



## UPDATE

# Linking climate change, environmental degradation, and migration: An update after 10 years

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## Abstract

In *WIREs Climate Change*, Issue 1(4), 2010, I suggested a typology of the data and methods used to assess links between climate change, environmental degradation and migration (Piguet, 2010). My review of the literature included publications up to 2009. Since then, the number of empirically based scientific publications on this topic has risen substantially to average 40 articles per year and the scope of methods, stock of results and diversity of questions has widened. Based on the CLIMIG database—a systematic and analytic collection of scientific references published on migration and the environment—this new synthesis provides a methodological typology of an exceptionally large number of published case studies. This will complement existing reviews and meta-studies and allow a global overview of the state of research by identifying consensus and disagreements, revisiting methodological challenges and mapping current and future research questions.

This article is categorized under:

- Vulnerability and Adaptation to Climate Change > Values-Based Approach to Vulnerability and Adaptation

## KEYWORDS

(climate) impacts, methodology, migration, vulnerability

## 1 | INTRODUCTION

In 2010, empirical research focusing on the links between climate change, environmental degradation and forced migration grew considerably.<sup>1</sup> This can be attributed to publications by the IPCC and Stern (IPCC, 2007; Stern, 2007) which forecast future “flows” of a substantial number of environmental migrants. One main line of inquiry at that time was to estimate the volume of population displacements in a political context, which described migration as a threat for rich countries (Piguet et al., 2018). Even though this quest for quantitative estimates was in vain—due to the impossibility of identifying clear-cut quantifiable categories in a context of multicausality of displacement and mixed migrations (Gemenne, 2011)—aggregate numbers appeared regularly and attracted media attention. In 2010 it was already clear to scholars that environmental stressors are highly contextual and do not impact all individuals, households, and communities equally. Even when confronted with severe environmental

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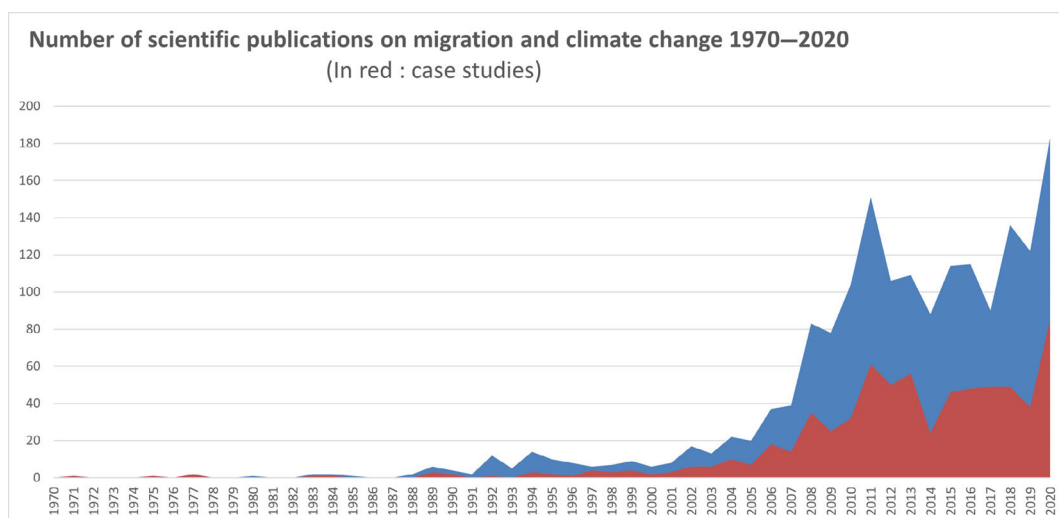
degradation, populations are resilient and have some level of agency in migration decisions or other adaptation strategies. In *WIREs Climate Change*, Issue 1(4) (Piguet, 2010), I reviewed these debates and suggested a typology of the methods used so far to assess the links between climate change, environmental degradation and migration. Ten years later the number of scientific publications has grown to approximately 100 a year, among them 40 empirical studies. This dynamism is attributable to major research projects such as FORESIGHT (Black, Adger, et al., 2011), KNOMAD (Martin et al., 2020), and Groundswell (Rigaud et al., 2018) but also to teams of researchers worldwide (Piguet et al., 2018). As recently noted by Ferris (2020), this development proceeded along five main strands: (1) climate change scientists focused on the nature of the environmental drivers, (2) migration researchers have been more and more likely to approach migration as an adaptation strategy, (3) disaster risk reduction (DRR) scholars and humanitarian actors have been mostly interested in the consequences of displacements linked to sudden-onset disasters, (4) development researcher and actors have focused on the long-term consequences of slow-onset events and planned relocations, and (5) international lawyers, conflict researchers, and security agencies have focused on the protection and security implications of climate change.

The article is a systematic search and review as defined by Grant and Booth (2009).<sup>2</sup> I address questions concerning a variety of methods recently implemented and seek to identify “best evidences,” consensual results and controversies. In conclusion, I point toward knowledge gaps and new research questions.

