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Human Migration in the Era of Climate Change

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"Human Migration in the Era of Climate Change"

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Human mobility is one response to climatic stress and shocks. In this synthesis article, we review the recent literature on the effects of climate change on human mobility within various disciplines. We explore key features of the interplay between climate change and migration, distinguishing between fast onset and slow onset climatic events, while taking into consideration causes of heterogeneity in migratory responses. Moreover, we shed light on the underlying mechanisms behind the nexus as well as the interplay between different means of adaptation. Based on our review, we identify gaps in the literature and present some general policy recommendations and priorities for research on climate-induced migration.

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Introduction

In the coming decades, hundreds of millions, if not billions, of people will be exposed to the impacts of anthropogenic climate change (hereinafter referred to simply as 'climate change'). Aside from the increase in average temperature and changes in precipitation patterns, rising sea levels and extreme weather conditions, such as heatwaves, droughts and floods, will increasingly become the norm (Jones and O'Neill, 2016). In turn, this will have serious implications for water supply, crop production, health and economic growth with some parts of the world much more affected than others (IPCC, 2014). People can then choose to adapt through migration. In both ancient and more recent history of civilizations, examples abound in which people responded to extreme weather conditions by moving out of regions into other areas (Romm, 2011, Marris, 2014).

However, even if migration offers an important margin of adaptation to changing climate for local populations, the effective migration response to climate stress is not trivial. The observed complexity of the phenomenon implies that the vulnerability to climate change does not automatically translate into higher migration probability. Alternative conceptual frameworks are therefore emerging. By reviewing the burgeoning literature on the nexus of climate change and migration within various disciplines, this paper aims to identify some regularities and derive messages that can ultimately contribute to generate policy recommendations. First, there is no unified theoretical approach that adequately represents the relationship

between climate change and human mobility. Climate variability is distinct from climate change and even if climate variability of the past can give clues to understand the future impact of climate change, the attribution of increased variability to climate change remains difficult. This has implications for the nexus between climate change and migration, in particular as far as reliable projections of future migration flows are concerned. At the same time, human mobility can take many forms, varying from internal to international and from seasonal displacement to definitive resettlement. In addition, human mobility can be driven by slow-onset events, like droughts and land degradation, as well as by fast-onset events like floods, storms and hurricanes and the migration outcome of slow onset events differ from that of slow-onset events. This paper will therefore contribute to identify some regularities in the relationship between different forms of migration and slow versus fast onset events.

Second, a new framework is emerging whereby, in some circumstances, climate change represents a constraint to migration. Far from forcing people to move, climate change can prevent certain populations at risk from escaping danger, trapping them in exposed locations and vulnerable situations. This is because, the causes of each type of human mobility are highly contextual, varying with the history of migration and the dynamics of economic, political, demographic, social and environmental factors at the origin and destination (Black et al., 2011; Martin et al., 2014). The interplay of these elements gives rise to heterogeneous migration responses to climatic change. A systematic assessment of the heterogeneous outcomes has not been done so far in the context of climate change and is the object of the current review.

This review will also evaluate the evidence related to two additional issues that have strong policy implications and at the same time received little systematic discussion in the literature. Given that migration is only one of the possible adaptation strategies to climate change, the paper aims to shed light on the possible substitutability of migration and alternative adaptation strategies. The identification of adaptation solutions that may alleviate migration pressures at the source is crucial given the sometimes involuntary nature of migration. Finally, this article provides a critical review of the underlying mechanisms involved in the relationship between climate change and migration. Understanding the channels through which climate change affects migration is another policy priority.

By critically reviewing the available evidence, the paper aims at synthesizing the state of research on the four main issues described above. Each of these issues carries strong policy implications, which we will discuss in the conclusions. Moreover, while discussing the regularities in the field, the paper has a second objective. It aims at identifying gaps and priorities that future research should address.

The paper is organized in the following way. In the first section, we summarize the state of knowledge regarding the impact of various climate drivers on migration. The following section is devoted to the difference in migration response according to different socio-economic characteristics. The paper then addresses the issue of adaptation, with mobility being considered as one adaptation strategy among others. In the last section, we review the evidence on possible mechanisms that explain why climate change translates into human mobility. Finally, we derive policy implications and outline research gaps.

