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Human Migration in the Era of Climate Change

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Migration is one response to climatic stress and shocks. In this article, we review the recent literature across various disciplines on the effects of climate change on migration. We explore key features of the relationship between climate change and migration, distinguishing between fast onset and slow onset climatic events and examining the causes of heterogeneity in migratory responses to climate events. We also seek to shed light on the interactions between different types of adaptation to climate events as well as the mechanisms underlying the relationship between climate change and migration. Based on our review of the existing literature, we identify gaps in the literature, present some general policy recommendations and priorities for research on climate-induced migration.

Jel code: R23; F22; Q54

Keywords: Migration; Climate Change; Adaptation

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’) (IPCC, 2018). Aside from the increase in average temperature and changes in precipitation patterns, rising sea levels and extreme weather events, such as heatwaves, 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 (IPCC, 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 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 the recent years, the influence of climate change on migration has been investigated by a growing body of literature. However, a complete understanding of the complex relationship between climate change and migration is far from being reached. There is no unified theoretical approach as yet which 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. 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 difficulty is related to the fact that short term responses to climatic drivers differs from long term responses and this makes it difficult to generate migration projections.

In the context of climate-induced migration there are also issues that have strong policy implications and at the same time received little systematic discussion in the literature. Migration is only one of the possible adaptation strategies to climate change. On-farm adaptation, informal credit (from participation to risk-sharing networks) and social protection policies are possible ways to adapt, and these forms of adaptation can both complement or substitute for migration when a climate shock occurs. Moreover, different

mechanisms may explain why climate change translates into migration. Climate change can affect income differentials between origin and destination countries, can increase economic uncertainty, or can influence socio-political factors. All these factors can in turn contribute to increase or lower the probability of migrating.

The purpose of this article is to examine the literature within various disciplines in order to advance our understanding of the complex relationship between climate change and migration. To this end, the paper is able to describe some regularities in the relationship between climate change and migration, identify gaps in the literature and recommend priorities for policy and future research in this area. More specifically, the paper will assess the empirical evidence on the effects of different types of climatic events on different types of migration; it will examine the causes of heterogeneity in migratory responses to climate events; it will shed light on the interactions between different types of adaptation to climate events as well as the mechanisms underlying the relationship.

LINKS BETWEEN CLIMATE DRIVERS AND MIGRATION

Different types of events are connected to climate change and different forms of migration exist. In this section we will synthesize the state of knowledge to better understand 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 distinguishes 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

¹ Moreover, as we will discuss in the penultimate section, it has been argued that events like droughts may exacerbate conflicts over resources, possibly contributing to violence, which may then force people to migrate.

onset events and between direct and indirect impacts and voluntary and involuntary movement. In the remainder of the section, we describe the different 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 such migration will not occur in the future.

The climate change literature recently recognized that not only the occurrence of a single fast onset event but also its repetitions in a short interval of time will have important impacts on populations' livelihoods and thus migration (Kim and Marcouiller, 2017; Devkota et al., 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 (citations?). Along these lines, several studies have mentioned a possible link between the frequency/repetition of hazards and migration (e.g., Buchenrieder, Mack, and Balga, 2017; Neumann et al., 2015), but these 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; Safra de Campos, Bell, and Charles-Edwards, 2017; Bohra-Mishra, Oppenheimer, and Hsiang, 2014).

² As we will discuss in the next section, the human responses to climate change depend not only on the type of event but also on the availability of resources. Marginalized segments of society tend to be immobile or mobile only in the short term because of a lack of resources, whereas other segments of the same society may be able (and willing) to diversify their income and life choices to move further and long term.

In addition, the way the affected populations view their future plays a central role in their decision to move or not. No studies however exist on the effect of expected (future) increases in the frequency of natural hazards on migration. Thus, understanding such impacts on migration 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 human 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 contrasting 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 (citations?). 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 pre-revolutionary Syria.

The literature also shows that slow-onset environmental events, such as drought, can also 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 emigrate, 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 in either 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 automatically 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 (Indus, Ganges Brahmaputra, etc.) and East Asia (Mekong, Yangtze, Pearl River, etc.) regions can resort to building sea defences. The projections of migration due to sea level rise specifically in certain Pacific states, such as Tuvalu and Kiribati, on the contrary are less uncertain, because in this case, the climate-related event is virtually irreversible. If migration becomes the only option for affected populations, it is possible to calculate the number of persons that will be threatened by rising water levels

and consequently migrate (Fornalé, Guélat and Pigué, 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; Jessoe, Manning and Taylor, 2018; Missirian and Schlenker, 2017).³ However, these results should be viewed only as indications of future migration, rather than accurate predictions, because they typically model *short-term* responses to climate-related shocks, whereas the further we look into the future, the greater the difference between short- and long-term responses. Short term responses are different from long term responses. Moreover, short-term responses can sometimes underestimate the long-term responses and sometimes overestimate them. 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 accurate from a methodological perspective, 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

³ Missirian and Schlenker (2017) examine the effect of temperature fluctuations on refugees. However, refugees are only a small fraction of total migration flows, are pushed to migrate by persecution, war, or violence, and mainly originate from a limited number of countries.

