Human Migration in the Era of Climate Change

Cristina Cattaneo*, Michel Beine†, Christiane J. Fröhlich‡, Dominic Kniveton§, Inmaculada Martinez-Zarzoso¶, Marina Mastrorillo#, Katrin Millock**, Etienne Piguet††, and Benjamin Schraven‡‡

Introduction

In the coming decades, hundreds of millions, if not billions, of people will be exposed to the impacts of anthropogenic climate change (hereafter referred to simply as "climate change") (Intergovernmental Panel on Climate Change 2018). Aside from the increase in average temperature and changes in precipitation patterns, rising sea levels and extreme weather events, such as heat waves, droughts, and floods, will increasingly become the norm (Jones and O'Neill, 2016). These trends will in turn have serious impacts on water supply, crop production, health, and economic growth, with some parts of the world much more affected than others (Intergovernmental Panel on Climate Change 2014). One response is for people to adapt to these events and their impacts through migration. In both the ancient and more recent history of human civilizations, examples abound in which people responded to extreme weather conditions by moving out of one region and into another (Romm 2011; Marris 2014). However, although migration may offer an important option

*RFF-CMCC European Institute on Economics and the Environment (EIEE), Centro Euro-Mediterraneo sui Cambiamenti Climatici, via Bergognone 34, 20144 Milano, Italy. Telephone: (+39) 342 6133782; e-mail: Cristina.cattaneo@eiee.org.
†University of Luxembourg, 161a avenue de la Faiencerie, L-1511 Luxembourg. Telephone: (+352) 46 66 44 6752; e-mail: michel.beine@uni.lu.
‡GIGA German Institute of Global and Area Studies, Neuer Jungfernstieg 21 / 20354 Hamburg / Germany. Telephone: (+49) 40 42825-582; e-mail: christiane.froehlich@giga-hamburg.de
§University of Sussex, Sussex House, Falmer, Brighton, BN1 9RH, United Kingdom. Telephone: (+44) 1273 877757; e-mail: D.R.Kniveton@sussex.ac.uk
¶University of Gottingen and University Jaume I. Platz der Goettinger Sieben 3, 37073 Goettingen, Germany. Telephone: (+49) 551399770; e-mail: imartin@gwdg.de
#Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00153 Roma RM. e-mail: marina.mastrorillo@gmail.com
**Paris School of Economics and CNRS, Paris School of Economics, 48 Boulevard Jourdan, 75 014 Paris, France. Telephone: (+33) 1 80 52 17 86; e-mail: millock@univ-paris1.fr
††Institute of Geography FLSH, University of Neuchâtel, 2000 Neuchâtel, Switzerland. Telephone: (+41) 32 7181919; e-mail: etienne.piguet@unine.ch
‡‡German Development Institute (DIE), Tulpenfeld 6, D-53113 Bonn, Germany. Telephone: (+49) 176 78024298; e-mail: benhamin.schraven@die-gdi.d

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for adapting, vulnerability to climate change does not necessarily lead to a higher probability of migration. As we will discuss, under some circumstances, climate change may actually constrain migration.

In recent years, a growing body of literature has investigated the influence of climate change on migration. However, there are still significant gaps in our understanding of the complex relationship between climate change and migration. More specifically, as yet, there is no unified theoretical approach that adequately represents the relationship between climate change and migration. For example, climate variability is distinct from climate change and the responses to the two phenomena are also different. In addition, migration can be driven by slow-onset events like warming, droughts, and land degradation, as well as by fast-onset events like floods, storms, and hurricanes, and the migration outcomes of slow-onset events differ from the outcomes of fast-onset events. Moreover, migration can take many forms, ranging from internal to international and from seasonal displacement to permanent resettlement. At the same time, the causes of migration are highly contextual, depending on migration history and the dynamics of economic, political, demographic, social and environmental factors at the origin and destination (Black et al. 2011; Martin et al. 2014). Another challenge is the fact that short-term responses to climatic drivers differ from long-term responses, which makes it difficult to generate migration projections.