The full corpus as of 31 December 2020 includes 1737 publications and 694 case studies (Figure 1). A case study is defined in CLIMIG through the use of a specific empirical material (survey, questionnaire, ethnographic methods, archives, etc.) (Yin, 2014).<sup>3</sup>

I remain focused on analytical research strategies which attempt to disentangle environmental impacts from other migration drivers. International laws and policies addressing environmentally induced migration—as well as their consequences—are beyond the scope of this article so that juridical and ethical literature is not considered among case studies. Also, I do not enter into theoretical discussions of migration studies, especially the recent proposal to broaden the scope of investigation to include other forms of mobilities (Boas et al., 2019; Wiegel et al., 2019).

By offering an empirical panorama encompassing all methodological orientations and all regions of the world I offer a broad picture that complements recent narrower syntheses (Borderon et al., 2019; Cattaneo et al., 2019; Ferris, 2020; Kaczan & Orgill-Meyer, 2020; Maretti et al., 2019; McLeman, 2018; Veronis et al., 2018), methodological overviews (Berlemann & Steinhardt, 2017; Fussell et al., 2014; Safra de Campos et al., 2017; Ty Miller & Thai Vu, 2021), and meta-analyses (Beine & Jeusette, 2021; Hoffmann et al., 2020; Šedová et al., 2021). This allows to speak transdisciplinary to all researchers interested in the migration climate change nexus and to stimulate collaborative and multidisciplinary research. I also hope to give policymakers a solid foundation for understanding the issues at stake, so that they are able to differentiate between the reality of future threats associated with environmental migration and the empirically questionable numbers and dramatic portrayals constantly circulating in the media (Gemenne, 2011).



**FIGURE 1** The number of publications has massively increased. Number of publications 1970–2020

## 2 | BIBLIOMETRIC METHOD AND TYPOLOGY

My overview is based on the CLIMIG database, a systematic and analytic collection of scientific references published on migration and the environment collected and maintained by the University of Neuchâtel. A detailed presentation of CLIMIG is given in Appendix. CLIMIG is much more comprehensive and therefore returns better results than keyword searches on Scopus or the Web of Science, as can be observed by the smaller number of case studies identified in syntheses making use of these tools (Kaczan & Orgill-Meyer, 2020; Maretti et al., 2019; K. Neumann & Hermans, 2017; Obokata et al., 2014; Priovashini & Mallick, 2021). CLIMIG distinguishes six families of research methods<sup>4</sup> on the basis of chronology and data typification (Figure 2):

1. “Spatial analysis”: statistical models based on area characteristics (aggregated geographical data);
2. “Multilevel”: multilevel analysis based on area and individual characteristics (combination of geographical and individual data);
3. “Survey”: analysis of individual data based on large sample surveys (>100);
4. “Historical analogues”: analysis based upon historical environmental change and migration (various types of data, most often archives);
5. “Hot spots”: indexes of vulnerability, scenarios, regional descriptive case studies;
6. “Qualitative”: qualitative field case studies using ethnographic data and methods.

Most case studies make use of one single method but several of them use mixed methods: a large sample survey beside qualitative interviews for example. In that case, they are counted simultaneously in different types of methods.

## 3 | TYPE 1: SPATIAL ANALYSIS

Spatial analysis disentangles the factors leading to migration at an aggregated level. If the environment triggers migration, the environmental characteristics of a specific geographic area should be correlated with the migratory characteristics of that same area. Whereas in the past, studies often used migration data based in one or several regions or countries, a notable recent evolution is the use of dyadic databases to measure migration flows that incorporate multiple geographic entities. This allows us to account for simultaneous push/pull factors, leading to larger-scale—and therefore more significant—observations, especially if migration flows are also measured temporally (time series with pooled samples). Dyadic databases also allow us to consider the distance between spatial entities as well as their size within “gravity models” (Anderson, 2011) along with other geographical links that might impact migration: colonial ties, common borders, common languages, diasporas, and existing networks) (Backhaus et al., 2015; Mahajan & Yang, 2020).

Whereas 20 case studies using such methods were published up to 2009, 73 have appeared since then. Overall, a much clearer consensus emerges from these new studies and confirms that environmental change and variability have a substantial impact on migration. The intensity but also the direction of the impact vary greatly across contexts.

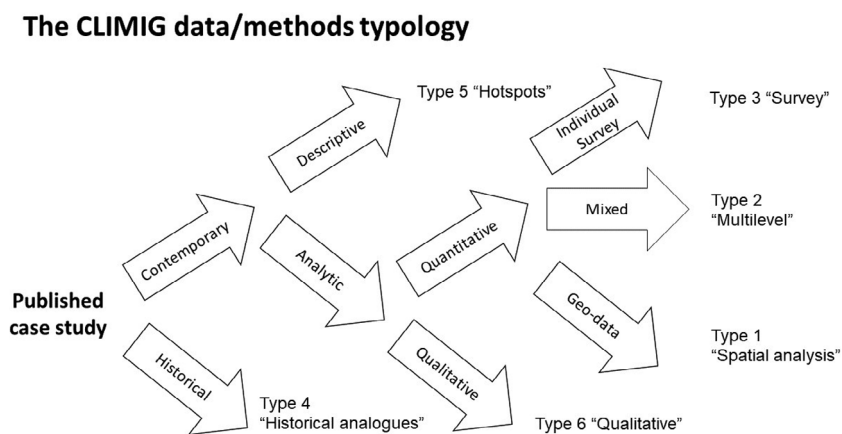


FIGURE 2 The CLIMIG data/methods typology

However, in most cases environmental variables appear as only one driving force among others, with which they interact. This confirms the already dominant message of 2010: “pure” environmental migration does not exist and multi-causality is the norm.

