Framing the Frame:

Cause and Effect in Climate-related Migration*

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Abstract

Analytic frames shape the *causality* we identify in climate-related crises. Here we contrast examples from two primary categories of analytic frames, which we label '*Environmental-Drivers*' and '*Social-Causal*' to draw attention to the implications of each frame with regards to causality. We explore each frame via cases of 'climate-related' migration. The article illustrates that each analytic frame carries implicit causal assumptions that prefigure causal findings. Analysis can be done within either category of frame; yet the findings, however rigorous, remain contingent on the chosen frame and its assumptions. An *Environmental-Drivers* model will hold the social context as fixed and quantify the incremental damages of a measure of climate change, while a *Social-Causal* model will show how damages are generated by social vulnerability and its antecedents. The latter may show that a given climate event may have no effect on a secure population but lead to massive damages among the vulnerable – and thus that the damage cannot be solely attributed to the climate event. Frame choice is normative as frames prefigure causes, potential solutions, the locus of responsibility, and suggested policy interventions. The article poses the question of how a productive dialogue between these two frames can be generated and recommends that causal predisposition of models be made explicit so that the findings they indicate can be understood as partial to the choice of models. As causal findings imply policy options, making the assumptions explicit while exploring the directions that other models would point in, will help broaden the range of possible policy responses.

Keywords: *climate change, migration, causality, vulnerability, risk, disaster, crisis, normativity*

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Introduction: Presumptive Causality in Analytic Frames

Today, within academia, policy circles and among the broader public, there is widespread discussion about the implications of human-driven climate change for dislocation, economic loss, hunger and famine, as well as migration. Yet, despite the preeminence of this question within public discourse, there is strong disagreement on the extent to which environmental change – which can include changes that are neither climate related nor human driven – contributes to damages or migration flows, and, in particular, to what extent environmental factors may be considered as having independent causal power. In this article, we discuss these issues and distinguish different perspectives on the interacting roles environmental and social factors play in migration. We primarily consider climate-related environmental change, mindful of the challenges that human-driven climate change poses to societies across the world. While the framing issues we explore have been reviewed for other environment-related crises (from O'Keefe et al. 1976 onward), they persist in the climate-change literature and are now prevalent in migration studies that interrogate the role of climate in displacement.

We contrast two common archetypical analytical frames for assessing the role of environmental change in migration. These frames differ primarily in how they analyze causation in the context of environmental shocks or change, referred to here as hazards. The first position, rooted in commonly used climate-centric 'impact' analyses and largely relayed in the media, policy think tanks and development agencies, takes social factors as fixed arrangements that are struck by a dynamic hazard. The conditions on the ground, such as vulnerability, are simple descriptions of the situation that the hazard finds in place. These conditions are not seen as themselves having a causality relevant to the

analysis.[1] The hazard arrives, strikes a fixed 'snapshot' situation, and damages or other changes, such as out-migration, unfold. In other words, this frame is concerned with the amount of damage due to an incremental change in environmental conditions prevalent in a given place. This frame is generally, though not systematically (e.g., Beine and Parsons 2015; Cattaneo and Peri 2016; Cottier and Salehyan 2021; Schutte et al. 2021; Flores et al. 2021), associated with claims that human-driven (anthropogenic) climate change is already causing many to leave their homes, as a result of, for example, decreasing crop and pasture productivity, increasingly inhospitable living conditions and subsequent food and economic insecurities (e.g., Barrios et al. 2006; Marchiori et al. 2012; Cai et al. 2016; Missirian and Schlenker 2017; Falco et al. 2019; Hoffmann et al. 2020; Helbling and Meierrieks 2021). A case in point is the recent investigation on international migration out of Central America by the *New York Times* and *ProPublica*, which warns that climate change will lead to what will "almost certainly be the greatest wave of global migration the world has seen" (Lustgarten 2020).[2]

By contrast, a second analytical frame perceives the effects of climate change and environmental factors on migration and damage as intrinsically tied to the social context, in which they occur (see for instance Boas et al. 2019; Bell et al. 2021, Franke and Chasin 1980 – among many others). Frequently associated with raising the profile of societal factors, this frame locates causality in the antecedent conditions that enable a natural or anthropogenic climate hazard to push people from their homes, and mediate its impact. Rather than attempting to measure the effects of the hazard on a given people or communities, it asks why people were exposed and vulnerable to the shock in the first place and does the social context channel the damages wrought. Under this frame, the social, economic and

[1] We acknowledge that many studies may not be neatly classified into one or the other frame of reference. In fact, several studies located under the *Environmental-Drivers* investigate the presence of heterogeneities in migration response to climate variability (e.g., agriculture, wealth, conflict) (e.g., Falco et al. 2019, Cottier and Salehyan 2021). Yet, by design, these studies only examine how migration differ in response to a narrow set of factors, selected in advance by the investigators, leaving the broader social context fixed. Such a narrow investigation differs in substance from a place-based investigation undertaken as part of the "Social-Causal" frame, which seeks to comprehensively trace the ensemble of antecedent conditions, integrating the causes of the social conditions into the causal model.

[2] See critiques of such environmental determinist arguments by O'Keefe et al. 1974; Peet 1985; O'Brien et al. 2007; Hulme 2011, Blaikie et al. 1994; Ribot 1995.

political factors responsible for the predisposition of the system are the causes of migration/displacement, with the hazard itself being perceived as an immediate triggering factor. In other words, the causes are located in the social arrangements that allow the same hazard to launch great devastation in a vulnerable community but to have no effect where people are secure. Here, cause is in society as the impact of climate depends on the pre-existing place-based conditions and vulnerabilities on the ground that enable a climate hazard to launch out-migration (for the origins of this vulnerability model see Sen 1981; Watts 1983; Watts and Bohle 1993; Blaikie et al. 1994; Ribot 1995, 2014). The fundamental question in this frame is then *why* people are on the sill of disaster rather than being secure? Concerning migration, this position also draws attention to explaining the ability and desire of people to leave (or not) in the face of both climate variability and change. We label the first causal position as *Environmental-Drivers* (commonly known as "hazards" or "impact" approaches) and the second position as *Social-Causal* (often referred also as "vulnerability" analysis).[3]

The following two studies illustrate each frame. First, for an *Environmental-Drivers* example, Mueller et al. (2020) examine the effects of temperature and precipitation on migration in three countries in Eastern and Southern Africa, holding the spatial (district) and temporal (census year) context, constant. The authors find that higher temperature correlates with a decrease in migration in Botswana, while higher precipitation increases migration in Botswana and Kenya, but decreases migration in Zambia.[4] A central aspect of this analytical frame is its capacity to evaluate and predict the incremental 'impact' of small changes in temperature or precipitation, yet it does not allow for a full accounting of the influence of the social context. Second, for a *Social-Causal* example, Ribot et al.