In the context of climate-induced migration, there are also issues that have strong policy implications but have received little systematic attention in the literature. For example, migration is only one of the possible adaptation strategies to climate change. On-farm adaptation, reliance on informal credit, and social protection policies are potential alternative ways to adapt, and these forms of adaptation may either complement or substitute for migration when a climate shock occurs. Moreover, different mechanisms determine whether climate change translates into migration. In particular, climate change may affect income differentials between origin and destination countries, increase economic uncertainty, or influence sociopolitical factors, all of which have an impact on the probability of migrating.

The purpose of this article is to examine the literature across various disciplines in order to improve our understanding of the complex relationship between climate change and migration. To this end, the article discusses some consistent factors in the relationship between climate change and migration, identifies gaps in the literature, and recommends priorities for policy and future research in this area. More specifically, we will discuss the empirical evidence on the effects of different types of climatic events on different types of migration, examine the causes of heterogeneity in migratory responses to climate events, and highlight the interactions between different types of climate-induced adaptation and the mechanisms underlying the relationship.

Links Between Climate Drivers and Migration

There are different types of events that are connected to climate change and different forms of migration. In this section we will synthesize the current state of knowledge on the impacts of different climatic drivers on migration and discuss projections of future migration. The literature on the links between climate change and migration often distinguish between

slow- and fast-onset events (United Nations Framework Convention on Climate Change 2012; Bohra-Mishra, Oppenheimer, and Hsiang 2014), as well as between direct and indirect links (Bardsley and Hugo 2010). For example, there is a direct link between a climatic event and migration if 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.[1] In practice, there is often a continuum between fast- and slow-onset events and between direct and indirect impacts and voluntary and involuntary movement. In the remainder of the section we describe these relationships in detail.

Fast-Onset Events

It is relatively easy to identify the impacts of fast-onset events such as hurricanes, torrential rains, floods, and landslides on migration because they manifest themselves in a brutal and direct manner. The literature finds that in most cases, displacements tend to be temporary and over short distances (McLeman and Gemenne 2018). In poor countries, the victims do not have adequate resources for long-distance migration (Lonergan 1998; Zickgraf and Perrin 2016), and the majority of those who are displaced return as soon as possible to rebuild their homes in the disaster zone.[2] In fact, the results of research projects conducted around the world tend to confirm this point with remarkable consistency (McLeman and Gemenne 2018). Thus the general conclusion at the global level is that the potential for fast-onset events such as hurricanes and torrential rains to cause long-term and long-distance migrations is limited, especially in the case of international migration, which requires crossing an international border. This is not to say that such migration will not occur in the future.

The climate change literature recently found that it is not only the occurrence of a single fast-onset event that has important impacts on populations' livelihoods, and thus migration, but also its repetition over a short period of time (Devkota et al. 2017; Kim and Marcouiller 2017). Indeed, the impact of a *succession* of such disasters can be very different from the impact of a single disaster, regardless of their intensity (Berlemann and Steinhardt 2017). Along these lines, several studies have suggested a possible link between the frequency/repetition of hazards and migration (e.g., Buchenrieder, Mack, and Balga 2017; Neumann et al. 2015), but these findings are not based on in-depth empirical analysis. Due to a lack of appropriate data, only a few studies have been able to quantify the specific impact of repeated disasters (Saldaña-Zorrilla and Sandberg 2009; Bohra-Mishra, Oppenheimer, and Hsiang 2014; Safra de Campos, Bell, and Charles-Edwards 2017). In addition, the way the affected populations view their future plays a central role in their decision to move or not. However, to date, there have been no studies on the effect of expected (future) increases in the frequency of natural disasters on migration. Thus, understanding these impacts is an important area for future research and data collection efforts.

Slow-Onset Events

The effect of events such as drought, desertification, and temperature increase on migration is generally less sudden (i.e., they are slower onset) than the meteorological events just

discussed, and they are generally associated with gradually progressive departures. The literature includes case studies that provide conflicting evidence of how these kinds of slow-onset environmental changes affect migration movements. On the one hand, there are many well-documented cases of mass departures (predominantly internal displacement) in response to drought, particularly in Africa (Sahel, Ethiopia), South America (Argentina, Brazil), the Middle East (Syria, Iran), Central Asia, and Southern Asia (Miyan 2015; Piguet and Laczko 2014). Indeed, Hammer (2004) shows that the drought in Niger in 1985 resulted in the migration (displaced temporarily or permanently) of one million people.