As could be expected, the links between migration and climate change are stronger in regions that are economically dependent upon the environment. The impacts of environmental degradation on the population is weaker in more affluent and industrialized countries (Cameron, 2018). However, one recurrent finding of the last decade is that liquidity constraints often prevent the poorest populations from migrating, a phenomenon already identified in a pioneering study by (Findley, 1994) but not studied in-depth until recently. Studies of liquidity constraints point out, for example, that changing temperatures (Cattaneo & Peri, 2016), general natural hazards (Gröschl & Steinwachs, 2017), or hurricanes (Mahajan & Yang, 2020) increase international emigration from middle-income countries but reduce emigration from poor countries. The issue of liquidity constraint is connected to the migration hump theory of an inverted U-shaped relation between development and migration (de Haas et al., 2019; Hoffmann et al., 2020) and more specifically to the concept of “trapped populations” in context of environmental shocks or slower degradations, which has attracted a lot of interest recently (DeLongueville, Hountondji, et al., 2020; Zickgraf, 2019). I will return to this concept in my conclusion. Regarding the modeling strategy, a distinction can be made between studies that use basic regressions with independent explanatory variables (Grecequet et al., 2017) and studies that complexify models in order to capture interactions between variables (Cai et al., 2016). The latter type takes into account that an environmental hazard might have a very different impact in regions where, for example, agriculture is the dominant activity, where irrigation is efficient or where policies to foster adaptation or prevent disasters are implemented. Other researchers build econometric simultaneous equation models to capture the dynamics of the systems under study. Most of these scholars are economists who ground their approach in neo-classical general equilibrium theories, which posit utility maximization by rational agents. This approach has certainly gained the most momentum recently, and is indeed the one that I identified 10 years ago as a promising path to incorporate environmental degradation scenarios in economic models that can then be used to forecast future migration. Cai et al. (2016), for example, have made use of a dataset on bilateral international flows of migrants from 163 origin countries to 42 (mostly OECD) destination countries during the period 1980–2010. This work confirms the presence of a strong environment/migration link and emphasizes the “agricultural channel,” where each 1°C increase in temperature implies a 5% increase in outmigration from the top 25% agricultural countries of the world, as compared with an insignificant increase in outmigration from the remaining, less agricultural, countries. Dallmann and Millock (2017) perform a similar analysis regarding internal migration in India. Their results show significant links between drought frequency (measured through Standard Precipitation Indexes) and bilateral migration rates. Most recently, Wesselbaum (2021) published results over a longer timeframe (1980–2015) for 16 destination countries and 198 origin countries. In contrast to articles using decennial averages for migration flows (Beine & Parsons, 2017; Cattaneo & Peri, 2016), Wesselbaum and Aburn use annual flows which more precisely link climate change variables to migration over time. Controlling for the usual factors related to migration—such as demography, openness to trade, political variables, and so on—the results show that temperature anomalies and weather-related disasters significantly affect international migration flows. A 10% increase in temperature in the country of origin will increase out-migration by 3% (roughly 150,000 migrants per year), while a 10% increase in the number of disasters in the country of origin increases out-migration by 2%. However, they also find evidence that liquidity constraints and climate shocks can potentially reduce migration.

A specific debate should be mentioned regarding asylum migration. Whereas in 2010, I was in a position to write that “no correlation at all has been found when the dependent migration variable is limited to asylum requests lodged in Europe,” it came as a surprise in 2017 when an article in *Science* measuring the relationship between asylum applications to the EU (2000–2014) and temperature fluctuations in 103 origin countries claimed the contrary (Missirian & Schlenker, 2017). This study has since been criticized for its sensationalistic tone and overinterpretation of results, but other studies confirm that a modest correlation does exist (Abel et al., 2019) beside political and other contextual drivers of asylum migration (Weber, 2019).

To this day, spatial analysis remains a very fruitful approach. Ecological variables are often easier to collect than individual data and allow for a good level of comparability between studies. Two limitations of spatial analysis were noted in the 2010 article: first, the paucity of documented environmental variables available is to a large extent remedied, as new and improved databases that use various geographical scales appear (Berlemann & Steinhardt, 2017; Fussell et al., 2014; K. Neumann & Hilderink, 2015). The second limitation was related to the fact that exposures and responses are only measured for spatial aggregates rather than for individuals. In the same vein, spatial analysis makes it difficult to differentiate the impact of environmental variables between population subgroups, such as gender,

ethnicity, or socioeconomic status, an issue to which I return in my conclusion. One strategy to overcome the drawbacks of aggregated data is to rely on individual surveys, as seen in Type 2 (multilevel) and Type 3 (survey) studies.