Links between Migration and Slow versus Fast Onset Events

The literature on the impact of climate change and climate variability on human mobility often distinguishes between slow versus fast onset events (United Nations Framework Convention on Climate Change, 2012; Bohra-Mishra, Oppenheimer and Hsiang, 2014). It also distinguishes between direct and indirect links. A direct link occurs if, for example, coastal erosion forces the inhabitants of a village to relocate (slow onset), or if people have to flee a hurricane or a flood (fast onset). An indirect link occurs if, for example, warming or progressive desertification affects traditional farming practices and leads some people to leave because

of a decline in agricultural productivity. Moreover, events like droughts are thought to potentially exacerbate conflicts over resources, possibly contributing to violence, which then may push people to flee. In practice, there is often a continuum between "fast and slow onsets" as well as between "direct and indirect impacts" and "voluntary and involuntary movement". What is more, the degree to which a given society or community is (un)able to adapt to changing environmental conditions in-situ, is an important contextual factor when distinguishing between responses to fast and slow onset events.

Fast Onset: hurricanes, torrential rains, floods, landslides

The consequences of hurricanes and floods on population displacement are relatively easy to identify in that they manifest themselves in a brutal and direct manner. In most cases, displacements tend to be temporary and over short distances (McLeman and Gemenne, 2018). Living mainly in poor countries, the victims have little resources for long distance mobility (Lonergan, 1998; Zickgraf and Perrin, 2016) and the majority of the displaced returns as soon as possible to reconstruct their homes in the disaster zone.[1] The results from numerous research projects conducted worldwide tend to confirm this point with remarkable regularity. On a global level, the general conclusion is thus that the potential of hurricanes and torrential rains to provoke long-term and long-distance migrations remains limited, especially regarding international migration, which involves crossing an international border. This is not to say this will not occur in the future and provisions for protecting the rights of the displaced have already been explored by such entities as the Nansen Initiative[2] and the Platform on Disaster Displacement.[3]

The literature on climate change recently recognized that the expected future increase in the frequency of natural hazards will have important impacts on populations' livelihoods (Kim and Marcouiller, 2017; Devkota et al., 2017). The impact of a succession of disasters can indeed be very different than the impact of one single disaster, regardless of the intensity of each. In addition, the way the affected populations see their future plays a central role in their decision to move or not. In that context, a link between hazards' frequency/repetition and migration has been mentioned by several studies (Buchenrieder, Mack, and Balga, 2017; Neumann et al., 2015), but without in-depth empirical analysis. Due to a lack of appropriate data, very few studies are indeed able to quantify the specific impact of hazards repetitions (Saldaña-Zorrilla and Sandberg, 2009; Safra de Campos, Bell, and Charles-Edwards, 2017; Bohra-Mishra, Oppenheimer, and Hsiang, 2014). The understanding of such impacts on mobility and of the thresholds associated with them (Bardsley and Hugo, 2010) therefore constitutes a central question for future research and data collection efforts.

Slow onset: Drought, desertification and temperature increase

The effect of drought and desertification on human mobility is generally less sudden than that of the meteorological events mentioned in the previous section, with droughts generally associated with gradually progressive departures. Various case studies have revealed a contrasting picture of the consequences of these kinds of environmental changes for migration movements. On the one hand, there are many well-known cases of mass population departures, predominantly internal displacement, in particular in Africa (Sahel, Ethiopia), in South America (Argentina, Brazil), in the Middle East (Syria, Iran), in Central Asia and in Southern Asia. Indeed, Hammer (2004) presents an impressive table of forced migration due to droughts

[1] As we will discuss in the section below, the human responses to climate change do not only depend on the type of event but also on the availability of resources. Marginalized parts of a society tend to be immobile or short-term mobile for lack of resources, whereas other parts of that same society may be able (and willing) to diversify their income and life choices to move further and long term.

[2] https://www.nanseninitiative.org

[3] http://disasterdisplacement.org/the-platform

(and floods) during the period 1973-1999 in the Sahel, with one case of a million people displaced temporarily or permanently during the drought in Niger in 1985.

On the other hand, other authors have argued that these numbers are still relatively small compared to the numbers of people affected by drought, with environmental push factors just one of many factors influencing migration decisions (Smith, 2001, Black et al., 2011; Martin et al., 2014). Some researchers hold similar views to those of the Nobel Prize winner for Economics, Amartya Sen, in remarking that mobility (like famines) is, in general, only marginally associated with environmental factors, with the movement more a function of political issues. For instance, a multivariate analysis on interprovincial migrations in Burkina Faso has shown that environmental variables only marginally explain human mobility (Henry, Boyle and Lambin, 2003). A similar result has been suggested for pre-revolutionary Syria (Selby et al., 2017).