[3] We acknowledge that the *Environmental-Driver* frame is generally employed by researchers working in the fields of economics or physical sciences, while the *Social-Causal* frame sees larger uses in disciplines, such as anthropology. At the same time, other disciplines, such as geography, sociology or political science, witness a wide use of both frames. Moreover, the two causal analytical frames accommodate both quantitative and qualitative methods as part of their investigations. Thus, disciplinary differences regarding the preferred causal frames cuts across, without changing, the present discussion.

[4] Their analysis further suggests that these flows may be associated with changes in economic activity that are related to climate variability (Mueller et al. 2020).

(2020) examine the case of Senegal, where the price of rural products is set below subsistence by government and government-supported intermediaries and some farmers remain in debt after usurious advances on seed and fertilizers are deducted from their sales. Market access and fair prices for producers would enable farmers to invest in their own security, including with regards to adverse environmental impacts brought about by climate change. In contrast, farmers have little surplus to invest locally and that the few who manage to save choose to migrate. Cause of vulnerability is not merely in proximate poverty but is rooted upstream in systematic extractive policies. In this case, a period of drought might trigger crisis by pushing already vulnerable farmers, living too close to the edge, off the cliff of precarity. While this frame illuminates how the damage wrought by a hazard is dependent on the local context, it also has limitations. For instance, its ability to predict future damage in other contexts is severely dampened as a result of the complex, location-specific chains of causation analyzed.

At the core, these two analytical frames differ with regards to the locus of causality. While it does not reject other factors having mediating effects, the *Environmental-Drivers* frame places the *cause* primarily within the hazard – by taking the socially generated setting as a given and fixed starting point. By contrast, the *Social-Causal* frame locates the *cause* within the chain of events that generated the local conditions and the ways in which it created or failed to prevent the exposures and fragilities called vulnerability – assigning little, if any, independent causal power to environmental factors. The framing discussion we raise has appeared previously under different forms (e.g., O'Keefe et al. 1976; Blaikie 1985; Ribot 1995; O'Brien et al. 2007; Füssel and Klein. 2006; Forsyth 2008). Nevertheless, with the ongoing academic and public debate on environmental migration, especially in relation to human-driven climate change, and their implications for public wellbeing, it remains important to draw attention of the scientific community to the ways their chosen analytical frames of causality shape policy implications of their research. For instance, many analysts and journalists have suggested that

the 2015 refugee crisis in Europe was at least partly the result of climate change (e.g., see The Guardian 2015), while similar claims have been made about migration to the US from Central America (e.g., see Washington Post 2018). This paper is thus a timely demonstration of how frames of causality continue to have new implications for the locus of causality in research, designing public policies, as well as assigning responsibility and blame (Lahsen and Ribot 2021).

In the ensuing text, we first discuss how each of these two perspectives differ with respect to their policy implications and implicit weights assigned to causal factors. We then successively explore how these two perspectives conceive causes of migration in order to illustrate some of their implications for policy and practice. We do not attempt a complete literature review of analytic frames or of migration, but discuss how causality is addressed in two concrete and rival conceptualizations of the role of climate change on migration: the *Groundswell* project of Rigaud et al. (2018), which models climate migration at a national and global scale, and Ribot et al.'s (2020) work on vulnerability and migration rooted in fieldwork in eastern Senegal. These two studies exhibit different approaches informed by different goals. The Groundswell project seeks to quantitatively model and project migration flows at national and international scales without explicitly addressing local conditions or personal decision making. It sets out to show the influence of climate change in migration. In contrast, the Ribot et al. study seeks to understand how the decision to migrate or not in one location is rooted in prevailing social conditions and does not attempt to build a predictive quantitative model of the migration 'impact' of climate variability and change. This frame sets out to identify the social processes and material conditions that inform the decision to depart. We chose these two frames as they represent, arguably, archetypes of each causal frame, and have been widely discussed in not only

academia, but also within policy fora and the broader public.[5] While many studies of environmental migration depart from these two archetypal representations, it remains that every investigator must choose, consciously or not, at the outset within which causal analytical frame his/her analysis will be grounded.

Finally, we consider how other methodological approaches, and specifically agent-based modeling, attempt to bridge these analytical frames and meet the challenge posed by Black et al. (2011) to explicitly model complex interactions between environmental and social drivers that lead to migration outcomes. While we do not believe it is possible to integrate both frames, we suggest that a cautious use of ABMs may promote dialogue between these, by enabling researchers to examine how the incremental change of a disaster on migration may be underwritten by different antecedent conditions. As a word of caution, while we contrast the *Environmental-Drivers* and *Social-Causal* frames in the ensuing text, we recognize that most studies in the literature, while fitting into one of these approaches, acknowledge elements of the other. Acknowledgement, however, is not enough. It is imperative to also query the implications for findings, and thus for policy, of how these different elements are integrated and used in causal models. With this in mind, we seek to highlight the implications of each frame with regards to causality.

Models, Values and Policy

The two causal frames imply different policy. In spite of a lack of consistent findings about the implication of climate change for future migration, the *Environmental-Drivers* position is often used in

[5] We note that these two studies not only differ in terms of frames of causality, but also as regards the form of migration examined: permanent internal migration for the *Groundswell* (Rigaud 2018)*;* permanent international migration for Ribot et al.'s study (2020). While these differences with regards to the focus of investigation of each study are significant, there are of little relevance for the present discussion. In effect, neither frame of causality is more applicable than the other when it comes to the form of climate-induced migration considered by researchers.

the public discourse (e.g., media, policy briefs) to convey the message that mitigating climate change is crucial to prevent future migration, which is presented as problematic. Policies advocated under this frame generally focus on interventions aimed at mitigating the impact of climate change and natural hazards, such as providing weather information to farmers, introducing drought-resistant crops, promoting sustainable agriculture and forestry practices or designing disaster risk reduction strategies specifically targeted at protecting against climatic stressors.[6] One critique of these policies is that they disregard the importance of social and economic agency and structures, as well as political institutions, in shaping vulnerabilities behind crises and migration flows. Accordingly, the *Environmental-Drivers* frame risks advocating climate-proofing policies that work at the margin, but provide little redress to the underlying social precarities or incentives that make migration likely – or that make any climate-related damages possible. In contrast, the *Social-Causal* frame relegates stressors to the role of trigger while focusing attention on the factors that enable or disable people from adapting and preparing for trends and extreme weather events (Ribot 2014).

The difference in implications for policy between these frames is key, as policy depends on which variables are considered subject to human manipulation. The *Environmental-Drivers* tends to focus on adaptation to climate and also sees anthropogenic climate change as manipulable – and adapting to, and restricting climate change is often a motive of hazards analysts. The *Social-Causal* frame views vulnerability or precarity that prefigure any climate hazards as socially generated. For future policy guidance and attribution of blame and responsibility it is important to take all socially manipulable elements, including those that effect the climate, into account.[7] Whichever frame analysts choose

[6] On weather information, see Carr et al. 2017. For sustainable forest practice, see the Swiss Development Agency 2013. Another illustration is the Great Green Wall project, which aims ostensibly at planting trees across the Sahel to restore degraded land and preventing environmentally-induced migration (The Guardian 2017).

