




# Natural resources, human mobility and sustainability: a review and research gap analysis

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## Abstract

Pressures on natural resources, such as from environmental change, have influenced the global human mobility landscape. In this article, we review the scientific evidence on the interlinkages between natural resources, human migration and sustainability. Drawing on a review of the existing literature in combination with the authors' research experience, we consider a range of conceptual perspectives and empirical studies covered in the literature since the turn of the millennium. Our analysis considers the broad mobility spectrum—from adaptive migration to forced displacement and immobility. Climate change both acts as a natural resource threat in this context as well as having the potential to influence mobility drivers, which, in turn, can influence natural resource availability. The review aims to provide scholars of sustainability science with a coherent curation of the research thus far on the topic for charting a way forward for more constructive and original investigations. To overcome scientific gaps identified, finally we suggest that the multiplicity of linkages and feedbacks between natural resources and migration across different spatial, temporal and social scales lends itself to a complex adaptive (sub)system (CAS) framing within larger socio-ecological systems. As a CAS, the outcomes of migration and natural resources linkages are highly non-linear and can be emergent: the sustainable management of them, therefore, requires flexible, robust and equitable approaches.

**Keywords** Natural resources · Migration · Displacement · Immobility · Environmental migration · Socio-ecological systems

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## Introduction: natural resources and human mobility

Global research on theories of human migration has often been predicated on economic or sociological observations and conceptual models that have often neglected ecological linkages (Massey et al. 1993). However, the migration literature has advanced dramatically in the last 20 years on environmental issues, particularly as research uncovers the potential ramifications of climate change on population distribution (Piguet et al. 2018). More often than not, however, scholarship linking population movements and environmental change falls under the heading of either 'climate migration' or 'environmental migration' but has rarely been explicitly researched or framed in terms of natural resources and human mobility (including migration, immobility and displacement). This is despite the potential theoretically and empirically intuitive links that natural resources might have with human livelihoods and movement, and that the

interlinkages of changes in natural resource use, viability, access and availability might have on migration and displacement have been the subject of study for several decades (Döös 1997).

In this review, we analyse how existing research explicitly and implicitly highlights emergent links between natural resources and human mobility. The aim of the review is: first, to extract and highlight the role of *natural resources* rather than the more macro-scale references to environment and climate in influencing migration, something which is lacking in current debates; and second, in doing so, to highlight key points of agreement in the literature and particular areas of ongoing discussion and debate. The question of how natural resource systems, and their associated stocks, functioning and viability, fit into our evolving understanding of migration, as opposed to more overarching (albeit inherently interlinked) environmental parameters such as temperature, precipitation and aridity patterns, is likely to be an important part of these debates.

In accordance with the definition of the International Resources Panel (IRP),<sup>1</sup> we here consider natural resources—including land, water, air and materials—as parts of the natural world that can be used in economic activities to produce goods and services. Material resources are biomass (like crops for food, energy and bio-based materials, as well as wood for energy and industrial uses), fossil fuels (in particular coal, gas and oil for energy), metals (such as iron, aluminium and copper used in construction and electronics manufacturing) and non-metallic minerals (used for construction, notably sand, gravel and limestone).

We piece together some of the insights from more than 120 articles, reports, and book chapters, mostly, but not exclusively, from the peer-reviewed literature since 2000. Selection of sources were based upon multiple entry points into the literature: the authors' knowledge of the existing literature, searching key terms<sup>2</sup> associated with natural resources within academic literature databases and general search engines for grey literature,<sup>3</sup> and consultations with various academic, governmental and civil society experts that took part within the wider exercise of writing the International Resource Panel report from which this review stems.

<sup>1</sup> <https://www.resourcepanel.org/glossary>

<sup>2</sup> 'Resources' is often in literature on environment and migration, but not necessarily deployed in our meaning. Resources often referred to a variety of types of capital, for example, or the 'resources to migrate'. Therefore, in many cases, we had to comb through studies to assess their relevance for our purposes. Thus, the inclusion of authors from a variety of fields and expertise and consultation with external experts offering relevant literature was invaluable to this study.