In certain contexts, the impact can even be reversed. This was the case in Mali during the drought of the mid-1980s. A reduction in international migration was observed due to the lack of available means to finance the journey (Findley, 1994). Cattaneo and Peri (2016) report that a gradual increase in temperatures reduces international migration from poor countries, consistent with the presence of liquidity constraints. In another study of international migration, a natural hazard index (including drought) also affects migration, but only for middle-income countries, which are not rich enough to have insurance schemes nor poor enough to be restricted by liquidity constraints (Gröschl and Steinwachs, 2017). For Kniveton et al. (2008) "[drought] seems to cause an increase in the number of people who engage in short-term rural to rural types of migration. [But] (…) it does not affect, or even decreases international, long distance moves". Here, the conceptualization of drought-affected people as helpless victims who are left with no choice but to flee seems to be false, since this view turns a blind eye to individual, community and national adaptation efforts. Consequently, it would be difficult to put a figure on the magnitude of populations at risk and on the potential migrations arising from global warming-induced droughts or more generally from gradual increases in temperatures.

To summarize, while slow-onset events, like droughts and land degradation, commonly result in mobility which is perceived as voluntary and often predominantly economically motivated, fast-onset events like floods, storms and hurricanes tends to lead to more sudden, involuntary and short-term movements.

Future migration projections

If, on the one hand, the number of studies linking climatic drivers and migration is growing, a lot of uncertainty still remains with regard to future migration outflows. Some projections exist but either lack robust scientific methodology or ignore the multi-causality of migration decision. For example, some studies take as estimate for potential migrants the number of people that live in areas "at risk". However, being exposed to a climate hazard does not automatically imply the decision to migrate. Some papers use statistical approaches to provide end of century projections based on historical estimates and climate scenarios. In general, these papers conclude that future climate change will increase the number of climate-induced migrants (Marchiori, Maystadt and Schumacher, 2012; Bohra-Mishra, Oppenheimer and Hsiang, 2014; Mueller, Gray and Kosec, 2014; Jessoe, Manning and Taylor, 2018; Missirian and Schlenker, 2017)[4], but their results should not be viewed as accurate predictions, only indications. These papers typically model short-term responses to climate related shocks, but the further ahead in the future, the more short and long term responses differ. Short-term responses either overestimate or underestimate the long-term ones. Moreover,

[4] Missirian and Schlenker (2017) consider the effect of temperature fluctuations on refugees. However, refugees are only a small fraction of total migration flows, are pushed by persecution, war or violence and mainly come from a limited number of origin countries.

a great degree of uncertainty surrounds not only the climate models used for such predictions, but also the socioeconomic scenarios. This is a major source of uncertainty given that human migration results from the interaction between climatic, socio-economic and other drivers. For example, in the future, a larger number of people may lack the available means to finance migration because climate change made them even more vulnerable. Rigaud et al. (2018) advance the state of the art, as they produce future estimates of the number of climate migrants using a gravity model that accounts for demographic and socioeconomic trends and climate migration scenarios.

Their projections of 143 million people migrating by 2050, however, refer to only internal migration, namely people moving within their own countries. A better formulation of future climate-related international migration projections is an important gap that future research should address.

One exception to this general rule is the potential for human mobility linked to the increase in sea level, which is less uncertain because this phenomenon is virtually irreversible. Human mobility becomes the only possible option for the populations affected, as exemplified by the historical case of Holland Island (Arenstam and Nicholls, 2006). The localization of the consequences of rising sea levels is a relatively easy task, because the configuration of coastlines, their elevation and population is known and thus easy to integrate into Geographical Information Systems (GIS) that permit simulations and projections. Hence, it is possible to calculate – on a global scale – the number of persons living in low elevation coastal zones that are threatened by rising water levels, higher tides or storm surges (Jones and O'Neill, 2016). McGranahan, Balk and Anderson (2007) define low elevation coastal zones as being situated at an altitude of less than ten metres above sea level. Even though these zones only account for 2.2 percent of dry land, they presently are home to 10.5 percent of the world population, some 602 million people, of which two-thirds live in Asia and one-third in the poorest countries of the world. It would certainly be an exaggeration, however, to consider that these hundreds of millions of people will all be migrants in the near future. On the basis of the scenario of an increase of 0.3-0.8 metre of the sea level (IPCC, 2014), it seems reasonable to consider the 150 million people living at an altitude of less than one metre as directly vulnerable during the next century, with many already resorting to building sea defences. Mainly situated in the major river deltas and estuaries, the flood zones are particularly populated in South Asia (Indus, Ganges Brahmaputra, etc.) and East Asia (Mekong, Yangtze, Pearl River, etc.). These two regions account for three-quarters of the population at risk. Certain Pacific states, such as Tuvalu or Kiribati, are – in the short-term – among the most threatened, as they are situated only centimetres above sea level (Fornalé, Guélat and Piguet, 2015; Klepp and Herbeck, 2016; McNamara et al., 2018).