[7] A way around this division would be to hold as constant the things that humans cannot influence while attributing causality to all elements that are subject to human manipulation. This 'sociodicy' – attention to those elements that are socially manipulable -- allows us to identify a full range of possible policy implications (Ribot 2014). It also allows the analysis of what could have been done (i.e., was a matter of social decision) and what was done (as matter of the locus of blame or credit —and thus responsibility).

shapes policy options and decisions. A full policy analysis would attend to the policy manipulable causes of precarity found in place and the causes of climate stressors, including any human-driven component. For damages, both hazard and vulnerability must be considered (Wisner et al. 2004).

Climate change is emphasized by an *Environmental-Driver*s analysis while social factors, such as political institutions, social networks, race and ethnicity, gender, education, opportunity, wage differentials, exploitation, are emphasized in a *Social-Causal* approach. As frames embed causes that have policy implications with social consequence, the choice of analytic frame is related to value- and knowledge-based judgements (including implicit ones) by the analysts concerning the feasibility and desirability of different 'solutions'. The choice may also be influenced by the implications of the analysis for broader attention to the issues with which the analysts are concerned or know about. The statement that a climate event causes a social outcome is not an objective scientific fact. It is a choice of variable weights (including presumptions about which variables are 'active' or 'given') that are implicit in each analytic frame – as in the *Environmental-Drivers* approach that takes the social conditions as given and examines the 'impacts' of the climate event in that setting, or the *Social-Causal* approach which may hold the hazard constant while explaining the social causes of the arrangements the hazard find in place. Once the frame is chosen – a normative choice – then the analysis conducted within it can be done with scientific rigor. But the very choice of the frame cannot be taken as a value-neutral scientific decision.[8] All approaches embed distinct normative stances, whether or not the analyst is aware that their choice is value laden.

Environmental-Drivers **as hazard models**

[8] On the choice of scientific frames concerning environmental analytics, see Dewey 1925; O'Brien et al. 2007:76; Forsyth, 2011; Thomas et al. 2019: 2. Frames for the analysis of any social outcome – such as disaster – are always chosen on normative grounds (Bates et al. 1998; Sayer 1992).

Models based on the *Environmental-Drivers* frame examine how a given variable, such as migration, responds incrementally to changes in environmental conditions (e.g., higher temperature) or to a natural hazard (e.g., a flood event). Often built on statistical or econometric approaches, their perspective is inherently mechanistic from a theoretical standpoint as they conceive of damage as being a direct function of an environmental shock that a social system is exposed to. Under this analytical frame, any hazard followed by an effect is a *cause*. In this sense, this analytical frame is closely associated with the well-known *potential outcome* model of causal inference, predominant in quantitative social sciences (Rubin 2005). Unlike the *Social-Causal* analytical frame, *Environmental-Drivers,* thus, sees causality as an intrinsic property of spatially and temporally discrete environmental events, which can be empirically measured (i.e., average monthly temperature, extent of flooding events, etc.). In this perspective, a causality effect is defined, thus, as the difference between the outcome (damages) in presence of an environmental hazard, compared to the outcome (damage) that would have occurred in absence of this environmental hazard, holding everything else constant.

The *Groundswell* project provides a useful illustration of *Environmental-Drivers* models. Based on a predictive approach, it models future migration flows within a 'gravity-model' framework (for details on the method, see Rigaud et al 2018). To do so, it builds on a historical record of movement from places of lower to higher population density (e.g., rural to urban). In general, gravity models can be adjusted to allow places to be more or less attractive in view of different factors (e.g., common language, wages, etc.). In the *Groundswell* report, climate variables are allowed to influence the attractiveness or desirability of places, and hence migration patterns. For example, climate change impacts crop yields and water availability. In turn, these factors influence the movement of people between places. To unpack the effects of climate change on migration and predict the number of future migrants resulting from climate change, the authors compare the magnitude of migration flows predicted under a non-changing climate scenario to those modeled under a warming climate scenario.

[Figure 1 about here]

Figure 1 shows the schematic of the modeling procedure taken from the Groundswell report. The climate influence is mapped out on the right-hand side: climate simulations are fed into models that, using local characteristics, simulate crop yields and water availability and these then influence the desirability of places to stay at or move to. The social (e.g., migrant networks, diasporas), political (e.g., conflict, migration policies) and economic drivers of migration (e.g., wage differentials, unemployment) are not explicitly modeled and their influences are embedded in the historical changes in population distribution, urbanization and economic growth, on which the model is trained.

Unlike the *Social-Causal* frame, a key aspect of this analytical frame is that it allows analysts to quantify the relative contributions of climate variability to migration, *when other factors are held constant, as well as make predictions about the number of migrants, which may be induced to leave under a set of different climate-warming scenarios*. For the case of East Africa, the authors of *Groundswell* report that climate change will increase the number of internal migrants by 10 to 20% by 2050. In a related, but distinct, projection of Central America to US migration conducted by the lead modeler of *Groundswell* in collaboration with the *New York Times*, the authors enlarged the focus to examination of international migration flows.[9] The results suggest that "climate change alone" will increase the number of migrants from Central America to the United States by about 5% over the same period (Lustgarten 2020). In these reports, as in many studies, while the message focuses on the climate component of migration, in the text the authors clearly underscore that social, economic and political drivers of migration have a larger impact than environmental ones. Hence, there is a potential discrepancy between the conclusion of the model with

[9] The Groundswell project did not examine international migration flows. This latter project in Latin America is not associated with the World Bank.

regards to quantifying and mapping potential climate migration patterns and the policy messages included in the report and circulated among the broader public.

It is important to note that in this perspective the climate and social influences are not integrated. The *Environmental-Drivers* frame does not see social factors and their configuration as having relevant causality. Thus, they are taken as static elements of a given landscape in which stressors occur and decisions to migrate are made. As a concrete illustration, how yields are converted into prices at which farmers sell depends on many social factors. For example, if rising yields do not convert into rising livelihoods because prices are fixed by powerful middlemen, or because land-tenure arrangements prevent them from benefiting from increasing crop prices, farmers might feel the only option is to migrate. At the same time, households near or below subsistence levels may decide against migrating in view of the inherent risks (Bryan et al. 2014) or lack of means (Ribot et al. 2020).[10] More importantly, these models do not take social and political-economic arrangements as themselves having causes (or needing to be explained) via an analysis of the broader social, economic and policy environment that enables or disables farmers to influence policies, access markets, or to own their land.