On the other hand, other researchers have argued that the migration numbers are small relative to the numbers of people affected by drought, and that climatic push events are just one of many factors influencing migration decisions (Smith 2001; Black et al. 2011; Martin et al. 2014). Moreover, some researchers argue that migration is more a function of political issues and generally only marginally associated with environmental factors. For example, in an analysis of interprovincial migrations in Burkina Faso, Henry, Boyle, and Lambin (2003) find that environmental variables only marginally explain migration. Selby et al. (2017) find a similar result for prerevolutionary Syria.

The literature also shows that slow-onset environmental events, such as drought, may have the opposite effect, resulting in a *reduction* in migration. For example, during the mid-1980s drought in Mali, there was a reduction in international migration due to a lack of available resources to finance the migration journey (Findley 1994). Similarly, Cattaneo and Peri (2016) find that, consistent with the presence of liquidity constraints, a gradual increase in temperatures reduces international migration from poor countries. In another study of international migration, Gröschl and Steinwachs (2017) show that drought increases migration, but only for middle-income countries, which are neither rich enough to have insurance schemes nor poor enough to lack resources to migrate, suggesting that liquidity constraints play an important role in the complex relationship between climate change and migration. Kniveton et al. (2008) find that "[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."

To summarize, the evidence in the literature appears to suggest that slow-onset events, like droughts and temperature increases, tend to result either in migration that is generally perceived as being voluntary and often predominantly economically motivated or in immobility. On the contrary, fast-onset events, like floods, storms, and hurricanes, tend to lead to more sudden, involuntary, and short-term and short-distance movements.

Migration Projections

Although the number of studies linking climatic drivers and migration is growing, there is still a lot of uncertainty concerning future migration flows. There are some projections, but they generally either lack a robust scientific methodology or ignore the multiple causes of migration decisions. Some studies base projections of future migrants on the number of people that live in areas "at risk" of climate events such as sea level rise (McGranahan, Balk, and Anderson 2007). However, exposure to a climate hazard does not necessarily mean that a person will decide to migrate. For example, even if directly vulnerable to the effect of rising water levels, higher tides, or storm surges, populations located in the major river deltas and estuaries in

South Asia (lndus, Ganges Brahmaputra, etc.) and East Asia (Mekong, Yangtze, Pearl River, etc.) regions could resort to building sea defenses. In contrast, the projections of migration due to sea level rise in certain Pacific states, such as Tuvalu and Kiribati, are less uncertain, because in this case the climate-related event is virtually irreversible. If migration is the only option for affected populations, it is possible to calculate the number of persons that will be threatened by rising water levels and migrate in response (Fornalé, Guélat and Piguet 2015; Klepp and Herbeck 2016; McNamara et al. 2018).

Some studies have used statistical methods to make end-of-century projections based on historical estimates and climate scenarios. In general, these studies 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; Missirian and Schlenker 2017; Jessoe, Manning, and Taylor 2018).[3] However, these results should be viewed only as indications of future migration rather than accurate predictions. This is because these studies typically model *short-term* responses to climate-related shocks (which are different from long-term responses), whereas the further we look into the future, the greater the difference between short- and long-term responses. Moreover, short-term responses can sometimes underestimate—and sometimes overestimate—long-term responses. At the same time, a great deal of uncertainty surrounds not only the climate models used for such predictions, but also the socioeconomic scenarios. These scenarios are a major source of uncertainty for future migration projections because human migration results from the interaction between climatic, economic, political, demographic, and social drivers. For example, in the future, a larger number of people may lack the resources to finance migration because climate change has made them even more vulnerable. Thus, even if methodologically sound, statistical methods cannot always make accurate future migration projections.

Rigaud et al. (2018) conduct a state-of-the-art analysis that accounts for demographic and socioeconomic trends and climate migration scenarios and project that there will be 143 million climate migrants by 2050. However, this projection refers only to internal migration (i.e., people moving within their own countries). This suggests that the development of projections of climate-related *international* migration is an important area for future research.