Heterogeneity in Responses

The climate-migration relationship is clearly shaped by the types of climatic events, whether slow or fast ones. However, as discussed above, the eventual outcome also depends on socio-economic and political characteristics of the individuals, households and communities exposed to the climatic events (Black et al., 2011; Martin et al., 2014). Risks associated with climate change and the consequent outcomes are influenced by hazard, exposure, as well as the vulnerability of the populations (IPCC, 2014). Given the interplay of these elements, migration outcomes are likely to be heterogeneous with respect to wealth, the level of financial and human capital, gender, age, health, the availability of places to move to, as well as the capacity to track what happens to property and assets left at home. This issue of selectivity in who migrates is an important one and has been largely studied in the literature around movements in general. However, the pattern of selectivity that can emerge in the case of ordinary migration may not apply in the case of climate-induced migration. A systematic assessment of the heterogeneous outcomes according to these characteristics has

not been done so far in the context of climate change. Below, we focus on two of the main characteristics for which selectivity may be different from what is found in the general literature on migration.

Heterogeneity with respect to wealth

The existing literature has suggested that the capacity for migration is much more limited than commonly perceived, given that climatic shocks can further reduce the means to finance relocation (Kniveton et al., 2008; Bryan, Chowdhury and Mobarak, 2014; Cattaneo and Peri, 2016). There is a trade-off between the incentives to move and the resources to do so. This trade-off is particularly prevalent in the context of climate-related migration. On the one hand, poor people have higher incentives to migrate, as they tend to be those most exposed and vulnerable to the impacts of climate change, with limited capacity to adapt in situ. On the other hand, poor people often cannot afford to pay the cost of migration. Poorer people thus face a "double set of risks" by being both unable to move away from climatic threats and especially vulnerable to their impacts (Foresight, 2011; Black et al., 2011). Which forces prevail is an empirical question.

Some studies document that low income families are more likely to move as a consequence of climatic events (Jayachandran, 2006; Gray and Mueller, 2012a; Mueller, Gray and Kosec, 2014; Mastrorillo et al., 2016). Other studies suggest the opposite view, whereby liquidity constraints prevent profitable migration (Kleemans, 2015; Cattaneo and Peri, 2016; Bazzi, 2017). The apparent contradictions in these narratives disappear when one considers the different forms that human mobility can take. Families with low levels of wealth address negative shocks through survival migration, which is characterized by temporary moves over short distances. On the contrary, richer families tend to engage in profitable investment migration, which involves urban moves or even longer distance international migration, which span a longer period of time.[5] Kleemans (2015) estimates that human mobility to distant and international destinations is about four times as costly as survival migration and becomes cost prohibitive to poor people. Moreover, she reports that the two migration strategies are substitutes, hence families migrating a short distance to cope with a negative shock are less likely to invest in long distance migration.

To some extent, because of liquidity constraints, climate change may thus generate immobility (Findley, 1994; Black et al., 2013). Climate change may have an immobilizing effect whenever its impact reduces the resources needed to move. The notion of 'trapped' populations has been introduced to describe those who are not able to migrate even if they wish to do so. It is also true that immobility can be a choice. In this respect, four different paradigms have been developed to describe why people choose to stay in the face of climatic threats. The first is a technical paradigm, where immobility is explained by messages of warning not being received or the response being deemed irrational (Morrow, 2009). The second is a socio-economic paradigm, where marginalized groups are seen as less able to perceive or respond to risk (Wisner et al., 2003). The third is a psychological paradigm, which acknowledges the subjectivity in decision-making and hence describes the lack of mobility in terms of differentiated attitudes towards risk (Kahneman, 2013). Finally there is a cultural paradigm, whereby culturally ingrained attitudes and norms regarding risk are seen as putting self-imposed limitations on behaviour (Beck, 1992; Douglas and Wildavsky, 1982). Nevertheless, even if immobility in some circumstances can be actively chosen, in many other circumstances it is the outcome of a lack of resources, as it is well documented in Bryan, Chowdhury and Mobarak (2014).

[5] The emigration of the most skilled and educated from a country, also called the brain drain, could harm a source country's welfare and development. Some papers, however, suggest instead that the brain drain could ultimately contribute to human capital formation in origin countries, and therefore be beneficial. See Docquier (2014) for a recent discussion on the topic.

These findings challenge the alarmist forced migration rhetoric and support scenarios in which people are trapped in place. Political decision-makers who are worried about the impact of climate-related natural hazards should be concerned as much about immobility as about mobility (Findlay, 2012).