As we have 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 characterised by different responses, like temporary migration, permanent migration, short-distance, long-distance, voluntary or forced and sometimes immobility. However, the impact on migration also depends on the socio-economic and political characteristics of the individuals, households, and communities exposed to the climatic events (Black et al., 2011; Martin et al., 2014). This implies that the migration outcomes can differ depending on 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 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 the causes of different migration responses based on wealth and gender in order to identify some regularities 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 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 incentive prevails over the liquidity constraint is an open question that will be assessed below using 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, 2012a; 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 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. This result suggests that future analyses should try to analyse different migration outcomes jointly and do not restrict the attention to either survival or investment migration.

Because it can reduce the resources needed to move, climate change may also generate *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 socio-economic 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 behaviour (Beck, 1992; Douglas and Wildavsky, 1982). 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, and suggest that policy makers 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 consequently 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 labour opportunities, which increase their incentive to move. However, women may also have fewer opportunities to participate in the labour market than men, which reduces their chances of migration.

Unfortunately, a clear pattern of migration responses with respect to gender cannot be designed with the available empirical evidence. Some studies find that female migration is constrained by climate change (Dillon, Mueller and Salau, 2011; Gray and Mueller, 2012b; Mueller, Gray and Kosec, 2014), while others find that women are more likely to undertake labour-related migration in response to environmental change (Gray and Mueller, 2012a; Thiede, Gray and Mueller, 2016; Baez et al., 2017a; Thiede and Clark, 2017). As in the case of wealth, gender can be responsible for different types of migration, with some being more profitable and other being more 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 possible factors that cause heterogeneity in migration response. The lack of empirical analyses on the heterogeneity with respect to other characteristics, such as human capital, age, health, prevents any conclusion and calls for additional research.

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 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, 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 consider migration as an option that opens up additional possible adaptation strategies, i.e., that it builds adaptive capacity. For example, the migration of household members may enhance 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 area 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 crop (citations?).

Different options to adapt to climate change exist and are available at both the micro and macro level. At the micro level, adaptation to climate change can occur through investments (particularly in agriculture), by seeking employment in the non-farm sector, or through informal networks (such as family networks that can ensure credit in case of need). 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 played by alternative adaptation mechanisms at the micro and macro levels in increasing or decreasing migration after a climatic event occurred. Specifically, we consider evidence concerning on-farm adaptation, off-farm adaptation through the labour 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 a substitutability of migration and on-farm adaptation, with families adapting through on-farm investment being less prone to migrate. However, this conclusion is drawn using only few empirical analyses. Very little research in fact has been done on this issue, as most analyses of climate-adaptation rarely model on-farm investment jointly with migration.⁴ Moreover very few studies try to assess if migration occurs before or after these alternative adaptation strategies are put in place. 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 might be more likely to increase their participation in the off-farm labour market, through either self-employment or wage labour (Ito and Kurosaki, 2009; Porter, 2012). This change from on-farm employment to wage labour often requires relocation. This type of off-farm adaptation allows not only income diversification but also sectoral diversification (Banerjee, 2017), which can mean

⁴ To the best of our knowledge, the majority of studies restrict their attention to either migration or on-farm investments as possible strategies to adapt to climate change.

that household income is re-orientated from being very climate-sensitive (e.g., because it depends on agricultural output that is influenced by climate) to one that may be less sensitive.

There is some evidence in the literature that households migrate to diversify income as a consequence of climatic events. For example, Rose (2001) finds that adverse rainfall shocks and climatic risks are associated with increased labour 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 US and from rural to urban areas in Mexico.

These findings suggest that migration is an important income diversification strategy, that allow to make income more stable and less susceptible to climate shocks. For example, Mueller and Quisumbing (2011) find that agricultural workers who moved into the non-agricultural 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, friends or community members) 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 works as a substitute for migration. On the contrary, 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. These informal networks ensure credit in case of need but discourage migration because individuals would lose the connection with the network by migrating.