<sup>3</sup> SCOPUS, and the CLIMIG database, compiled by the University of Neuchâtel offered important databases for this review, <https://climig.com/>

Natural resources both shape (im)mobility and can be shaped by their outcomes. Therefore, the review is presented in two broad sections: first, natural resources as intermediaries in the environment-migration nexus in shaping (im) mobility decision-making and dynamics (Sect. [Natural resources within environment-migration debates](#)) and, second, the impacts of (im)mobility on natural resources for migrants, societies of origin, and destination areas (Sect. [The natural resource impacts of mobility](#)). Emerging narratives, discourses and debates are addressed within each section. The varying ways in which natural resources link to migration underline the importance of understanding the unique context and specific circumstances of each case (Rigaud et al. 2018). Black et al. (2013a) note that the factors that may apply in one situation may not apply to another. Thus, in the Sect. [Discussion: resources and mobility as a complex adaptive system](#), to overcome scientific gaps identified, we suggest that one path forward is to apply a complex adaptive (sub)system (CAS) framing in future research.

## Natural resources within environment-migration debates

Current international policies around human mobility have, broadly speaking, been based on a 'dualistic' framing of why people move. On one end of this polemic, people are perceived to be forced to move as a result of conflict or political persecution and are seen as 'refugees'. On the other end, people are perceived to be enticed to move by the promise of better living conditions elsewhere and are labelled as 'migrants' (Ionesco et al. 2017). Yet, human mobility has existed throughout history, with people moving for, or being displaced by, a range of environmental, economic, political, social, humanitarian and cultural reasons that intertwine (Van Praag and Timmerman 2019). Migration behaviour is determined to differing degrees by a host of multi-level influences, such as access to financial and social capital, viability of alternative livelihoods, existence of institutional barriers to migration, and a diverse mixture of other political, social, security and economic issues (Black et al. 2011a; Foresight 2011).

Accordingly, as Call et al. (2017) argue, the links are much more complicated than are typically proposed by prevailing 'environmental refugee' hypotheses presented in the media, whereby one is forced to flee for environmental reasons alone. Changes to natural resources and ecosystem services are among many different variables driving migration and displacement (Black et al. 2011a, b; Foresight 2011). Public and political narratives around environmental migration makes it appear as though the causal relationships are clear, universal, and agreed (Betts and Pilath 2017), but the extent to which environmental change and natural resource

availability are significant or more minor, contributory factors driving migration, is a major point of discussion in the literature and one where the causal link remains complex and ambiguous (Brown 2008). Reviewing the literature, there are relatively strong indications that natural resources do act directly and indirectly on the macro-, meso- and micro-social, political, economic, environmental and demographic determinants of human (im)mobility in various ways. Two themes come through in this regard when surveying literature on shaping (im)mobility decision-making and dynamics: first, the potential role of resources in influencing mobility decisions in the first instance: and, second, the role of resources in what form mobility takes when it does occur.

### The role of natural resources in influencing mobility

A sizable portion of the associated literature since the turn of the millennium has focused on the role of localised environmental degradation, and particularly, the overshadowing impacts of climate change in the diminishment of natural resource systems and their subsequent role in stimulating migration and forced displacement. The factors are often (imperfectly) categorised by their temporal scope (Cattaneo et al. 2019). Slow onset stress—drought, desertification, sea-level rise, land degradation and growing water insecurity—disrupts livelihoods, especially natural resource-dependent ones such as farming, pastoralism or fishing over time (Kabir et al. 2018). Meanwhile, sudden or rapid onset events—flooding, industrial accidents, storms and glacial lake outburst floods—present more imminent dangers to people’s lives and livelihoods, and disruption or destruction of natural resource and ecosystem services (Brown 2008). The way in which the two types of events can and do occur in parallel and influence one another has led to the development of multi-risk scenarios that highlight and attempt to capture their convergence (e.g. Adger et al. 2015).