Causes of Heterogeneity in Migration Responses to Climate Events

As we discussed in the previous section, the climate–migration relationship is shaped by the types of climatic events, particularly whether they have a slow or fast onset, and can be characterized by different migration responses—temporary, permanent, short-distance, long-distance, voluntary or forced migration, and sometimes immobility. However, the impact on migration also depends on the socioeconomic and political characteristics of the individuals, households, and communities exposed to the climatic events (Black et al. 2011; Martin et al. 2014). This suggests that migration outcomes are likely to differ depending on factors such as wealth, the level of financial and human capital, gender, age, health, the availability of places to move to, and the capacity to track what happens to

property and assets left behind. This heterogeneity in migration outcomes has largely been studied in the more general migration literature (Hatton and Williamson 2006). However, the findings from this literature may not apply to the case of climate-induced migration, and there has been no systematic assessment of heterogeneous migration outcomes in the context of climate change. In this section we examine how wealth and gender affect the heterogeneity of migration responses in order to identify some consistent factors in migration outcomes.

Heterogeneity of Migration Responses with Respect to Wealth

As discussed in the previous section, the capacity for migration in response to climate events is often much more limited than commonly believed because climatic shocks can increase liquidity constraints (Kniveton et al. 2008; Bryan, Chowdhury, and Mobarak 2014; Cattaneo and Peri 2016). There is sometimes a trade-off between the incentives to move and the resources needed to do so. This trade-off is particularly relevant in the context of climate-related migration, with poor people having higher incentives to migrate (because they tend to be the most exposed and vulnerable to the impacts of climate change, with limited capacity to adapt), but often lacking the resources to pay the cost of migration. Thus poorer people face a "double" set of risks—i.e., they are both unable to move away from climatic threats and especially vulnerable to their impacts (Foresight 2011; Black et al. 2011). Whether the incentives to move prevail over the liquidity constraint is an open question, which we will assess here based on the available empirical evidence.

Some studies show that low-income families are more likely to move in response to climatic events (Jayachandran 2006; Gray and Mueller 2012b; Mueller, Gray, and Kosec 2014; Mastrorillo et al., 2016), while others have found the opposite, because liquidity constraints prevent migration (Kleemans 2015; Cattaneo and Peri 2016; Bazzi 2017). This apparent inconsistency disappears when one considers the different forms that migration can take. More specifically, poor families may respond to negative climatic shocks through "survival" migration—i.e., temporary moves over short distances (Kleemans 2015). In contrast, wealthier families tend to engage in "profitable investment" migration, which involves urban moves, longer-distance migration, or even international migration, and spans a longer period of time. Kleemans (2015) estimates that migration to distant and international destinations is about four times as costly as survival migration and is thus cost prohibitive for poor people. Moreover, she finds that survival and profitable investment migration are substitutes, which means that families migrating a short distance to cope with a negative shock are less likely to invest in long-distance migration. These results suggest that future analyses should try to analyze different migration outcomes jointly rather than restricting attention to either survival or investment migration.

Because it can reduce the resources needed to move, climate change may also result in *immobility* (Findley 1994; Black et al. 2013). The notion of "trapped" populations has been used to describe those who are not able to migrate even if they wish to do so. However, in some cases, immobility may be a choice. In fact, four different paradigms have emerged to describe why people choose not to migrate in the face of climatic threats. Under the technical paradigm, immobility occurs because messages of warning are not received or a migration response is deemed to be irrational (Morrow 2009). In the socioeconomic paradigm,

marginalized groups are viewed as less able to perceive or respond to risk (Wisner et al. 2003). The psychological paradigm acknowledges the subjectivity in decision making and hence describes the lack of mobility in terms of different attitudes towards risk (Kahneman 2013). Finally, under the cultural paradigm, culturally ingrained attitudes and norms regarding risk are seen as placing self-imposed limitations on behavior (Douglas and Wildavsky 1982; Beck 1992). Nevertheless, even if immobility can, in some circumstances, be actively chosen, in many other circumstances it is clearly due to a lack of resources, as is well documented in Bryan, Chowdhury, and Mobarak (2014). The findings concerning immobility support the notion that people are trapped in place, suggesting that policymakers considering the impact of climate-related natural hazards should be concerned as much about immobility as mobility (Findlay 2012).