## 4 | TYPE 2: MULTILEVEL ANALYSIS AND TYPE 3: SURVEY

About 10 years ago, researchers began to advocate for working more intensively with individual quantitative data (Bilsborrow & Henry, 2012; Milan et al., 2014). Effectively, several inventories and new approaches were put to the fore (Fussell et al., 2014; Nawrotzki et al., 2016) and the number of such studies rose sharply, from 37 before 2010 to 233 since.

Two types can be identified: the first simultaneously analyzes geographical data (including official statistics or satellite imagery) and household surveys (hence the keyword “multilevel”), and the second uses surveys only. The current overlap between the two leads us to consider them together although they were separated in my 2010 article. A further distinction should be made between official or pre-existing surveys data, which usually have a higher sample size but fewer details on migration issues, and surveys designed purposely by researchers which often target a smaller sample but allow a focus on migration and can include open-ended, more qualitative questions. The main strength of surveys is that they allow us to differentiate individual and household attitudes and to link them with socioeconomic and environmental variables. However, in my 2010 article I noted that a weakness of such studies was the incomplete characterization of “environmental”. Indeed, none of the studies based on sample surveys before 2010 drew on detailed environmental measures, and it thus remained difficult to disentangle environmental variables from other contextual effects. I noted that this weakness could be overcome by designing large panel questionnaires including, over a sufficient period of time, a broad array of environmental questions, or by combining official measures of rainfall, temperature, sudden hazards, and so on with repeated waves of questionnaires. To a large extent, subsequent studies followed this approach. Whereas prominent results from the period before 2010 mainly indicated weak links between environmental hazards and migration, studies published between 2010 and 2020 document a much more contrasted picture: the links remain weak in some cases but are much stronger in others. This contextuality is to a large extent in line with Type 1 (spatial analysis) results.

A fine example of a recent multilevel/panel study examines rural migration in India (Šedová & Kalkuhl, 2020). The authors combined meteorological gridded data on temperature and precipitation at a geographical resolution of 31 km with data from the India Human Development Survey panel on 25,000 households. This enabled them to establish a causal relationship between temperature and precipitation anomalies and overall migration but also shows the complexities of the relations: adverse weather shocks do indeed *increase* interstate migration toward cities but *decrease* rural–rural and international migration. This result brings to mind a canonical 2004 study on Burkina-Faso (Henry et al., 2004) and underlines the importance of the liquidity constraint mentioned in the previous chapter. In a more recent study on Indonesia (Thiede & Gray, 2017), data from the Indonesian Family Life Survey on 14,421 individuals aged 15–49 years were matched with high-resolution climate data. It revealed that the impact of anomalous temperatures, rainfall levels and monsoon timing on intra-provincial and inter-provincial migration do not operate systematically as a push factor and vary according to an individuals' gender, membership in a farm household, and location. A similarly contrasted picture, emerges in studies of the migration intentions of populations conducted in Ghana (Codjoe et al., 2017) and Malawi (Suckall et al., 2017). Both show that all households and individuals do not respond in the same way to current or forecasted environmental degradation (Codjoe et al., 2017; Suckall et al., 2017).

Overall, the main lesson from this family of studies is that, even if they confirm the impact of environmental drivers on migration, they contend that these links are often indirect and heterogeneous according to population profiles. Interdependencies are multiple and other drivers intervene in migration decisions (van der Geest et al., 2020).

### 4.1 | Agent-based modeling

Taking into account heterogeneities of behavior is precisely the aim of agent-based modeling (ABM), a method that I considered promising in my 2010 article. The central idea is to make explicit the rules of behavior that lead to migration decisions in a context of environmental degradation. A computer simulation then allows researchers to observe outcomes on a population of agents over time and to modify the contextual parameters—for example, the amount of rainfall (Smith, 2014)—while taking into account interactions, retroaction loops, and thresholds (e.g., if a certain number of

agents decide to emigrate, the remaining agents face an increased incentive to leave) (Thober et al., 2018). The parameterization of the model is usually based on survey data (hence its inclusion in the family of methods). Ten years ago, however, I also noted that environmental migration is quite a different process from the classical fields of application of ABM, mostly while it displays fewer regularities of behaviors regarding sudden impacts and less predictability regarding more progressive environmental degradations. This might explain why, with a total of eight identified publications, the number of empirical studies on environmental migration making use of ABM did not flourish as expected. It remains that the big data revolution might still nurture interesting developments in this field.