In general, the *Groundswell* report is representative of a broad series of studies, that share this analytical frame. Going back to early work by Myers (1993), a number of other scholarly works, originating from different fields of research and drawing on distinct methods, have adopted this analytical frame to study the causal impact of climate change and variability on migration. For instance, Barrios et al. (2006) report evidence for an effect of rainfall on migration in Sub-Saharan Africa channeled through the agricultural sector. Similarly, works by Marchiori et al. (2012), Cai et al. (2016), Falco et al. 2019,

[10] It should be noted that we do not wish to imply that researchers utilizing the *Environmental-Drivers* frame deny the role of contextual factors. In fact, many recognize the importance of the context in shaping migration outcomes, but they are primarily interested in examining the average effects of environmental change on migration (as opposed to individual/location specific effects), which is often of particular importance to policymakers and practitioners.

and Hoffmann et al. 2020 suggest that higher temperature induces more people to migrate internationally.[11]

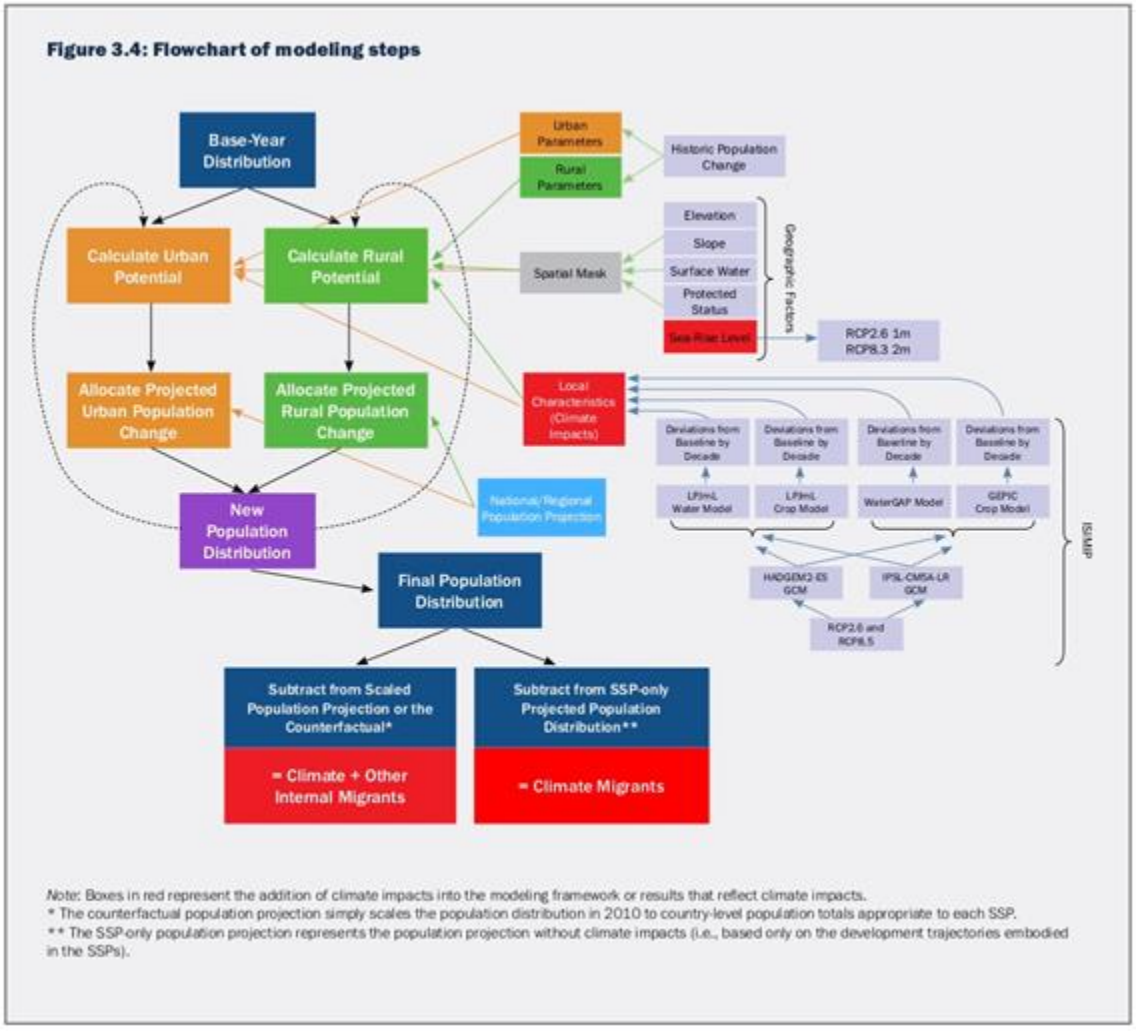

Figure 1 Schematic diagram of how climate migration is modeled in the Groundswell project (Rigaud et al. 2018: 64).

[11] While this analytical frame is frequently associated in the media with claims linking climate change to migration, it does not, in fact, presuppose any conclusion about the association between climate change and migration (e.g., Beine and Parsons 2015; Cattaneo and Peri 2016; Cottier and Salehyan 2021).

Social-Causal model of climate-associated migration in a Vulnerability Model

While it is clear that climate can have an impact on agriculture and other environment-based livelihoods, the conditions under which those livelihood effects translate into crisis or into migration must be specified – outcomes would differ greatly depending on many other elements of security, such as assets and social security systems (Sen 1981). So, in contrast to the *Environmental-Drivers* analytical frame, *Social-Causal* models vary the social, economic and political drivers, demonstrating that under different security conditions, climate change would trigger greater or lesser migration – or none at all (Franke and Chasin 1980; de Haas 2011; Lucht 2012; Vigh 2009). Explanations of causality refer not only to environmental variables, but crucially to the social and political-economic conditions of vulnerability. Hence, proponents of a *Social-Causal* frame argue it is not possible to evaluate the causal role of climate for the portion of migration increase, as the extent of the migration is predicated on and mediated by the conditions in place. The *Environmental-Drivers* frame is able to evaluate the change in migration levels predicted under fixed scenarios, in which they hold the social, economic and political conditions constant.[12] Yet the social conditions cause the possibility of migration; thus, even the change in migration for a given scenario must still give causal weight to those social conditions. Damage or migration estimates can be valid for a fixed condition, however, in a *Social-Causal* model the changes in damage or migration would still be caused by the social conditions.

[Figure 2 about here]

It is useful to compare the *Groundswell* conceptualization to more socially oriented conceptualizations of the climate-migration relationship. To do that, in this paper we consider the vulnerability approach

[12] The *Groundswell* model partially mitigates this problem by implicitly modeling the influence of the social context. In other words, the historical population patterns, against which the model is trained, reflect the influence of education, urbanization and economic growth in conditioning the effects of environmental variables on migration. However, by not explicitly modeling the influence of the context, it is not able to provide an assessment of the relative importance of the various social, economic and political variables. Appropriately modeled, one would have to explain security or vulnerability and attribute causality to the variables that cause this underlying condition.

offered by Ribot et al. (2020). While, like many in the literature, *Groundswell* investigates how select socio-economic factors moderate the impact of environmental factors on migration, Ribot et al.'s vulnerability approach is much less bounded, as it directly embeds the analysis of vulnerability into a broader analysis of its causes in the social, cultural and political-economic context in the region.[13] Causality in this model does not consider proximate social arrangements as root cause, but accounts for the causes of these social arrangements. Following a critical realist social science approach (Sayer 1992; Bhaskar 1998; Flyvbejerg, Landman and Schram 2012), their conceptualization emphasizes the endogeneity and complexity of migration outcomes and causal pathways, including non-stochastic causal factors and chains. While their model, depicted in Figure 2, does account for changing climatic conditions in the Tambacounda region of Senegal, these effects are embedded in a web of social and political-economic variables, which are crucial in explaining the flight of young men to Europe in the hope of better economic opportunities and social status.