Heterogeneity of Migration Responses with Respect to Gender

The issue of heterogeneity of migration responses (and thus the resulting vulnerability to the impacts of climate shocks) also applies to the relationship between climate change–induced migration and gender (Chindarkar 2012). For example, female household members may be more vulnerable to climate change impacts because of unequal gender relations, access to resources, and labor opportunities, which increase their incentive to move. However, women may also have fewer opportunities to participate in the labor market than men, which reduces their ability to migrate.

Unfortunately, a clear pattern of migration responses with respect to gender cannot be identified with the available empirical evidence. Some studies find that female migration is constrained by climate change (Dillon, Mueller, and Salau 2011; Gray and Mueller 2012a; Mueller, Gray, and Kosec 2014), while others find that women are more likely to undertake labor-related migration in response to environmental change (Gray and Mueller 2012b; Thiede, Gray, and Mueller 2016; Baez et al. 2017b; Thiede and Gray 2017). As in the case of wealth, gender can be responsible for different types of migration, with some being more profitable and others being more about survival. Further research is needed in this area so that policies can be effectively targeted to address gender-related climate vulnerabilities. Finally, wealth and gender are only two of the possible factors that cause heterogeneity in migration responses. The lack of empirical analyses on heterogeneity with respect to other characteristics, such as human capital, age, and health, prevents us from drawing firm conclusions, suggesting a need for additional research on this issue.

Migration and Alternative Adaptation Strategies

Migration is only one possible strategy for adapting to climate change. Thus, in this section, we discuss the broader issue of adaptation, including the possible substitutability of migration and alternative adaptation strategies. Migration is often considered to be an adaptive measure by those who undertake it, or at least one of several adaptation strategies (Wang and Cao 2015; Alam, Alam, and Mushtaq 2016; Bawakyillenuo, Yaro, and Teye 2016; Stojanov et al. 2016; Kattumuri, Ravindranath, and Esteves 2017; McNamara et al.

2018). However, migration could also be viewed as a failure to adapt (Banerjee 2017), with the decision to migrate occurring when alternative adaptation strategies are seen as being unavailable or have failed. For example, Wodon et al. (2014) find that migration may be seen as a solution of last resort by families, because it is perceived as being more costly than other strategies such as using savings, selling assets, getting into debt, or withdrawing children from school.

An alternative approach would be to view migration as an option that opens up additional possible adaptation strategies (i.e., it helps build adaptive capacity). For example, the migration of household members may encourage the adoption of agricultural innovations that in turn act as adaptations (Karanja et al., 2016). More specifically, remittances earned by migrants may help to relax local capital constraints (in the origin location) on the adoption of innovations such as changing livestock species (from cattle to camels), introducing feed conservation measures, or introducing drought-tolerant and fast-maturing varieties of cereal crops (Damon 2010; Gonzalez-Velosa 2011).

Various options to adapt to climate change are available at both the micro and macro levels. At the micro level, adaptation to climate change can occur through investments (particularly in agriculture), by seeking employment in the nonfarm sector, or through informal networks (such as family networks that can provide credit when needed). At the macro level, adaptation can be facilitated through external policies such as food aid or credit programs. In the remainder of this section we examine the available empirical evidence on the role alternative adaptation mechanisms play—at the micro and macro levels—in increasing or decreasing migration after a climatic event has occurred. Specifically, we consider evidence concerning on-farm adaptation, off-farm adaptation through the labor market, informal credit, participation in risk-reducing networks, national social protection policies, and international development assistance.

On-farm Adaptation

For households that depend on agricultural income, investment in new cultivars and technology (such as improved seeds or irrigation) that are less sensitive to climate change provide a potential alternative to migration as a way to increase resilience and adapt to climate change. Dallmann and Millock (2017) find some evidence that Indian states that have a higher net rate of irrigation have a lower rate of migration in response to drought. Similarly, 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 irrigation access. In another study of 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 also have many fewer migrants than other households.

These findings suggest that migration and on-farm adaptation can be substitutes, with families that adapt through on-farm investment being less prone to migrate. However, this conclusion is based on only a few empirical analyses. In fact, there has been very little research on this issue, as most analyses of climate adaptation rarely model on-farm investment jointly with migration.[4] Moreover, very few studies attempt to assess whether migration occurs

before or after these alternative adaptation strategies have been put in place. Thus additional research is needed to improve our understanding of the dynamics of the relationship between on-farm adaptation and migration.