## 5 | TYPE 4: HISTORICAL ANALOGUES

Most of the climatic changes related to CO<sub>2</sub> emissions are yet to come, so their impact on migration is difficult to witness and measure. Documented historical episodes of migration related to environmental hazards are few and thus precious by analogy, even if not related to current climate warming (Ljungqvist et al., 2021). In 2010 I cited two studies: one on the abandonment of Holland Island (Chesapeake Bay, USA) in 1918 due to sea level rise (Arenstam Gibbons & Nicholls, 2006), and one on drought adaptation in Oklahoma during the 1930s (McLeman et al., 2008). The publication of historical studies linking migration and climate-related events has not massively increased during the last 10 years but remains substantial with a total of 28 articles identified in CLIMIG before 2010 and 35 since then. One study of 19th-century German migration to North America—based on official migration statistics, population data, weather data and cereal price records—estimated that up to 20%–30% of migration from Southwest Germany was indeed attributable to climate factors (Glaser et al., 2017). This result is fully in line with the multicausal reasons for migration observed in contemporary case studies.

Grolle (2015) provides historical case studies of famines and migration in West African Sahel. Three episodes (1953–1954, 1972–1973, 1983–1985) are addressed on the basis of existing literature and official archives as well as oral histories collected from village heads, farmers, traders, and so forth. They reveal an historical function of the savanna as refuge for environmentally stressed populations to collect wild food, fodder, and firewood (rural to rural migration) which coincide with rural to urban mobilities. The author stresses once again the importance of contexts and policies and raises concerns for the sustainability of the traditional mobility-based forms of adaptation.

Another study (Jennings & Gray, 2015) compares longitudinal data from the Historical Sample of the Netherlands capturing the migration of 24,835 individuals between 1865 and 1937 with climate data over the same period. Their results are fascinating as they again confirm contemporary research: detrimental climate conditions do lead to internal migration but only in certain periods and for certain social groups, whereas international migration decreases with extreme rainfall.

Studies of non-climatic factors—such as earthquakes or tsunamis—also offer interesting insight into a population's response to sudden environmental hazards. However, it remains difficult to obtain a global picture of this family of research, which is scattered between many fields of study and where migration and mobility issues are often only marginally mentioned. Significant avenues of research are open to bridge the disciplinary gaps in this field.

## 6 | TYPE 5: HOT SPOTS

My 2010 article briefly mentioned hot spot identification (or exposure/vulnerability mapping) as an approach to the migration/environment nexus. Such studies are distinguished from other methodological types because they are mainly descriptive and/or prospective. Most focus on the ex-ante identification of threatened regions, the assessment of vulnerability and the resilience of inhabitants. Following specific disasters such as Hurricane Maria in Puerto Rico (2017) or Typhoon Haiyan (Philippines, 2013), ex post studies focused on assessing the consequences of disasters and the number of displaced persons (Rivera, 2020; Yonetani & Yuen, 2014). Published assessments of this kind have almost doubled since 2010 (82, up from 42) and this has given rise to an important methodological discussion regarding climate vulnerability mapping in general (de Sherbinin et al., 2019). Hot spot assessments also provided global maps of regions at risk (Ericksen et al., 2011; Grecequet et al., 2017) as well as future scenarios (Jones & O'Neill, 2016; B. Neumann et al., 2015; Xu et al., 2020). The most ambitious research project was conducted on behalf of the World Bank regarding internal migration related to slow-onset environmental degradation with detailed foci on East Africa, South Asia, Mexico, and Central America (Rigaud et al., 2018). The Internal Displacement Monitoring Center and the International

Organization for Migration in Geneva as well as the Hugo Observatory in Liège also play a significant documentation role by publishing annual reports and by improving quantifying methodologies regarding population displacements (Hugo Observatory, 2020; Internal Displacement Monitoring Center [IDMC], 2020).

One challenge that remains to be addressed in the context of climate vulnerability mapping lies in applying population projections to vulnerable areas: paradoxically, many hot spots—especially urban zones and more at risk disadvantaged neighborhoods within them—are currently migration destinations where populations are growing rather than zones of departure (de Sherbinin et al., 2019; DeLongueville, Hountondji, et al., 2020; Foresight, 2011; Jones & O'Neill, 2016).

## 7 | TYPE 6: QUALITATIVE

Qualitative methods were the most widely used research design before 2010 (51 articles). With 192 articles they are now second only to multilevel analysis and sample surveys. These studies use interviews, small sample questionnaires, contacts with privileged informants, focus groups, text and image analysis, and so forth.

Although, by definition, they do not provide a quantitative measure of the weight of environmental factors on migration, such studies offer invaluable insights into threatened population's attitudes, perceptions, and representations of climate change in general and of their migration/mobility options in particular. Recently, efforts have also been made to better incorporate local and indigenous knowledge into such research (Pearce, 2018).

Providing an exhaustive list and summary of all these case studies is beyond the scope of the present article, but as noted 10 years ago, most strongly support the multicausality hypothesis regarding mobility and migration (see, e.g., Groth et al., 2020). Whereas numerous authors confirm the role of environmental degradation in migration worldwide, many also challenge the idea that climate change is already a central driver of mobility, insisting that many populations are simply eager to leave their homelands regardless of environmental factors.