Concerning endogeneity, Ribot et al. (2020: 52) point out that emigration from the Tambacounda region in Senegal accelerated in spite of improved, higher, levels of rainfall in recent times and a partial recovery from the severe droughts of the 1970s and 1980s (Nicholson et al. 2018) – in contradiction to drought-driven migration claims. They also show how factors such as poverty or debt that leave people at risk are outcomes of structural elements of pricing policy and access rights to forests and markets as well as unequal access to political representation (Ribot et al. 2020: 56). The *Groundswell* conceptualization, in contrast, is the basis for a computational model of migration which provides quantitative simulations of the past, which can be used to examine (under imposed conditions) hypotheses concerning drivers, and projections of the future. The Ribot et al. (2020) conceptualization instead aims to illustrate the deep, layered, social complexity behind migration decisions and forced

[13] For similar approaches, see also Adams and Kay 2019; Wiederkehr et al 2019; Wrathall 2012; Wrathall et al. 2014; Sen 1981; Watts 1983; Blaikie et al. 1994.

departures. Its observational accounting and process-tracing methods (Bennett 2010; Bates et al. 1998) help discern structural and endogenous causes of vulnerability (Galtung 1969; Watts 1983). Their approach makes clear how challenging it will be to incorporate these *Social-Causal* processes into computational models of migration or to generate the data needed to guide model development or to run such models.

The deep and local characteristics of the *Social-Causal* model of climate impacts limits substantially the application of conclusions from these studies to other contexts and times. In fact, not being computational models of damage or migration, the *Social-Causal* frame does not allow for projections of future damages due to climate impacts.[14,15] Further, such social-causal studies, being unbounded, can search for causality ad infinitum. Thus, when does causal analysis stop, as it cannot arrive at 'first cause'? As its objective is to identify policy responses, these analytics trace cause to social elements that can be manipulated – and thus are amenable to intervention. How far to trace back causality is a choice that modelers must make – and are implicitly making regardless of which model they use when they choose or use their model.

Grounded in the same *Social-Causal* analytical frame, other researchers have used this approach to evaluate the effects of climate (and environment) on migration. For instance, Wrathall's (2012) analysis shows that the impact of Hurricane Mitch caused a migration cascade among poor and marginalized coastal communities in Honduras. Drawing on the concept of "socio-ecological regime," he shows that coastal erosion accelerated by the hurricane negatively affected livelihoods leading some to out-migrate. These out-migration flows then further destabilized these communities by depressing existing

[14] While *Social-Causal* models systematically integrate non-quantitative elements and processes, they do employ quantitative evidence and methods (e.g., correlation) when tracing the complex association between a hazard and a resulting damage.
[15] Nonetheless, when multiple social-causal analyses are conducted and similar causal elements emerge, generalization is possible (Sayer 1992; Bhaskar 1998; Lund 2014).

norms of reciprocity and causing poverty traps. As a result of these second-order consequences, a run-away migration process emerged.

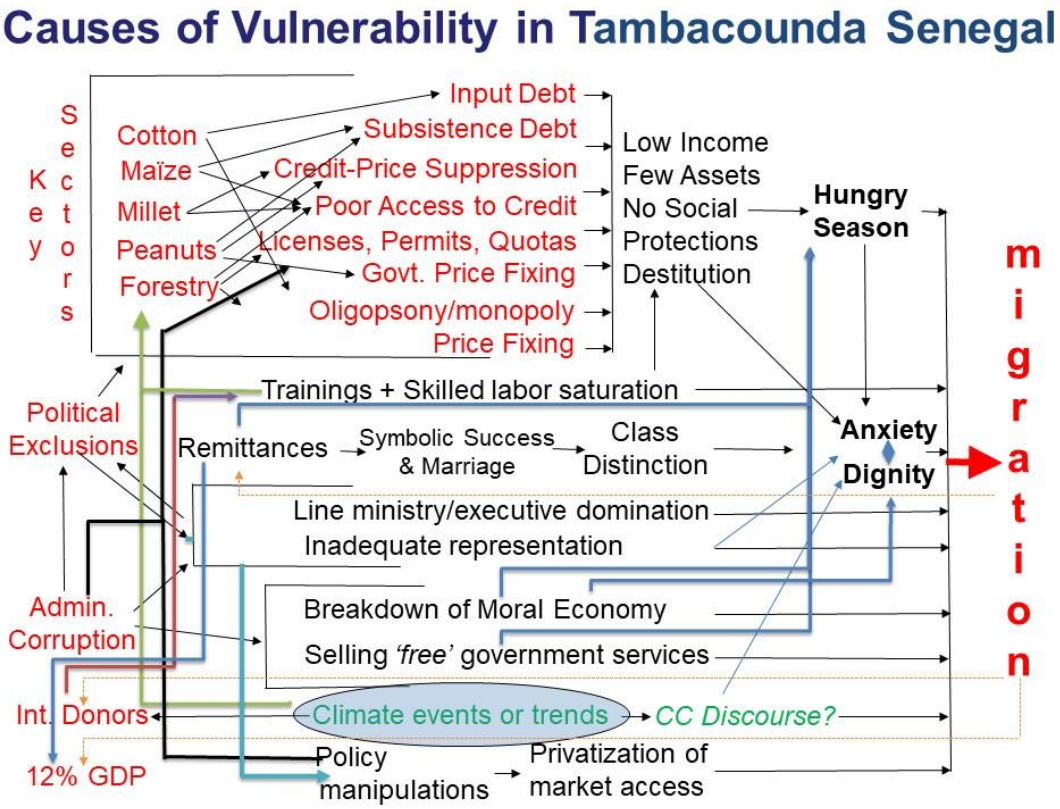

Figure 2 Schematic diagram of how climate migration is modeled in Ribot (2014) and Ribot et al. (2020).

Agent-based modeling as tool for dialogue between both frames?

Each of the *Environmental-Drivers* and *Social-Causal* frames bring important considerations to the table in regard to understanding migration. While we do not believe it is possible to integrate both analytical frames due to the sharp differences in what constitute 'cause', we pose the question of how a

productive dialogue between them can be generated? If possible and successful this could lead to a deeper understanding of the complex interplay between social and environmental factors that shape migration that, in turn, could inform how migration will evolve in the future, including with the use of quantitative models. A main challenge confronted when attempting to identify links and incompatibilities between these two analytical frames is to integrate the non-computational elements identified by observational and process tracing into quantitative models. Another is to outline each approach's implicit normative assumptions that shape causal findings. These challenges are about accounting for, but not necessarily resolving the differences among, the elements and assumptions of the two approaches.