Off-farm Adaptation

Adaptation to climate events does not occur only through on-farm investments. Indeed, households that experience weather shocks may be more likely to increase their participation in the off-farm labor market, through either self-employment or wage labor (Ito and Kurosaki 2009; Porter 2012). This change from on-farm employment to wage labor often requires relocation. This type of off-farm adaptation allows not only income diversification, but also sectoral diversification (Banerjee 2017), which means that household income could be reoriented away from being very climate sensitive (e.g., because it depends on agricultural output that is influenced by climate) toward one that may be less sensitive.

There is some evidence in the literature that households migrate to diversify income due to climatic events. For example, Rose (2001) finds that adverse rainfall shocks and climatic risks are associated with increased labor market participation by Indian households. Jessoe, Manning, and Taylor (2018) examine the effects of temperature and precipitation on employment decisions in rural Mexico and find a reduction in (local) rural employment due to extreme heat. They also find that negative weather shocks induce migration to the United States and from rural to urban areas in Mexico.

These findings suggest that migration can be an important income diversification strategy, making income more stable and less susceptible to climate shocks. For example, Mueller and Quisumbing (2011) find that agricultural workers who moved into the nonagricultural sector following the 1998 flood in Bangladesh suffered smaller reductions in income than those who remained in the agricultural sector after the flood.

Informal Credit, Participation in Risk-reducing Networks, Social Protection Policies, and International Development Assistance

When financial and insurance markets are missing, as is often the case in developing countries, informal credit (received, for example, from family or friends) can serve as insurance. Credit can act as an alternative to migration because it allows the household to maintain its consumption level following a reduction in income due to a climate shock. However, credit may also increase migration because it enables households to pay the costs of migration. This means that ex ante, the effect of credit on migration is ambiguous. The empirical evidence on the effect of credit on migration is also mixed. For example, Kleemans (2015) finds that after a negative income shock, a policy of supplying credit in Indonesia worked as a substitute for migration. In contrast, Bryan, Chowdhury, and Mobarak (2014) show that credit can work as a complement to migration because without credit, households were liquidity constrained or risk averse.

Similarly, Munshi and Rosenzweig (2016) argue that in India, more developed formal insurance could substantially increase migration because it would reduce the importance of informal networks for risk-reducing purposes. More specifically, they find that in India, where caste-based rural insurance networks are in place, households that face greater rural income risks are less likely to have members who migrate. Thus these informal networks

ensure credit is available when needed, but they also discourage migration because individuals would lose their connection to these networks if they migrate.

Unfortunately, even if formal insurance is available, poor households often do not have access to it, nor do they always benefit from social protection policies (Hallegatte et al. 2016). Thus social protection schemes must be targeted to help these segments of the population cope with shocks. Otherwise the only option for poor households may be survival migration or remaining trapped in place. In an example of the benefits of well-targeted schemes, Rigaud et al. (2018) show that portable social security schemes can facilitate migration in Brazil, where social security beneficiary cards can be redeemed in many urban centers across the country. In another example, Hallegatte et al. (2016) show that existing registries for social protection schemes can be used to target poor populations, as was done in the Philippines after Typhoon Yolanda in 2013.

Governments can offer assistance or transfer compensation payments to regions affected by natural disasters or extreme weather events, which may alleviate the economic impact of such shocks. In this case, the issue of effective targeting is less of a problem because the assistance is directed to the people in the areas affected by the shock. The empirical evidence suggests that this type of assistance reduces migration by the affected population. For example, Paul (2005) finds that government disaster aid to areas affected by a 2004 tornado in north-central Bangladesh reduced the migration response. Similarly, Mueller, Gray, and Kosec (2014) find that floods in rural Pakistan have little impact on internal migration, and suggest that this finding may be due to relief programs being directed to flood victims. Chort and de la Ruppelle (2017) find that although precipitation shortages increase undocumented migration from Mexico to the United States, Mexican states with higher payments from a national fund providing assistance related to natural disasters experienced reduced migration to the United States.

International development assistance can also mitigate the migration response to climate shocks. For example, in a study of seven Latin American and Caribbean countries, Baez et al. (2017a) find some evidence that official development assistance may have reduced youth migration induced by drought.