At the same time, after the move, migrants, in particular low-income and socially excluded, also risk to cluster in high-density areas that are themselves exposed to flooding and landslides (Chatterjee, 2010; De Sherbinin et al., 2011; Fox and Beall, 2012; McMichael, Barnett and McMichael, 2012). In this respect, migration is an adaptation strategy that needs to be carefully managed.

Heterogeneity with respect to gender

The issue of vulnerability described above also applies to the relationship between gender and climate change-induced migration decisions (Chindarkar, 2012). On the one hand, female household members are more vulnerable to climate change impacts because of unequal gender relations and access to resources. Gender barriers may prevent women from accessing wage labour opportunities and thus limit their adaptive capacity to climate change. These factors increase their incentive to move. On the other hand, women also have less opportunities to exploit in the labour market by migrating compared to men, and this limits their chance of successful migration.

Some contributions confirm that female migration is constrained by climate change (Dillon, Mueller and Salau, 2011; Gray and Mueller, 2012b; Mueller, Gray and Kosec, 2014). Other papers, on the contrary, find that women are more likely to undertake labour-related human mobility in response to environmental change (Gray and Mueller, 2012a; Thiede, Gray and Mueller, 2016; Baez et al., 2017a; Thiede and Clark, 2017). It should be noted that marriage-related moves by women are very common in some regions of the world, for instance in some African countries. The bridegroom's family is expected to transfer assets to the bride's family to formalize the marriage, which often is an important factor for the bridal household's economy. Households may choose to delay marriage migration after a climatic shock if the shock lowers bride prices and the family hopes to realize a higher bride price in the future. Households may also simply postpone marriage migration to limit wealth expenses connected to marriage in time of bad climatic shocks. A better understanding of the patterns of migration with respect to gender is another priority that calls for further research. This is extremely important in order to better target policies that address climate related vulnerabilities.

Migration versus Alternative Adaptation Strategies

Human mobility is often considered to be an adaptive measure by those who undertake it, or at least as one of several adaptation strategies (Alam, Alam and Mushtaq, 2016; Bawakyillenuo, Yaro and Teye, 2016; Wang and Cao, 2015; Kattumuri, Ravindranath and Esteves, 2017; Stojanov et al., 2016, McNamara et al., 2018). However, from a different perspective, migration can be seen as a failure to adapt (Banerjee, 2017). The decision to migrate may occur when alternative adaptation strategies are perceived as unachievable. Wodon et al. (2014) report that migration can be seen as a solution of last resort by families, because it is perceived as more costly than other strategies such as using savings, selling assets, getting into debt, or withdrawing children from school. Migration implies not only high material costs, but also high immaterial costs, connected to unknown outcomes and the uprooting of individuals, households, and sometimes even communities.

Within the discourse of adaptation to climate change, there are two dimensions that should be considered, namely a micro and a macro level. At the micro level, adaptation to climate change can be achieved through investments, in particular in agriculture, by seeking employment in the non-farm sector, or through informal

networks. At the macro level, adaptation can be facilitated by economic and institutional reforms, which address structural vulnerabilities, or by external policies such as food aid or credit programs. In both cases, access to information, markets, governance, and credit shape the adaptation potential.

In most analyses of climate-induced migration, however, adaptation at the micro and macro levels is rarely modelled jointly with human mobility. Therefore, it is hard to assess if the adaptation potential of migration can be realised before or after these alternative adaptation strategies are put in place. In what follows, using the available evidence, the current paper tries to shed light on alternative adaptation mechanisms and their relative efficiency compared to human mobility. We consider on-farm adaptation, off-farm adaptation through the labour market, informal credit and participation in risk-reducing networks, national social protection policies and international development assistance.

On-farm adaptation

For households that are dependent on agricultural income, increased resilience to climate change through investment in new cultivars and technology that are less sensitive to climate change could provide an alternative to human mobility. Dallmann and Millock (2017) find some evidence that Indian states with a higher net rate of irrigation display an attenuated migration response to drought. Likewise, Laube, Schraven and Awo (2012) find that in the ecologically vulnerable Northern part of Ghana, households with access to small-scale irrigation during the dry season have fewer migrants than households without access to it. Nonetheless, (seasonal) migration still remains an important fall-back or emergency option for households with access to irrigation in times of stress after a shock (e.g. market failure or harvest failures due to water shortages). In another study on Ghana, Antwi-Agyei, Stringer and Dougill (2014) report that households applying on-farm adaptation measures such as crop rotation, are not only more resilient to the effects of climate change, but they also have much fewer migrants than other households.