Agent-Based Modeling (ABM) is a possible tool to confront and engage these two frames because of its potential to model complex interconnections between processes and human decision-making. ABMs of migration seek to model migration outcomes by accounting for the decisions made by people in response to one or more drivers (for a review, see Thober et al. 2018; for a recent application see Bell et al. 2021).[16] Designers of ABMs may consider any number of factors and how they might interact. These models, therefore, have the potential to represent social situations that precondition responses to environmental events. In ABMs this is done by incorporating conditionalities (if *x* occurs, given conditions *y*, the outcome will be *z*), and decisions that can be subject to thresholds and switches (e.g., acquiring sufficient resources to act on a desire to migrate), representing inputs and outputs in probabilistic terms. Moreover, the flexibility of ABMs makes it possible to analyze multiple outcomes at the same time, such as migration, *in situ* adaptation, trapped populations or even return migration.

Yet, ABMs are not free of drawbacks. The degree to which this approach will integrate elements of a *Social-Causal* model depends on the social theories that the modelers take into account. ABMs are

[16] Importantly, we do not claim that ABMs is the only possible approach to engage both frames in a dialogue.

based on a micro-level perspective focused on interaction between agents. *Social-Causal* models of migration frequently consider structural factors, such as a political or political-economic environment that severely constrains individual decisions – whether that be via discourse, norms, doxa, habitus, a history of violence, racism or an embedded class hierarchy that limit – or even make unthinkable – some options. While a worker may take a wage or the price of her goods as a given, it is still incumbent upon the model to show that such wages and prices are products of political-economic forms of domination or of struggle and achievement. Here the cause of migration or hunger may be the lack of representation in pricing arrangements, not merely of the poverty these arrangements generated. How to trace causality, then, is an epistemological question that comes back to implicit assumptions about the nature of causality. The objective would be to make these assumptions explicit (whether or not compatible) by identifying contradictions or overlaps that emerge in modeling efforts.

One approach would be to quantitatively and qualitatively assess the influence on model findings of the imposed conditions chosen by its designers. This means modulating out of the frame to a historical political-economy view in which the determinants of those static elements are considered for how they might influence any future changes in them. This involves an iterative relation between computation and reflective consideration of the estimates and projections made by such models. In this approach the modelers are able to quantify potential outcomes, while being forced to make explicit the causes of both the static conditions and the ways that both proximate and more distal or structural social causes might shape or reshape the computational findings (similar to practices in realist and analytic-narrative based social sciences, see Sayer 1982; Bates et al. 1998; Flyvbejerg et al. 2012).

Specifically, this approach requires authors to acknowledge that the change in outcome observed following a given climate-change increment is dependent on the conditions that enable that increment to trigger additional damages. Thus, this approach would acknowledge a) that the ABM findings are

true only for effects of agency within the situation characterized by the conditions and structures imposed on the model, and b) that damage that follows a climate event is caused by the processes that give rise to this set of conditions. As a result, such an iterative approach would help validate the findings and outline its limits. It would also help ensure that causality is not attributed to the climate event when other factors that cannot be given specific weights may play more important roles – factors which may be more amenable to policy intervention than are climate stressors or protection against them. The ultimate objective of a fuller causal accounting is to identify the fullest possible range of policy interventions that could reduce the risks of damage to human wellbeing.

In terms of causation an iterative relation among models gains important insights into how environmental and social factors combine to influence a migration decision. Moreover, in line with the *Environmental-Drivers* perspective, such an approach would allow research to quantify the effect of climate change on migration, but only under imposed conditions. In any case, quantitative claims concerning the role of climate or climate change will remain a function of the modeler's (or the model's) assumptions about which variables matter and which factors must be set as given. The quantitative measure of the effects of climate or climate change is thus always a matter of subjective choice – followed, of course, by rigorous analysis. There are also normative considerations in the choice of the causal models. So, explicit specification of the assumptions implicit within frames and made within each analysis for any form of model helps readers understand the origins and limits of presented estimates.

Going forward

This article has contrasted two distinct analytical frames in the study of the relation between environmental change and migration, and their implication for the locus of causality, and thus for

policy response. It shows that analytical frames evaluating causes of migration differ in the causal weight they attribute to climate or climate change. Although it may be impossible to resolve the tensions around how these different analytical frames treat *causality* according to a single framework, we nevertheless believe that it is possible for both frames to benefit from comparison and dialogue about underlying and adopted assumptions. This is urgent because currently claims about the consequences of climate change for migration are routinely made in public discourses with substantial consequences for policy responses to climate change and migration that can impact those who desire or need to migrate. Because it is important to advance understanding of the full range of causes and consequences of migration, we recommend that future research:

(1) *Consider and model the role of the social and political-economic context in shaping climate-related migration and non-migration*. Because the effects of climate (or any other environmental) variations are mediated by the social and political-economic context in which they occur, it is important to incorporate the latter in modeling exercises and to analyze how context and changes in the context affect migration decisions. A vital question to address then is why, in locations hit by environmental events of similar magnitude, some see significant out-migration, while others do not record more migration than usual? Why in these circumstances do some migrate and others stay? In other words, what constellation of factors give rise to opportunities and vulnerabilities? Also, what enabled people to adapt to past climate and environmental changes, and the factors that shape how they are, or might, adapt to ongoing and future changes (e.g., by planting different crops, infrastructural investments, household income diversification etc.), needs to be studied since it should not be assumed that adverse climate or environmental change necessarily leads to migration.

(2) *Acknowledge the assumptions and limits of migration or of climate-related damage models*. Researchers need also to be transparent, in particular when communicating their findings, about the assumptions

made by their models, whether conceptual or quantitative, the form of migration considered, the data used, and the factors or relations attended to (and not). This is especially important in view of designing new policies in response to climate risks.

(3) *Recognize the moral content embedded in choosing an analytical frame*. As we discuss at the outset, differences in analytical frames also shape perceptions of migration, and the tools to address this issue. While we acknowledge that many scholars working in an *Environmental-Drivers* frame have questioned the links between climate change and migration, it remains that by focusing disproportionally on climate variables as *causes of migration*, we ignore the many other factors that shape migration patterns. Hence, we risk advocating policies that contribute little to address the underlying causes of migration, and the many challenges migrants face (Ribot 2014; Ribot et al. 2020).