Unfortunately, even if available, poor households often do not have access to formal insurance nor do they always benefit from social protection policies (Hallegatte et al., 2016). Thus, social protection schemes must be well 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 centres 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, since the assistance is directed to the persons hit by the shock. The empirical evidence suggests that this type of assistance reduces migration of 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 U.S., 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. (2017b) 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 is 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: FROM CLIMATIC CHANGE TO 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 outlined at the beginning of this article, climate change can have a direct or an indirect effect on migration. Hurricanes, torrential rains, floods, and landslides have a direct effect on migration because they manifest themselves in a direct manner. In this case, there is no need to discuss why climate change affects migration. On the contrary, events like warming, progressive desertification, and droughts do not exert a direct effect on migration. In this case, understanding the mechanisms requires an understanding of how climatic events affect other drivers of migration, such as the economic and socio-political drivers. In this last section we review the evidence on the mechanisms underlying the relationship between climate change and migration. To respond to this question, which has been little researched, we will focus on the sensitivity of economic and socio-political drivers 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 labour between origin and destination) and income variability (fluctuations in income over time) -- may be sensitive to changes in climate. We examine the empirical evidence in the literature that gives support to 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 determinant of poor economic growth in sub-Saharan African countries. Dell, Jones and Olken (2009) find that temperature has a negative impact on per capita GDP in twelve Latin American countries. These results suggest that if income in the origin country 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-US border.⁵ Similarly, Viswanathan and Kumar (2015) find that in India, the decline in the value of agricultural output related to weather variations increases inter-state migration.

The impacts of climate change on income and consequently 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. For example, Dallmann and Millock (2017) show that the effect of drought frequency on inter-state 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 causes migration to OECD countries. Beine and Parsons (2015) show that by causing a decrease in wages in affected areas, natural disasters lead to internal migration (i.e., within the countries) as well as some international migration in developing countries. Developing countries are often agriculture dependent and often lack sufficient adaptive capacity to cope with climate change impacts.

⁵ However, the methodology used has raised some concerns (Auffhammer and Vincent, 2012).

There is evidence in the literature that income variability is another economic factor that is affected by climate change and that influence 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 analyse 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. On the contrary, 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 Socio-political Drivers of Migration to Climate Change

Socio-political 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; Hsiang, Burke and Miguel, 2013; Ciccone, 2011; Buhaug, 2010), 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 pre-existing 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 on its possible relation to migration (Fröhlich, 2016; Selby et al., 2017). Moreover, the relationship between migration, climate change, and conflict is particularly complex and context specific, because climate-related conflicts may trigger migration, but at the same time may restrict migration. 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 synthesized the state of knowledge on the relationship between climate change and migration focusing on four important sub-topics, each discussed in the different sections of the article. In the first section, we discussed the effect of the different climatic drivers on different forms of migration; in the second, the causes of heterogeneous migration responses based on wealth and gender; in the third, the possible substitutability of migration and alternative adaptation strategies; in the fourth, the mechanisms underlying the relationship between climate change and migration. Based on our review of the literature, in this section we summarize the outcome, identify policy implications and discuss research priorities in this area.

This review has identified different possible migration outcomes associated with the different climate (!) events. As a consequence of slow onset events, the most common outcomes are voluntary migration (both temporary and permanent) and immobility, while a consequence of fast-onset events are involuntary migration and short-term, short-distance movements. The relationship between climate and migration however is complex and depends 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. Some segments of society may be able to adapt successfully to climatic threats through migration, while other parts may not. Marginalised and disadvantaged groups like the poor or women are often unable to move away from climatic threats. Another result of this review is that crop rotation and irrigation can partially mitigate the impact of climatic shocks on migration. Finally, income losses, income variability, and risks, which drive migration, have generally been found to be sensitive to climate change, which can thus result in increased migration.

Policy Challenges and Recommendations

Based on the findings of our review of the literature, we present some broad policy recommendations.

First, policies need to focus on both facilitating migration and providing assistance to vulnerable parts 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, especially because migration is an important engine of development (Cattaneo, 2009).

Thus, a key policy recommendation is 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. At the same time, by implementing policies that increase resilience, by increasing the efficiency of agricultural production, and improving water supply systems, governments can help to reduce the magnitude of those drivers (income losses, income variability, and risks) that are sensitive to climate change and at the same time increase migration.

Research Priorities

While our review of the literature has allowed us to draw some general conclusions and policy recommendations, it has also helped us identify important gaps, 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 analyse the specific impact of increases in the frequency of natural hazards 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 analyse different migration outcomes jointly and to not restrict the attention to either survival or investment migration. This would guarantee a better understanding of the heterogeneity of migration responses with respect to wealth and gender. Fourth, future research should also try to analyse additional causes of heterogeneity such as human capital, age, health. Fifth, more research is needed on the impacts of social assistance, 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, to understand if migration occurs before or after on-farm adaptation strategies are put in place.

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