One should bear in mind however that the current framing of migration as adaptation tends to assume that a person or a household migrates only after alternative adaptation strategies fail. An alternative framework, on the contrary, would consider human mobility as an instrument that opens up additional possible adaptation strategies, i.e., that it builds adaptive capacity. For example, the migration of household members enhances the adoption of agricultural innovations that in turn act as adaptations (Karanja et al., 2016). Remittances earned from migration relax local capital constraints on the uptake of such innovations as changing of livestock species (from cattle to camels), introducing feed conservation measures or introducing drought tolerant and fast maturing varieties of cereal crop. A better understanding of the dynamic of the relationship, whether from on-farm adaptation to migration or conversely from migration to on-farm adaptation constitutes a central question for future research.

Off-farm adaptation

Adaptation to climate does not only occur through on-farm investments. The literature has extensively documented that households which experience weather shocks are more likely to increase their participation in the off-farm labour market, either in self-employment or through wage labour (Ito and Kurosaki, 2009; Porter, 2012). This change in job from agriculture to wage labour often implies relocation. The potential of off-farm adaptation mainly lies in its income diversification characteristics, but also in allowing sectoral diversification (Banerjee, 2017). Sectoral diversification can mean that the household income is re-orientated from being very climate-sensitive (e.g. agriculture) to one that maybe is less so.

In a study on Indian households in eighty districts, Rose (2001) finds that adverse rainfall shocks and climatic risks are associated with increased labour market participation. Jessoe, Manning and Taylor (2018)

investigate the effects of temperature and precipitation on local employment decisions in rural Mexico, distinguishing between agricultural and non-agricultural employment. They find a reduction in (local) rural employment due to extreme heat, mainly in the non-agricultural sector. They also find that the negative weather shocks extend beyond local labour markets and influence the migration decision. Mueller and Quisumbing (2011) report that agricultural workers who moved into the non-agricultural sector following the Bangladesh 1998 flood suffered smaller reductions in income than those who remained in the agricultural sector after the flood.

Participation in risk-reducing networks, credit and social protection policies

When financial and insurance markets are missing, as is often the case in developing countries, informal credit and participation in risk-reducing networks can serve as insurance. Credit can work as an alternative to human mobility in that it allows the household to maintain consumption following a reduction in income. But credit can also enhance human mobility, in that it allows households to pay for migration costs. Ex ante, the effect of credit on human mobility is thus ambiguous. Munshi and Rosenzweig (2016) find that in India, households facing greater rural income risk and therefore benefitting more from the caste-based rural insurance networks are less likely to have migrant members. India is characterised by much lower migration rates than other comparable countries and this might be due to either weak formal insurance, such as private credit and government safety nets, or strong informal insurance. The authors report that small improvements in formal insurance could substantially increase human mobility. Kleemans (2015) finds that a policy of supplying credit works as a substitute to human mobility after a negative income shock. However, Bryan, Chowdhury and Mobarak (2014) report that credit works as a complement to human mobility that was previously constrained by liquidity constraints or risk-aversion.

Poor households are often excluded from formal financial instruments and do not always benefit from social protection policies (Hallegatte et al., 2016). Unless social protection schemes are effectively targeted, these segments of the population, who most often cannot rely on either credit or insurance to cope with shocks, can only resort to survival migration or remain trapped in place. Rigaud et al. (2018) point to the importance of portable social security schemes to facilitate mobility. In Brazil, the Bolsa Familia beneficiary cards can be redeemed in many urban centres across the country. Existing registries for social protection schemes can also be used to target poor populations, as was done in the Philippines after Typhoon Yolanda in 2013 (Hallegatte et al., 2016). One of the most common assistance schemes is food aid. There is some evidence that food aid can postpone human mobility (Meze-Hausken, 2000), but unfortunately, there is no detailed quantitative analysis of the potential substitutability or complementarity between food-for-work and free food aid programs and human mobility.

Governments can offer assistance or transfer compensation payments to regions affected by natural hazard-related disasters or extreme weather events, and these payments may alleviate the economic impact of shocks. Paul (2005) suggests that the disaster aid provided by the government to tornado-affected areas in north-central Bangladesh limited the migration response after the disaster in 2004. In rural Pakistan, Mueller, Gray and Kosec (2014) find that flood has little impact on internal migration and interpret this finding as a possible result of relief programs being directed to flood victims. Chort and de la Ruppelle (2017) find that, while precipitation shortages increase undocumented migration from Mexico to the U.S., states with higher payments from "*Fonden"*, a national fund providing assistance to natural hazard related disasters, experienced reduced emigration. Similarly, the agricultural cash-transfer program "*Procampo"*, which provides direct payments to non-irrigated plots, decreases documented human mobility along the same Mexico-U.S. corridor. Boustan, Kahn and Rhode (2012) find that flood-prone U.S. counties experienced net in-migration in the 1920s and 1930s, and argue that this could be explained by the flood assistance schemes

implemented in the U.S. at the time, such as the construction of levees and flood control programs. On the contrary, counties struck by tornados – for which no early warning systems existed - experienced net out-migration.