Finally, our analysis holds promises for other research arenas. First, research is in order on how and why different analysts interested in the role of environmental factors in crises choose different models and then what are the social and political-economic drivers and consequences of model choice? Second, the identified modeling limits could inform research on other (non-climate-related) forms of disasters. For instance, Neumayer et al. (2014), show how, despite the awareness of the risk posed by tsunamis in Japan, very little had been undertaken to protect coastal populations prior to the 2011 earthquakes, which induced a devastating tsunami. Sen (1981; also see Drèze and Sen 1989; Watts 1983; Blaikie et al. 1994) showed that no modern famines are caused by absolute food shortage due to crop deficits from droughts or any other weather events. Famines are often a product of markets in which farmers sell their food in a period of relative scarcity (a poor crop, perhaps drought-induced), merchants purchase and hoard, prices rise due to relative shortage, and then farmers and the poor cannot afford to purchase food – resulting in famine. Famines almost always unfold where there is

more than enough food for everyone. Rather than being a product of weather-induced deficits, famines can be the product of markets – which allocate food away from the hungry. As for famine, so too for migration, environmental events and the outcome for people are connected by a web of causality that reaches deep back into social and political-economic conditions. A fuller understanding of migration or of crises that follow climate trends and events will thus better illuminate how ongoing climate change will interreact with migration, what the causes are, and what the policy options are to ensure well-being of migrants and their home and destination communities.

References

Adams, Helen, and Susan Kay. 2019. "Migration as a Human Affair: Integrating Individual Stress Thresholds into Quantitative Models of Climate Migration." *Environmental Science & Policy* 93: 129–138.

Barrios, Salvador, Luisito Bertinelli, and Eric Strobl. 2006. "Climatic Change and Rural-Urban Migration: The Vase of Sub-Saharan Africa." *Journal of Urban Economics* 60(3): 357–371.

Bates, Robert, Avner Greif, Margaret Levi, Jean-Laurent Rosenthal, and Barry R. Weingast. 1998. *Analytic Narratives*. Princeton: Princeton University Press.

Beine, Michel, and Christopher Parsons. 2015. "Climatic Factors as Determinants of International Migration." *The Scandinavian Journal of Economics* 117(2): 723–767.

Bell, Andrew R., Wrathall, David J., Valerie Mueller, Joyce Chen, Michael Oppenheimer, Matt Hauer, Helen Adams, Scott Kulp, Peter U. Clark, Elizabeth Fussell, Nicholas Magliocca, Tingyin Xiao, Elizabeth A. Gilmore, Kali Abel, Maia Call, and Aimée B.A. Slangen. 2021. "Migration towards Bangladesh Coastlines Projected to Increase with Sea-Level Rise through 2100." *Environmental Research Letters* 16(2): 024045.

Bennett, Andrew. 2010. "Process tracing and causal inference." Ch. 10 in Henry Brady and David Collier (eds.). *Rethinking Social Inquiry*. Rowman and Littlefield.

Bhaskar, Roy. 1998. "Philosophy and Scientific Realism," in *Critical Realism: Essential Readings*, Margaret Archer, Roy Bhaskar, Andrew Collier, Tony Lawson and Alan Norrie (eds.), London: Routledge, pp. 16-47.

Black, Richard, Neil W. Adger, Nigel W. Arnell, Stefan Dercon, Andrew Geddes, and David Thomas. 2011. "The Effect of Environmental Change on Human Migration." *Global Environmental Change* 21: S3–S11.

Blaikie, Piers. 1985. *The political economy of soil erosion in developing countries*. London: Longman Press.

Blaikie, Piers, Terry Cannon, Ian Davis, and Ben Wisner. 1994. *At Risk: Natural Hazards, People's Vulnerability and Disasters*. London: Routledge. Also see their updated version: Wisner, Benjamin, Piers M. Blaikie, and Terry Cannon. *At Risk: Natural Hazards, People's Vulnerability and Disasters*. Edition: 2. Published by Routledge, 2004.

Boas, Ingrid, Carol Farbotko, Helen Adams, Harald Sterly, Simon Bush, Kees van der Geest, Hanne Wiegel, Hasan Ashraf, Andrew Baldwin, Giovanni Bettini, Suzy Blondin, Mirjam de Bruijn, David Durand-Delacre, Christiane Fröhlich, Giovanna Gioli, Lucia Guaita, Elodie Hut, Francis X. Jarawura, Machiel Lamers, Samuel Lietaer, Sarah L. Nash, Etienne Piguet, Delf

Rothe, Patrick Sakdapolrak, Lothar Smith, Basundhara Tripathy Furlong, Ethemcan Turhan, Jeroen Warner, Caroline Zickgraf, Richard Black and Mike Hulme. 2019. "Climate Migration Myths." *Nature Climate Change* 9(12): 901–903.

Bryan, Gharad, Shyamal Chowdhury, and Ahmed Mushfiq Mobarak. 2014. "Underinvestment in a Profitable Technology: The Case of Seasonal Migration in Bangladesh." *Econometrica* 82(5): 1671–1748.

Cai, Ruohong, Shuaizhang Feng, Michael Oppenheimer, and Mariola Pytlikova. 2016. "Climate Variability and International Migration: The Importance of the Agricultural Linkage." *Journal of Environmental Economics and Management* 79: 135–151.

Carr, Edward R., Rob Goble, Helen M. Rosko, Catherine Vaughan, and James Hansen. 2017. "Identifying Climate Information Services Users and Their Needs in Sub- Saharan Africa: A Learning Agenda." Washington, DC: United States Agency of International Development (USAID).

Cattaneo, Cristina, and Giovanni Peri. 2016. "The Migration Response to Increasing Temperatures." *Journal of Development Economics* 122: 127–146.

Cottier, Fabien and Salehyan, Idean. 2021. "Climate Variability and Irregular Migration to the European Union." *Global Environmental Change* 69: 102275.

de Haas, Hein. 2011. "The determinants of international migration. Conceptualizing policy, origin and destination effects", IMI Working Paper 32, International Migration Institute, University of Oxford, 35 p.

Dewey, John. 1925[1958]. *Experience and Nature*. New York: Dover Publications.

Drèze, Jean, and Amartya Sen. 1989. *Hunger and public action*. Oxford: Clarendon.

Falco, Chiara, Marzio Galeotti, and Alessandro Olper. 2019. "Climate Change and Migration: Is Agriculture the Main Channel?" *Global Environmental Change* 59: 101995.

Flores, Martínez Flores, Sveta Milusheva, and Arndt R. Reichert. (2021). "Climate Anomalies and International Migration." World Bank Policy Research Working Paper 9664.

Flyvbejerg, Bent, Todd Landman, and Sanford Schram. 2012. *Real Social Science: Applied Phronesis*. Cambridge: Cambridge University Press.

Forsyth, Timothy. 2011. "Politicizing Environmental Explanations." Ch. 1, pp. 31–46 in M.J. Goldman, P. Nadasdy and M.D. Turner (eds). *Knowing nature: Conversations at the intersection of political ecology and science studies*. Chicago: Chicago University Press.

Forsyth, Timothy. 2008. "Political Ecology and the Epistemology of Social Justice." *Geoforum* 39: 756–764.

Franke, Richard W., and Barbara H. Chasin. 1980. *Seeds of Famine: Ecological Destruction and the Development Dilemma in the West African Sahel*. Montclair, NJ: Allanheld, Osmun.

Füssel, Hans-Martin, and Richard .J.T. Klein. 2006. "Climate Change Assessments: An Evolution of Conceptual Thinking." *Climatic Change* 75(3): 301–329.