## 8 | CONCLUSION: NEW DATA AND NEW QUESTIONS

This methodological review update shows that research on the environment-migration nexus has significantly progressed along six now well-established methodological paths within the last 10 years. If my 2010 inventory, I noted that “the empirical research has often been pursued in isolation by a fairly limited number of authors,” one can now consider that a worldwide network has emerged and that the field has matured. This is exemplified by regular meetings in various contexts and vivid debates in scientific journals. A consistent common basis of knowledge now exists and syntheses and textbooks make it easier for new researchers to contribute (Hunter & Nawrotzki, 2016; McLeman & Gemenne, 2018). Meta-studies—considered in my 2010 article as “yet impossible”—have also appeared in the meantime, allowing us to map out consensus and disagreements (Beine & Jeusette, 2021; Hoffmann et al., 2020; K. Neumann & Hermans, 2017). Simultaneously, new data have been suggested, new questions have come to the fore and results previously taken for granted have been challenged. In this conclusion, I will briefly mention the new data sources that appear promising and list the (re)newed questions that are keeping researchers busy.

### 8.1 | New data

A full review article would be required to synthesize the applications of new kinds of data to assess the environment/migration nexus during the last 10 years. However, two major trends can be outlined.

The first consists in data disaggregation and refers mainly to Type 1 (spatial analysis) and Type 6 (qualitative) research. This allows researchers to overcome the major weakness mentioned in my 2010 article: the analysis of predefined large (often administrative) spatial units might not reflect the spatial distribution of the phenomenon at stake. Disaggregation consists here in analyzing phenomenon at a finer scale, whether spatial (i.e., municipalities rather than districts, or gridded portions of the territory rather than administrative units), temporal (months rather than years) or social (subgroups of the population rather than population as a whole). In all cases it necessitates significantly improved databases which have largely benefitted from the development of remote sensing and satellite imagery (Kugler et al., 2019; Thalheimer & Heslin, 2020). A good example is the World Bank's “Groundswell

Report” which used gridded population data at a global level with an approximate resolution of  $14 \times 14$  km (Rigaud et al., 2018).

The second trend consists in the use of completely new data sources and can be witnessed in all types of research (except perhaps Type 4). Among the most innovative data sources recently suggested, mobile phone connections (Lu et al., 2016), Facebook (Alexander et al., 2019), Twitter (Martín et al., 2020), and even consumer credit data (DeWaard et al., 2020) allow researchers to follow populations on the move after an environmental disaster or in climate-stressed areas. Another unexpected source of information is night light measurement, which offers a proxy for population density changes (Ash & Obradovich, 2019). The results of such “Big Data” analyses are promising but raise significant challenges: they mainly address rapid-onset environmental hazards and mobility rather than migration issues and their representativity regarding population groups remains tricky. Unexpectedly, it is perhaps in combination with qualitative field work that the most promising results can be produced using these new data sources. This was recently illustrated by a study conducted in Bangladesh during and after Hurricane Mahasen in 2013. The first part of the study identified displacement through mobile phone networks, while the second part interpreted these movements on the basis of qualitative interviews (Boas et al., 2020). Another important point is that these information and communication technologies (ICTs) not only offer new sources of data to researchers but also have a direct—and usually facilitating— influence on mobility itself and should be thematized as such. This is a field that has only recently emerged in the literature (Boas, 2017).

## 8.2 | New questions

What I could now call “classic” research questions identified 10 years ago (How many people move because of environmental drivers? What is the weight of such drivers compared with others? What are the regional specificities, hot spots and scenarios for adaptation?) have certainly not found consensual and definite answers, but a series of new questions testifies to the advance of our understanding of the phenomenon at stake. I will conclude by listing five which appear especially stimulating beside the more general endeavor of improving the theoretical underpinning of this subfield which I have addressed elsewhere (Piguet, 2018).

### 8.2.1 | Does mobility and migration allow for better adaptation?

Conceptualizing migration as a cure rather than as a symptom emerged shortly before my 2010 article. Following the Foresight report (Black, Bennett, et al., 2011), mobility as a coping strategy has become prominent in research (Gemenne & Blocher, 2017). Correlatively, the issue of immobility and trapped populations due to poverty and liquidity constraints emerged (Zickgraf, 2019) as well as the question of what are environmental migration destinations (Thiede et al., 2016). Both concepts of adaptation and trapped population have attracted some criticism since then and researcher noted that migration only holds potential for effective adaptation for specific groups and circumstances (Vinke et al., 2020; Wiegel et al., 2019), but empirical research documenting precisely such mechanisms remains scarce.

### 8.2.2 | Which populations are affected by environmental change?

Suggested decades ago, the label “environmental refugee” has served to personify the dramatic consequences of climate change but has also been criticized for oversimplifying the mechanisms at stake. It also obfuscates the diversity—and future—of the affected populations. What classic migration theories call selectivity of migration in relation to age, race, class, gender and so forth has therefore attracted growing attention in recent years. A recent study in India indicates, for example, in contrast to other migrants, that those affected by climate are more likely to be from low-skilled households strongly dependent on agricultural production (Šedová & Kalkuhl, 2020). A study in Latin America (Baez et al., 2017) shows that individuals in the youngest age category are most likely to migrate in response to either droughts or hurricanes whereas (Drabo & Mbaye, 2015) points toward possible brain drain consequences of natural disasters for the Global South. Gender is among the most important dimensions that shape vulnerabilities and mobilities (Lama et al., 2021). As shown recently in Bangladesh, gender norms might, for example, create additional social

costs for women who migrate although female mobilities are imperative to sustain livelihoods within communities (Evertsen & van der Geest, 2020).