When national policies are not enough, international development assistance can also cushion the migration response. Baez et al. (2017b) find some indication that official development assistance could mediate drought-induced youth migration in an analysis of migration induced by drought and hurricanes in seven countries in Latin America and the Caribbean.

While this preliminary evidence suggests that social protection programmes and development assistance tend to mitigate the effect of climate related episodes on migration, too few analyses have been done so far to drive a solid conclusion. This is an important priority for future research.

Mechanisms: from climatic change to migration

The majority of papers aim at assessing if climate influences migration, and very few contributions shed lights on possible mediating channel through which climate change may affect migration. The identification of the mechanisms that explain why climate change translates into human mobility requires a deep understanding of whether and how such climatic events affect the other drivers of migration. In the case of sudden abrupt events, the identification of the mechanisms is relatively trivial because these events are directly responsible for temporary displacement. In contrast to that, the identification of the mechanisms is more complex if the link between climate change and human mobility is mediated by additional factors. This is because the various drivers of migration are influenced by climate change.

Sensitivity to economic drivers

In general, a key driver of migration is considered to be economic, with climate change impacting this through livelihood losses at source. Lilleør and Van den Broeck (2011) highlighted the role of (expected) income differentials and of income variability, suggesting that both these factors may be sensitive to changes in climate. The income differential driver refers to differences in return to labour between origin and destination, while the income variability driver refers to fluctuation of income over time.

The impact of adverse climate conditions on the incomes of households has been highlighted by Barrios, Bertinelli and Strobl (2010) for Sub-Saharan African countries, and by Dell, Jones and Olken (2009), for twelve countries in the American continent. In particular Dell, Jones and Olken (2009) document a positive impact of rainfall on GDP growth and a negative impact of temperature on per capita GDP, respectively. If income falls, then the gap between origin and destination income widens and this translates into higher migration. Marchiori, Maystadt and Schumacher (2012) show that, in Sub-Saharan Africa, weather anomalies tend to boost rural-urban migration through a decrease in rural wages. Also, an influx of workers into the cities results in downward pressure on urban wages, which in turn induces international mobile workers to move to other countries. Cai et al. (2016) show that, in agriculturally-dependent countries, increases in temperature beget outmigration to OECD destinations. Coniglio and Pesce (2015) use an index of rainfall variability for 158 countries and show that higher variability leads to outmigration to OECD countries. Similar results are found by Backhaus, Martinez-Zarzoso and Muris (2015).

Such impacts are stronger, the higher the vulnerability and exposure of the origin countries to climate change. The individuals and households that are most likely to suffer income drops are those whose income is directly or indirectly related to agriculture. In fact, because of a reduced profitability of their lands and lower agricultural output, rural households or some household members may be pushed to migrate to other rural areas or to cities. This happens especially in the LDCs, which often lack sufficient adaptive capacity to

cope with climate change impacts. Beine and Parsons (2015) confirm that natural hazard related disasters lead to internal mobility of individuals in developing countries. They also document some indirect effect of these disasters on international migration, through a decrease in wages in affected areas.

Feng, Krueger and Oppenheimer (2010) provide some evidence on the linkages among climate change, crop yields and Mexico-US cross-border migration, although the methodology has raised some concerns (Auffhammer and Vincent, 2012). Mastrorillo et al. (2016) show that climate variability in South Africa has a negative effect on the share of people employed in agriculture, and such a negative effect in turn tends to boost inter-district migration. Similarly, Viswanathan and Kumar (2015) find that the decline in the value of agricultural output related to weather variations increases inter-state out-migration in India. Dallmann and Millock (2017) show that the effect of drought frequency (measured on the basis of the Standardized Precipitation Index) on inter-state migration in India is stronger in states with a higher share of net domestic product from agriculture.

Income variability is thought to be a second economic factor that is influenced by climate change and translates into higher human mobility. Income variability refers to the risk of income losses, which could induce (rural) households to resort to human mobility of some members as a strategy to diversify income sources across sectors, and therefore to smooth uncertainty. Some initial evidence on the importance of human mobility as a risk-mitigating factor emerged from studies that were not primarily aimed at explaining the effects of environmental risks on migration (Rosenzweig and Stark, 1989; Yang and Choi, 2007).