Galtung, Johan. 1969. "Violence, Peace, and Peace Research," *Journal of Peace Research* 6: 167-91.

The Guardian, 2015. "Mass Migration Is No 'Crisis': It's the New Normal as the Climate Changes." August 18.

The Guardian. 2017. "Will Africa's Great Green Wall discourage migration to Europe?" July 19.

Helbling, Marc, and Daniel Meierrieks. 2021. "How Climate Change Leads to Emigration: Conditional and Long-Run Effects." *Review of Development Economics* 25(4): 2323-2349.

Hoffmann, Roman, Anna Dimitrova, Raya Muttarak, Jesus Crespo Cuaresma, and Jonas Peisker. 2020. "A Meta-Enalysis of Country-Level Studies on Environmental Change and Migration." *Nature Climate Change* 10, 904–912.

Hulme, Mike. 2011. Reducing the Future to Climate: A Story of Climate Determinism and Reductionism. *Osiris* 26: 245-266.

Lahsen, Myanna, and Jesse Ribot. 2021. "Politics of Attributing Extreme Events and Disasters to Climate Change." *WIREs Climate Change*.

Lucht, Hans. 2012. Darkness before Daybreak: African Migrants Living on the Margins in Southern Italy Today. Berkeley: University of California Press.

Lund, Christian. 2014. "Of what is this a case? Analytical Movements in Qualitative Social Science Research." *Human Organization* 73(3): 224-34.

Lustgarten, Abraham. 2020. "The Great Climate Migration". July 23, https://www.nytimes.com/interactive/2020/07/23/magazine/climate-migration.html (accessed November 30, 2020).

Marchiori, Luca, Jean-François Maystadt, and Ingmar Schumacher. 2012. "The Impact of Weather Anomalies on Migration in sub-Saharan Africa." *Journal of Environmental Economics and Management* 63(3), 355–374.

Missirian, Anouch, and Wolfram Schlenker. 2017. "Asylum Applications Respond to Temperature Fluctuations." *Science* 358 (6370), 1610-1614.

Mueller, Valerie, Clark Gray, and Douglas Hopping. 2020. "Climate-Induced Migration and Unemployment in Middle-Income Africa." *Global Environmental Change* 65: 102183.

Myers, Norman. 1993. "Environmental Refugees in a Globally Warmed World." *Bioscience* 43(11): 752–761.

Neumayer, Eric, Thomas Plümper, and Fabian Barthel. 2014. "The Political Economy of Natural Disaster Damage." *Global Environmental Change* 24: 8–19.

Nicholson, Sharon E., Andreas H. Fink, and Chris Funk. "Assessing Recovery and Change in West Africa's Rainfall Regime from a 161-Year Record." *International Journal of Climatology* 38: 3770–3786.

O'Brien, Karen, Siri Eriksen, Lynn P. Nygaard, and Ane Schjolden. 2007. "Why Different Interpretations of Vulnerability Matter in Climate Change Discourses." *Climate Policy* 7: 73-88.

O'Keefe, Phil, Ken Westgate, and Ben Wisner. 1976. "Taking the Naturalness out of Natural Disasters." *Nature* 260: 566-567.

Peet, R. 1985. "The Social Origins of Environmental Determinism." *Annals of the Association of American Geography* 75: 309–33.

Ribot, Jesse. 1995. "The Causal Structure of Vulnerability: Its Application to Climate Impact Analysis." *GeoJournal* 35(2): 119–22.

Ribot, Jesse. 2014. "Cause and Response: Climate Vulnerability in the Anthropocene." *Journal of Peasant Studies* 4(5): 667–705.

Ribot, Jesse, Papa FayeFaye, and Matthew D. Turner. 2020. "Climate of Anxiety in the Sahel: Emigration in Xenophobic Times." *Public Culture* 32(1): 45–75.

Rigaud, Kanta Kumari, Alex de Sherbinin, Bryan Jones, Jonas Bergmann, Viviane Clement, Kayly Ober, Jacob Schewe, Susana Adamo, Brent McCusker, Silke Heuser, and others. 2018. *Groundswell: Preparing for Internal Climate Migration.* World Bank.

Rubin, Donald B. "Causal Inference Using Potential Outcomes: Design, Modeling, Decisions." Journal of the American Statistical Association 100, no. 469 (2005): 322-331.

Sayer, Andrew. 1992. *Method in Social Science: A Realist Approach,* Second Edition. New York: Rutledge.

Schutte, Sebastian, Jonas Vestby, Jørgen Carling, and Halvard Buhaug. (2021). "Climatic Conditions are Weak Predictors of Asylum Migration." *Nature Communications* 12(1).

Sen, Amartya. 1981. *Poverty and Famines: An Essay on Entitlement and Deprivation*. Oxford: Oxford University Press.

Swiss Development Agency 2013. "Global Brief: Trees to the Rescue of Climate and Development." Directorate of Global Cooperation.

Thober, Jule, Nina Schwarz, and Kathleen Hermans. 2012. "Agent-Based Modeling of Environment-Migration Linkages: A Review." *Ecology and Society* 23(2): 41.

Thomas, Kimberley, R. Dean Hardy, Heather Lazrus, Michael Mende, Ben Orlove, Isabel Rivera-Collazo, J. Timmons Roberts, Marcy Rockman, Benjamin P. Warner, Robert Winthrop. 2019. "Explaining Differential Vulnerability to Climate Change: A Social Science Review," *WIREs Climate Change* 10:e565.

Vigh, Henrik. 2009. "Wayward Migration: On Imagined Futures and Technological Voids." *Ethnos* 74 (1): 91–109.

Washington Post, 2018. "How Climate Change is Affecting Rural Honduras and Pushing People North." November 6

Watts, Michael J. 1983. *Silent Violence: Food, Famine, and Peasantry in Northern Nigeria*. Berkeley: University of California Press.

Watts, Michael J., and Hans Bohle. 1993. The Space of Vulnerability: The Causal Structure of Hunger and Famine. *Progress in Human Geography* 17(1), 43–68.

Wiederkehr, Charlotte, Matthias Schröter, Helen Adams, Ralph Seppelt, and Kathleen Hermans. 2019. "How Does Nature Contribute to Human Mobility? A Conceptual Framework and Qualitative Analysis." *Ecology and Society* 24(4).

Wisner, Ben, Piers Blaikie, Terry Cannon, and Ian Davis. 2004. *At Risk: Natural Hazards, People's Vulnerability and Disasters*. Routledge, London.

Wrathall, David J. 2012. "Migration Amidst Social-Ecological Regime Shift: The Search for Stability in Garífuna Villages of Northern Honduras." *Human Ecology* 40(4): 583–596.

Wrathall, David J., Jeffrey Bury, Mark Carey, Bryan Mark, Jeff McKenzie, Kenneth Young, Michel Baraer, Adam French, and Costanza Rampini. 2014. "Migration amidst Climate Rigidity Traps: Resource Politics and Social–Ecological Possibilism in Honduras and Peru." *Annals of the Association of American Geographers* 104(2): 292–304.