Gemenne et al. (2017) argued that vulnerability and the probability of migration of individuals in West Africa is influenced by the extent of their dependence on natural resources, their socio-economic status, and their demographic characteristics. In fact, much of the existent literature on human mobility in response to gradual environmental changes cites the importance of natural resource-dependent livelihoods (particularly agriculture) in explaining populations’ (rural but also urban) vulnerability. Reviewing the literature, it is clear that much of natural resource-related migration is often labelled economic migration, with its environmental roots frequently masked by its legal pathway, by the economic impacts of natural resource use and management in the area of origin, or economic opportunities presented in destinations. Joarder and Miller (2013) suggest the probability of migrating may be significantly affected by prior occupational experience: in Bangladesh migrants

who were farmers or fishermen are more inclined to move permanently due to their natural resource dependence. Afifi (2011) identified a number of internal and cross-border ‘environmentally induced economic migration’ trends in Niger, explicitly including natural resource considerations including those relating to water (droughts, the shrinking of Lake Chad, problems in the Niger river) and land (soil degradation, deforestation, and sand intrusion). Differentiating between economic and environmental migration, moreover, has little value in countries whose economies are natural resource-dependent: in agriculture-based economies, environmental migration *is* economic migration.

Other case studies have identified mechanisms through which natural resource dependence can affect ecosystem services (i.e. instrumental and supporting resource bases) and the likelihood to migrate. Household surveys from Guatemala, El Salvador and Honduras identified a notable increase in out-migration following the onset of drought, its impact on agricultural land, and subsequent food security (IOM 2015). A study in Burkina Faso showed that people from drier regions are more likely than those from wetter areas to engage in both temporary and permanent inter-rural migration in response to rainfall deficits to access viable agricultural land resources (Henry et al. 2003). Similarly, in Tanzania, whose economic growth depends on natural resources, a village-level study of the Kilimanjaro district in Tanzania showed a positive relationship between rainfall shortage, crop failure, and out-migration, even after controlling for other important socio-economic variables (Afifi et al. 2014).

Sudden-onset disasters drive both direct and indirect impacts on natural resources: the former including the destruction of raw material, mineral resources, and high-yielding crops; the latter including the losses concerned with economic activities, for example. A review of select Asian countries for a period between 2005 and 2017, found that disasters such as floods and storms generally increased external migration via natural resource depletion of forests and minerals (Abbas Khan et al. 2019). In Vietnam, regular flood events were linked to individual migration decisions as well as government-initiated resettlement of households (Dun 2011). In this case, the resettlement initiatives moved people relatively short distances partially to maintain people’s access to their agricultural land so as not to exacerbate poverty (Zickgraf 2019).

Natural resource use and management also affect mobility responses outside of slow or sudden contexts of climate change.<sup>4</sup> Natural resource depletion through overuse

<sup>4</sup> This, however, is less prominent in reviewed literature, which in many cases highlighted the impacts of climate change over, for example, development projects.

(Bilsborrow and DeLargy 1990), or natural resource loss as a result of infrastructure projects, conservation measures and land grabbing<sup>5</sup> have also been identified as important in natural resource-related migration and displacement (Salerno et al. 2014). Hamilton et al. (2004) cite the example of unemployment, business failures and consequent out-migration among younger demographic groups as a result of overfishing in the Faroe Islands. Vigil (2018), meanwhile, provides an analysis into the controversial phenomenon of large-scale land acquisition ('green grabbing') in numerous locations by overseas investors, particularly for biofuels and forest carbon projects that, in some cases, have displaced local groups living or working on that land. In northern Ghana, large-scale land appropriation authorized by the Ghanaian state for gold mining is displacing subsistence farmers and reworking agrarian social relations with an evolving class of landless and near-landless farmers (Nyantakyi-Frimpong and Bezner Kerr 2017).

As demonstrated in other parts of the world, such 'food to non-food' land appropriation (Hall 2011: 20), often leaves surplus populations who migrate when their "land is needed, but their labour is not" (Li 2011: 286). Focusing on control and governance of natural resources, therefore, may highlight what 'climate migration' or 'climate refugees' obscures: the politics around entitlement to natural resources, including productive land, that underpin migration patterns. In Bangladesh, Iqbal (2019: 348) profiles the case of so-called 'climate refugees' moving in large numbers daily to Dhaka, in examining the underlying sources of migrants' vulnerability, they note: "Climate change is certainly a major concern for Bangladesh, but it must not be conflated with the more immediate manmade ecological challenges with roots in specific political and social contexts across the country".

