per capita. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and serial correlation and clustered across origins.

Table B3. Impact of actual occurrence of environmental hazards in subsamples

	Natives	HS	LS	Rural	Rural LS	Urban	Female	Rich	Poor
DOMESTIC									
Environmental stress									
Self-reported	1.175***	1.172***	1.166	1.131	1.099	1.277***	1.135**	1.217***	1.195*
	(2.66)	(3.92)	(1.32)	(1.42)	(0.69)	(5.08)	(1.99)	(3.18)	(1.87)
Actual occurrence	0.784*	0.778***	1.088	0.898	1.198	0.688***	0.972	0.780**	5e49***
	(−1.90)	(−38.73)	(0.08)	(−0.84)	(0.16)	(−4.64)	(−0.06)	(−2.11)	(1,071.59)
INTRAREGIONAL									
Environmental stress									
Self-reported	1.703***	1.750***	1.831***	1.904***	1.873***	1.558**	1.438**	1.691*	2.107***
	(3.86)	(3.26)	(3.54)	(3.93)	(3.21)	(2.04)	(2.18)	(1.74)	(3.28)
Actual occurrence	2.661***	2.584***	3e18***	2.334***	0.139***	1.9e7***	2.1e6***	3.327***	2e14***
	(4.92)	(5.06)	(101.88)	(33.21)	(−6.68)	(16.37)	(13.60)	(6.34)	(169.01)
OECD									
Environmental stress									
Self-reported	1.323***	1.305***	1.361**	1.199	1.275	1.507***	1.218*	1.475**	1.342**
	(3.45)	(2.88)	(2.13)	(1.22)	(1.04)	(3.60)	(1.71)	(2.07)	(2.04)
Actual occurrence	1.846***	1.409	0.000***	7e7***	9e6***	0.502	1.639	2.389***	3e98***
	(2.91)	(0.65)	(4,426.51)	(19.53)	(17.69)	(−0.72)	(1.44)	(3.27)	(1,773.58)
Pseudo R^2	0.107	0.111	0.114	0.111	0.112	0.116	0.111	0.108	0.114
Observations	73,381	52,693	23,791	46,345	18,093	30,139	34,270	18,142	16,623

Notes: *HS* and *LS* denote high and low skilled respondents, respectively. The table reports exponentiated coefficients. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications include country of origin dummies. Standard errors are robust to heteroskedasticity and serial correlation and clustered across origins.

1–3 for convenience) when it comes to intraregional migration intentions and those towards the OECD, but the results seem to suggest that respondents are less inclined to migrate domestically in the next 12 months in countries hit by environmental hazards. The results thus confirm that the occurrence of environmental hazards increases international migration intentions, especially in terms of intraregional migration, in line with our benchmark regression, but for domestic migration intentions, the opposite effect is found. Notice that all of these effects concern a *direct* impact of environmental stress on migration intentions.

Subsequently, we can test whether the inclusion of actual environmental indicators affects our benchmark results. Table B2 reports the results of a regression in which we add both our self-reported variable of environmental stress as well as the actual indicator of the occurrence of environmental hazards used in Table B1 (columns 1–3) and a regression in which we consider instead the occurrence of different types of environmental hazards. When we add our self-reported environmental stress variable back into the last regression reported in Table B1, the estimated coefficient of the occurrence of environmental hazards during the 12 months preceding the month of the interview is largely preserved. When separating out the actual environmental indicator in separate dummies capturing the occurrence of different types of hazards reveals quite diverse effects. International migration intentions are still significantly larger in countries hit by floods and storms (both intraregionally and towards the OECD), and those hit by drought (though only for migration intentions towards the OECD, while intraregional migration intentions seem to be lower). Furthermore, it seems that the negative impact of actual environmental hazards on domestic migration intentions is driven by the effect of floods, storms, and wildfire (for which a negative significant effect is observed) while drought and extreme temperatures are found to increase domestic migration intentions. Again, caution is required in the interpretation of the coefficients for these actual environmental indicators as identification comes only from variation in the month of the interview given that our country of origin fixed effects absorb most of these effects.[31]

Most importantly, we can safely conclude that the inclusion of these actual indicators of environmental stress does not affect our main result: the estimated coefficients for self-reported environmental stress all remain positive and highly significant, and are fairly similar to those obtained in the benchmark regression. This confirms the relevance of our indicator of self-reported environmental stress in determining migration intentions (as put forward in Section 2).

Finally, we add also the indicator of the actual occurrence of environmental hazards to our regressions on subsamples by individual characteristics reported in Table 4. Interesting patterns emerge, as revealed in Table B3. For instance, the negative impact of the actual occurrence of environmental hazards on domestic migration intentions seems to be the case for high skilled respondents only (not for the low skilled), for those living in urban areas (not for those in rural areas) and for respondents from rich households only. The last column reports a positive significant impact from the occurrence of environmental hazards on domestic migration intentions for individuals in poor households, though the estimated coefficient is huge suggesting that this result should be interpreted with caution.[32]

[31]This is also clear from the large coefficients for some of these variables as well as a warning signal in Stata that several observations are completely determined so that standard errors need to be interpreted with care.

[32]For this regression, Stata produces a warning flag signaling that some observations were perfectly determined so that standard errors should be interpreted with care. In fact, this is the case for many of the regressions on subsamples (many of which have a huge coefficient for this variable) which can be related to the limited variation in these variables after controlling for country of origin fixed effects.

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