One of the most common assistance schemes is food aid. Although there is some evidence that food aid can delay migration (Meze-Hausken 2000), unfortunately, there has been no detailed quantitative analysis of the potential substitutability or complementarity of food-for-work and free food aid programs and migration. Further research is needed in order to draw firm conclusions.

Mechanisms Underlying the Relationship Between Climate Change and Migration

The majority of studies seek to examine *whether* climate influences migration; very few contributions examine *why* and *how* climate change may affect migration. As discussed earlier, climate change can have a direct or an indirect effect on migration. Hurricanes, torrential rains, floods, and landslides clearly have a direct effect on migration. In this case there is no need to discuss why climate change affects migration. On the other hand, events like warming, progressive desertification, and droughts do not exert a direct effect on migration. In this

case we need to understand how climatic events affect other drivers of migration, such as economic and sociopolitical factors. Unfortunately there has been only limited research on this issue. In this section we review the limited available evidence on the mechanisms underlying the relationship between climate change and migration, focusing on the sensitivity of economic and sociopolitical drivers of migration to climate change.

Sensitivity of Economic Drivers of Migration to Climate Change

One of the key drivers of migration that is affected by climate change is economic. Lilleør and Van den Broeck (2011) suggest that two of the economic drivers of migration—income differentials (differences in the return to labor between origin and destination) and income variability (fluctuations in income over time)—may be sensitive to changes in climate. In the discussion that follows, we examine the empirical evidence that supports this hypothesis.

Barrios, Bertinelli, and Strobl (2010) and Dell, Jones, and Olken (2009) examined the impact of adverse climate conditions on economic growth. Barrios, Bertinelli, and Strobl (2010) find that rainfall has been a significant cause of poor economic growth in sub-Saharan African countries. Dell, Jones, and Olken (2009) find that temperature has a negative impact on per capita gross domestic product in twelve Latin American countries. These results suggest that if income falls, then the gap between income in the origin and destination countries will widen, which results in higher migration. This hypothesis is confirmed by several studies. 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, and that an influx of workers into the cities puts downward pressure on urban wages, which in turn causes workers to migrate to other countries. Feng, Krueger, and Oppenheimer (2010) provide some evidence on the linkages among climate change, crop yields (which determine farm-household income), and migration across the Mexico–U.S. border.[5] Similarly, Viswanathan and Kumar (2015) find that in India, the decline in the value of agricultural output related to weather variations increases interstate migration.

The impacts of climate change on income, and hence on migration, are stronger the higher the vulnerability and exposure of the origin countries to climate change, with the individuals and households most likely to suffer income drops being those whose income is directly or indirectly related to agriculture. In fact, because of 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. Developing countries are particularly vulnerable in this regard because they are often agriculture dependent and often lack sufficient adaptive capacity to cope with climate change impacts. For example, Dallmann and Millock (2017) show that the effect of drought frequency on interstate migration in India is stronger in states with a higher share of net domestic product from agriculture. Cai et al. (2016) show that increases in temperature in agriculturally dependent countries cause migration to Organisation for Economic Co-operation and Development countries. Beine and Parsons (2015) show that by causing a decrease in wages in affected areas in developing countries, natural disasters lead to internal migration (i.e., within countries) as well as some international migration.

There is evidence in the literature that income variability is another economic factor that is affected by climate change and that influences migration. Income variability and the risk of

income losses could induce (rural) households to use migration as a strategy to diversify income sources across sectors and thus reduce uncertainty. There is some initial evidence of migration being used as a risk-mitigating strategy (Rosenzweig and Stark 1989; Yang and Choi 2007); however, these studies did not focus specifically on the effects of environmental risks on migration. Marchiori, Maystadt, and Schumacher (2015) explicitly analyze the link between environmentally induced income variability and migration in sub-Saharan African countries, but they find that income variability has a negligible impact on migration decisions. In contrast, in a study of internal migration by Nigerian households, Dillon, Mueller, and Salau (2011) show that male household members do migrate in response to ex ante agricultural income risk that results from weather variability and shocks.