Despite these insights a lack of empirical research persists and meta-studies are needed in order to gain some generality.

### 8.2.3 | How do people perceive their environment?

The issue of the way people perceive environmental hazards and climate change has not been addressed much over the last decade. Is there a discrepancy between objective measures and perceptions? What is the role of religion, culture, and local histories in the way people conceive their environment, experience place-attachment (Dandy et al., 2019), and eventually plan to migrate? While there has been research on the role of perception in climate adaptation and environmental decision-making in general, far less work exists in relation to migration. A recent article on Burkina-Faso (DeLongueville, Ozer, et al., 2020) shows that no single study addressing migration issues has systematically combined climate data and data on climate change perceptions yet. This pioneering research reveals that meteorological data and perceptions regarding rainfalls indeed differ. Another study surveyed individuals in five developing countries and found that perceiving oneself as being at risk of harm from a sudden-onset environmental event, such as flooding or extreme storms, creates a relatively high potential for migration (Koubi et al., 2016). When such migration does occur, it does so in a sharp, non-linear fashion. By contrast, the perception of slow-onset environmental risks, such as droughts or soil erosion, are unlikely to stimulate thoughts of migration. This is consistent with studies of populations living on low-lying Pacific atolls (Stojanov et al., 2017). The issue of perception is currently addressed in a joint research project from the Universities of Namur (B) and Neuchâtel (CH).<sup>5</sup> An especially interesting methodological development in this regard is the use of Q-methods to capture subjectivities, while providing a certain level of quantification. Q-methods are not new (Watts & Stenner, 2012): participants are asked to rank statements which are then grouped by factor analysis to produce typologies or synthesis narratives. They have been used to map expert discourses on the climate-migration nexus (Morinière & Hamza, 2012) and more recently to approach perceptions of populations confronted with environmental hazards and transformations (Ayebe-Karlsson, 2020; Ayebe-Karlsson et al., 2020; Oakes, 2019; van der Geest et al., 2019). In Kiribati, Tuvalu and Nauru, Oakes (2019) shows, for example, that culture and especially how Islanders relate to land and religion influence mobility decision-making, thereby either promoting or hindering mobility.

### 8.2.4 | What about non-linearities and indirect linkages?

Thresholds were identified as crucial to understanding the context of climate change rather early (Barnett & Adger, 2003), but questioning them in relation to migration emerged only recently (Bardsley & Hugo, 2010; McLeman et al., 2017). In addition to the idea of thresholds as tipping points beyond which massive migration starts, the more general idea that the mechanisms linking climate and migration evolve over time (Gray et al., 2020) and that a distinction should be made between direct and indirect linkages (DeLongueville et al., 2019) has also gained momentum recently, as well as an interest in the impacts of series of successive hazards rather than hazards taken in isolation (Nawrotzki & DeWaard, 2016). The issue of tipping points is, by the way, at the center of a large European research project led by the University of Liège which began in 2020.<sup>6</sup>

### 8.2.5 | What is the role of immigration policies in shaping (im)mobilities?

A common result of research on environmentally induced migration is that most people who move do so locally and that international moves are less frequent, especially following sudden disasters such as hurricanes. This conclusion certainly holds true in most cases and remains an essential message for policymakers worldwide in a context of unjustified fears of migrant flows. It was, however, recently nuanced by a study of the impact of hurricanes over 25 years of international migration to the United States (Mahajan & Yang, 2020): hurricanes indeed cause immediate and substantial increases in legal permanent immigration to the United States. Estimations regarding migrations from Puerto Rico to the mainland United States following Hurricane Maria (2017) also point toward substantial displacements (around 6% of the total population). At first glance such a result might fuel the argument of future flows of

climate refugees, but it mostly points toward the fact that immigration policies play an important role in allowing or preventing migration. In the case of the United States, post-hurricane flows are mainly attributable to origin countries with large pre-existing populations of immigrants in the United States who provide opportunities for family reunification in case of need. In the case of Puerto Rico, these links are exacerbated by its special status of association with the United States and the free migration it implies (Alexander et al., 2019). This positive impact of immigration policy is very specific to the United States but symmetrically raises the question of the negative impact of restrictive policies on potential migrants affected by environmental change. In some cases, local—rather than international—migrations might be attributable not to choice but to policy constraints.

This last point connects to what is perhaps the most striking weakness of the current research on environmental migration regardless of method: it remains difficult to contextualize empirical results within larger sets of power relations and governance (Boas et al., 2018; Geddes et al., 2012; McCarney & Kent, 2020). It also remains a challenge—beyond overall policies to limit climate change—to frame appropriate mobility policies that do not simply force people to either stay in place or migrate. This is perhaps one of the central works in progress over the next 10 years.