The literature describes a number of natural resource disparities that also encourage migrants to move in the hope of increased income, expanded or more reliable livelihood options. For example, several case studies have looked at the role of mineral resources (particularly informal, artisanal mining) in shaping internal and cross-border migration: Sardadvar and Vakulenko (2017) detailed widespread net internal migration rising in mining areas of Russia between 2004 and 2010; Nyame et al. (2009) linked different stages of mine development (growth, stagnation and closure) in Ghana to characteristic (particularly transitory) migration

patterns; Makhetha (2020) has noted the transition of migrants from Lesotho operating in South Africa's mining sector from large scale, formalised to informal, artisanal mining as the former operations closed; and surveys from artisanal miners in the eastern DRC found that artisanal mining sites were the destination for many internal migrants, but that escape from economic hardship were a more significant factor than perceived potential economic gains (Maclin et al. 2017). Other work has assessed the opportunity of differing natural resource ownership or management systems (i.e. ability to own land elsewhere, availability of services) as being a factor in encouraging natural resource-related migration. The Mecúfi district of northern Mozambique has seen a significant migration of people to coastal areas since the civil war, in part to access coastal and marine resources (Bryceson and Massinga 2002). Contrastingly and interestingly, Brain (2017) links the diminishment and degradation of water and land resources as being a notable influencer on outwards migration in parts of the Andes where large-scale extractive industries have expanded.

Research that has examined more localised and contextual underpinning 'natural' influences on mobility decisions clearly begins to point towards the centrality of *resource bases* and their influence on livelihoods and habitability versus more general environmental changes that have made up much of the existing studies in the 'environmental migration' field. As yet, however, our ability to effectively quantify and monitor changes in the quality and availability of land, water, fertility, etc. in many locations where resource degradation is at its most acute is unfortunately lacking.

### The role of resources in influencing forms of mobility

Natural resource use and management affects mobility, and different interactions among social, political, environmental, economic, and demographic factors lead to varying outcomes. Yet, literature (particularly on the impacts of climate change) skews towards questions of causality or the volume of future displacement rather than the dynamics and outcomes of that movement in terms of who goes and stays, to what extent they aspire and need to move, and for how long and where they go.

The dearth of literature is indicative of the historic lack of weight placed on the context and nuances of the spatio-temporal dynamics of mobility (Safra de Campos et al. 2017). Much of the available research focuses on determining the causes for migration and displacement at the expense of, as Findlay (2011) notes, attention towards where migrants might move. Black et al. (2013a) highlights *where* people will go in the future and *which* key 'tipping points' may be associated with a significant rise (or fall) in migration to a particular destination may be more significant than the

<sup>5</sup> Following Borrás and Franco (2013: 1725), land grabbing is defined as 'the capturing of control of relatively vast tracts of land and other natural resources through a variety of mechanisms and forms, carried out through extra-economic coercion that involves large-scale capital, which often shifts resource use orientation into extraction, whether for international or domestic purposes'.

overall number of migrants globally. As with the causes of migration and displacement, the ‘natural resource picture’ also affects where people might choose, or be forced, to move, if they indeed move at all (Kniveton et al. 2008).

The majority of migration related to environmental and resource changes occurs along pre-existing routes (Black et al. 2013a). While fear-based illusions of international mass migration from lower income states are common in public discourses, the scientific evidence show that most mobility occurs *within* people’s countries or regions (Ionesco et al. 2017). This is especially true when rural agricultural (i.e. natural resource dependent) livelihoods are disrupted or made untenable, and with a particular trend in migration from rural areas to urban areas (de Sherbinin et al. 2012). Most migration scholars agree that international displacement or movements due to natural resource changes are rare (McLeman and Gemenne 2018). However, populations certainly can and do cross borders, especially in regions where permeable, international migration is not necessarily long distance, and social capital can encourage and facilitate the move. For example, Nawrotzki et al. (2016) study of migration patterns within rural Mexico between 1986 and 1999 found stronger international than national migration trends (due to their US relation).