Sensitivity of Sociopolitical Drivers of Migration to Climate Change

Sociopolitical factors may also affect the relationship between climate change and migration. For example, climate change may contribute to the onset and spread of (violent) conflicts (Miguel, Satyanath, and Sergenti 2004; Buhaug 2010; Ciccone 2011; Hsiang, Burke, and Miguel 2013), which could result in migration and forced displacement (Reuveny 2008). This is especially likely when institutional responses to the environmental challenges are weak (Bernauer, Bohmelt, and Koubi 2012). For example, Kelley et al. (2015) suggest that a prolonged (and climate change–related) drought in parts of Syria exacerbated the preexisting vulnerability that was due to unsustainable land and water use practices and ineffective agricultural policies, which together led to migration.

However, the idea of a Syrian "climate war" needs to be examined more carefully before drawing conclusions about its possible connection to migration (Fröhlich 2016; Selby et al. 2017). Moreover, the relationship between migration, climate change, and conflict is particularly complex and context specific because although climate-related conflicts may indeed trigger migration, they may also restrict it. For example, during the 2000 drought in the Horn of Africa, the ongoing conflict in the region prevented pastoral nomads from moving to seek water sources, which only worsened the consequences of the drought (Simpkins 2005).

Conclusions: Policy Recommendations and Priorities for Future Research

This article has presented a synthesis of the current state of knowledge on the relationship between climate change and migration. Our review of the literature has identified the possible migration outcomes associated with different climate events. The literature finds that the most common impacts of slow-onset events are voluntary migration (both temporary and permanent) and immobility, while the most common migration outcomes of fast-onset events are involuntary migration and short-term, short-distance movements. However, the relationship between climate and migration is complex, depending not only on the type of climatic drivers, but also on economic, political, demographic, and social drivers. In fact, the research thus far suggests that climatic factors are generally only one factor in the decision to migrate. Moreover, some segments of society may be able to successfully adapt to climatic threats through migration, while other parts may not. Indeed, marginalized and

disadvantaged groups like the poor or women are often unable to move away from climatic threats. Our review of the literature also suggests that crop rotation and irrigation can partially mitigate the impact of climatic shocks on migration. Finally, income losses, income variability, and risks, all of which drive migration, have generally been found to be sensitive to climate change, which can thus potentially also result in increased migration.

Policy Recommendations

Based on the findings of our review of the literature, we next present some broad policy recommendations. First, policies need to focus on both facilitating migration and providing assistance to vulnerable segments of the population who remain in place, without locking them into areas that become increasingly unviable (Rigaud et al. 2018). This is in the interest of not only the "trapped" population, but also the country as a whole, in particular because migration is an important engine of development (Cattaneo 2009).

Thus a key policy recommendation is to take steps to increase the resilience of populations at risk by encouraging alternative adaptation strategies, including on-farm adaptation measures that mitigate the impact of climatic drivers on migration. Moreover, by implementing other development policies such as increasing the efficiency of agricultural production and improving water supply systems, governments and international development agencies can help to reduce the magnitude of drivers that are sensitive to climate change (e.g., income losses, income variability, and rural income risks) and that also increase migration.

Research Priorities

While our review of the literature has allowed us to draw some general conclusions and make some broad policy recommendations, it has also helped us to identify important gaps in our understanding of the relationship between climate change and migration, and thus areas where further research is needed. We focus here on six priorities. First, as we have discussed, much uncertainty surrounds future migration projections, in particular concerning international migration. Thus research and data are needed to improve the climate models used for predicting migration and to identify the specific characteristics of those who will be induced to migrate by climate change versus migrants more generally. Second, there is a need for case studies that analyze the specific impact of increases in the frequency of natural disasters and the way populations respond to the risk of cumulative shocks. As we have discussed, to date, there have been very few such studies because of a lack of data. Third, future analyses should try to analyze different migration outcomes jointly rather than focusing on either survival or investment migration. This would improve our understanding of the heterogeneity of migration responses with respect to wealth and gender. Fourth, research is need on the other causes of heterogeneous migration responses, such as levels of human and financial capital, age, and health. Fifth, more research is needed on the impacts of social and development assistance programs, in particular food-for-work and free food aid programs, on migration. Finally, another important topic for future research is developing a better understanding of the dynamics of the relationship between on-farm adaptation and migration, in order to understand whether migration occurs before or after on-farm adaptation strategies are put in place.

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