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## CONFLICT OF INTEREST

The author has declared no conflicts of interest for this article.

## DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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## ENDNOTES

- <sup>1</sup> The term “forced” migration is used here to indicate that such studies consider the environment as exercising a significant level of coercion on the decision to move. Each migration case is however to be situated along a continuum between “forced” and “voluntary” (Piguet, 2018).
- <sup>2</sup> “Such a review combines the strengths of a critical review with a comprehensive search process. Typically, this type of review addresses broad questions and the result is a ‘best evidence synthesis’” (p. 102). This review is based on all empirical publications identified between 1 January 2010 and 31 December 2020 (several 2021 publications were added upon request from reviewers). All case studies were read and coded by the research team. Each finding is grounded in an evaluation of underlying evidence and agreement following IPCC guidelines ([https://www.ipcc.ch/site/assets/uploads/2017/08/AR5\\_Uncertainty\\_Guidance\\_Note.pdf](https://www.ipcc.ch/site/assets/uploads/2017/08/AR5_Uncertainty_Guidance_Note.pdf)). The cited publications were selected because they exemplify consensual results or illustrate specific phenomenon.
- <sup>3</sup> Syntheses and overviews are not considered as case studies. Meta-studies pooling various empirical research are included as I consider that they offer a unique empirical contribution. A case study might be counted several times if the authors have published different papers, but working papers are not kept in the database if a paper is subsequently published.
- <sup>4</sup> The original typology of the 2010 paper was slightly different: (1) Ecological inference based on area characteristics; (2) Individual sample surveys; (3) Time series; (4) Multilevel analysis; (5) Agent-based modeling; and (6) Qualitative/ethnographic studies. The CLIMIG typology emerged from this initial version but was improved on the basis of research developments.
- <sup>5</sup> PEEMPASS—Environmental change perception and mobilities in Western Africa: [http://www.unine.ch/geographie/Migration\\_and\\_Climate\\_Change](http://www.unine.ch/geographie/Migration_and_Climate_Change)

<sup>6</sup> HABITABLE—Linking Climate Change, Habitability and Social Tipping Points: Scenarios for Climate Migration: <https://www.habitableproject.uliege.be/>

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## APPENDIX

### Literature search in the CliMig database

The CLIMIG data base is presented in more details here: [http://www.unine.ch/geographie/climig\\_database](http://www.unine.ch/geographie/climig_database). A searchable demo version on WordPress can be accessed: <https://climig.com/> and the full database is available upon request.

### Literature monitoring

We work in collaboration with the Swiss Forum for Migration and Population (SFM), which performs a literature watch and uses the information-management platform Delicious to upload potential articles for CliMig. After articles of primary relevance to CliMig are selected, all references and keywords are entered into Endnote.

The literature watch uses traditional sources (publishers' catalogues, e-alerts, group lists and discussions, newsletters, etc.) and a set of keywords to monitor scientific literature. Tools such as Google Scholar alerts, Feedinformer, the Old Reader, Update Scanner, and editors' alerts are added to the monitoring system in order to filter and locate gray literature (reports, working-articles, conference proceedings, etc.).

### Selection of topics

To ensure coherence and comprehensiveness, references are included only if they focused on—or bring significant insights into—the following topics:

- Population displacement potentially caused by environmental change
- Displacement as a coping strategy due to environmental change
- Perception/representation of the migration/environment nexus
- Policies and legal issues related to migration and environmental change

In principle, the database does not include references focused on the impact of migration on the environment, the links between conflicts and environment, displacement linked to development/infrastructure projects, amenity migration (environment as a pull factor), vulnerability in general, and environmental change if unrelated to displacement of people.

## Selection of relevant types of literature to be included

The CliMig database is focused on original research material. The following types of publications are included:

- Articles in scientific (peer-reviewed) journals (journal article)
- Books published by scientific publishers (book)
- Chapters of edited books published by scientific publishers (book chapter)
- Reports from scientific (peer-reviewed) research projects (report)
- Working articles based on scientific (peer-reviewed) research projects (report)
- Conference proceedings, synthesis or research reports by NGOs—administrations, UN bodies, and so on if they are based on original empirical work or represent a synthesis not available elsewhere (report)
- Special issues of “large public” reviews, journals, or encyclopedias can be included in the database if they bring additional insights.

The database does not include magazine and newspaper articles, leaflets, advocacy documents, websites, blogs, entries in encyclopedias/dictionaries, or syntheses that do not bring original information.

## Implementation of specific keywords

CliMig keywords are assigned on the basis of a uniform procedure for all publications, and manually entered to ensure scientific accuracy and clarity. For further details and usage, see: [https://www.unine.ch/geographie/Migration\\_and\\_Climate\\_Change](https://www.unine.ch/geographie/Migration_and_Climate_Change).

Four families of keywords are used: “Area,” “Type—Method,” “Focus,” and “Environmental hazard.” The origin (country) of the author and the funding are also recorded.