In recent years, the question of whether and to what extent migration plays a role in risk management has become key in the research on the interlinkages between environmental change and human mobility (Milan et al., 2016). Marchiori, Maystadt and Schumacher (2015) specifically analyse the link between environmentally-induced income variability and human mobility in Sub-Saharan countries, but they find that income variability is only a negligible driver of migration decisions. A study by Dillon, Mueller and Salau (2011) on internal migration of Nigerian households shows that male household members migrate in response to ex ante agricultural risk due to weather variability and shocks. Gröger and Zylberberg (2016) similarly find that households with settled migrants ex ante receive more remittances. Evidence from Ghana, in turn, suggests that human mobility as a climate change related risk management strategy can also be a driver of agricultural decline and shifts towards non-agricultural/natural-resource based livelihoods (Rademacher-Schulz, Schraven and Mahama, 2014). At a national scale, Couharde and Generoso (2015) show that remittances have an ambiguous role for the macroeconomic performance of West African countries facing climate variability, and may aggravate economic dependence, when drought conditions prevail.

Sensitivity to socio-political drivers

Similar to economic drivers, socio-political factors also mediate links between climate change and human mobility. In contexts of high political and social instability, the effects of climate change could contribute to the onset and propagation of (violent) conflicts (Miguel, Satyanath and Sergenti, 2004; Hsiang, Burke and Miguel, 2013; Ciccone, 2011; Buhaug, 2010) and these could produce forced displacements (Reuveny, 2008). This is especially the case when the institutional responses to the environmental challenges are weak and unequal across populations (Bernauer, Bohmelt and Koubi, 2012). It has been suggested that a prolonged and climate change related drought in parts of Syria (Kelley et al., 2015) added to pre-existing vulnerability due to unsustainable land and water use practices and ineffective agricultural policies, leading to human migration. These two events have been framed as having contributed to exasperating the population and asking for reforms, but this thesis of a Syrian “climate war” needs to be dealt with cautiously (Fröhlich, 2016; Selby et al., 2017).

The relationship between mobility and conflict is particularly complex and context specific, since climate-related conflicts may not only trigger migration, but, in turn, conflicts can impair mobility. In the Horn of Africa, for example, during the 2000 drought, the ongoing conflict prevented the pastoralists to move seeking for water sources, and this amplified the consequences of the drought (Simpkins, 2005).

Conclusions, policy implications and future research

To summarize, three possible outcomes of climate related events, both rapid and slow-onset, have been identified in terms of population movements: human mobility, displacement and immobility. Each of these outcomes corresponds to multiple drivers and is embedded in socio-economic, political and demographic processes. For the most part, climatic factors are usually merely a contributing factor to the decision to migrate. This entails what Castles (2002) has termed 'conceptual fuzziness', meaning that it is very difficult to attribute the extent to which the climate has played a role in a specific migration decision, unless human mobility has followed a fast-onset environmental event such as a hurricane. Climate impacts on migration in many cases operate through non-environmental drivers.

While some parts of the society may be capable of adapting successfully, other parts may not. Marginalised and disadvantaged groups like the poor or women are often unable to move away from climatic threats. Policies hence need to be adapted to facilitate migration and help remaining parts of the population without locking them into areas that become increasingly unviable (Rigaud et al., 2018). This is true not only in the interest of the trapped population, but also in the interest of the country as a whole, given that human mobility is an important engine of development and growth.

A main challenge for policy is to better coordinate development and social protection programmes and to increase the resilience of populations at risk by encouraging alternative adaptation strategies. On-farm adaptation measures such as crop rotation and irrigation are able to mitigate partially the effect of climatic shocks on migration. Improving adaptive capacity in the form of other strategies than migration is a better solution than progressive displacement as an involuntary outcome.

At the same time, income losses, income variability and risks in origin countries are found to be mediating channel through which climate change affect migration and in some circumstances generate displacement. By mitigating the impact of climate change, promoting access to clean energy, increasing the efficiency of agricultural production and improving water supply systems one can also limit the magnitude of these drivers. This issue is important because people do not always move from areas that are the most exposed to the impacts of climate change to less climate-vulnerable ones.

While this review paper is able to formulate some conclusions based on the current state of research, many open research questions remain. We selected four of them, which we suggest to prioritise. First, much uncertainty surrounds future migration projections, in particular as far as international migration is concerned. Research and data are needed to improve the climate models used for predictions and determine the specific characteristics of migrants induced by climate change compared to migrants in general, since this will determine the outcome of climate change induced migration both in the destination and in the source countries. Second, due to a lack of appropriate data and case studies, very few studies have analysed the specific impact of increases in the frequency of natural hazards and the way populations deal with the risk of cumulative shocks. Third, more studies are needed to formulate solid conclusions on the effect of social protection programmes and development assistance on migration. Finally, a better understanding of the direction of the relationship between on-farm adaptation and migration constitutes another central question for future research.

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