Closely linked to the question of distance is the issue of time. Mobility takes many forms with people moving for different periods of time, depending on their means, their needs, and existing migration systems (Ionesco et al. 2017). Temporary and circular migration has, of course, been a traditional way to adapt to seasonal natural resources (un)availability (Ionesco et al. 2017), but climate change and fluctuating natural resource dynamics are shifting these traditional routes (Adger et al. 2015). For example, Zickgraf (2018b) found that Senegalese artisanal fishers are moving to Mauritania for longer periods of time because of local overfishing and the maritime impacts of climate change, which has left them with depleted halieutic resources. The availability of fish, lack of local expertise, and the presence of factories equipped to process fish in Mauritania facilitates this move.

Economic, social and personal opportunities or aspirations can turn temporary migration or displacement into a permanent move (Black et al. 2013b). For instance, Islam and Shamsuddoha (2017) suggest that gradual changes in Bangladesh that affect local ecosystem services and livelihood opportunities appear to encourage people to undertake routine economic migration at first, but that this later turned into permanent migration. Movements are also more likely to be longer term when people have chosen or been forced to pursue a new livelihood strategy (e.g. for rural migrants to urban areas) or when the natural resources in the origin areas do not support their return, such as may be the case for sea-level rise (Hauer et al. 2020), for example.

In general, studies indicate that spatio-temporal patterns are largely contextual and that macro, meso, and micro level factors interact to shape these dynamics. A common criticism of the early ‘environmental migration’ literature was its deterministic assumptions that people affected by environmental change would, could or wanted to move (Gemenne 2011). A growing body of literature demonstrates that that not only is population movement multi-causal, its outcomes range greatly according to the aspirations and abilities to migrate (Carling 2002; de Haas 2014; Ayeb-Karlsson et al. 2020; Zickgraf 2019). As previously established, countries and societies that depend on natural resources for livelihoods may find themselves particularly vulnerable to environmental stress. However, even within such points of origin, natural resource differentials can also explain non-linearities such as why one household or individual migrates, while another becomes displaced, and another remains in situ (Bohra-Mishra et al. 2014; Ayeb-Karlsson et al. 2016, 2020).

People may also move in anticipation of adverse natural resource change rather than in response to it. In certain contexts, environmental and associated natural resource parameters might not actually represent a key determining factor for group or individual decisions to move, and thus resource availability or scarcity do not dictate destination choices or the duration of movement. For example, social capital and networks are an important determinant of individual and household migration patterns (Munshi 2003). In the Punjab region of Pakistan, a strong link between families’ social links and the extent of rural to urban migration was noted (Imran et al. 2016). Likewise, van der Land (2017) refutes the assumption that environmental stress and associated natural resource changes are a dominant migration driver in the regions of concern such as the West African Sahel, and instead points to the role of individual aspirations for educational opportunities and urban lifestyles. Slow onset changes, Van der Land suggests, may prove to be less important as migration drivers as the literature and media might have us believe. In line with classic studies on migration, migration may primarily act as an individual or household investment in human capital (Becker 1962; Sjaastad 1962).

The most vulnerable people are not necessarily the ones most likely to migrate, as they may lack such social and financial means to move ( Foresight 2011). Diminishing natural resources may, however, exacerbate a need for migration, again via the livelihood pathway. Environmental changes, for instance, can erode a household’s access to natural resources and threaten livelihoods so that migration becomes less likely (Geddes et al. 2012). People desiring to move but lacking the necessary capital and means are sometimes called ‘trapped’ populations whose involuntary immobility may increase their vulnerability (Foresight 2011). In fact, ideas of mobility and immobility have attracted increasing attention in recent years as one of the key non-linearities

in the relationship between environment and human (im) mobility (Adams 2016; Zickgraf 2018a; Ayeb-Karlsson et al. 2018; Nawrotzki and DeWaard 2016; Blondin 2020).

Two persistent gaps remain: the role of political factors (including natural resource management) and that of intra-household dynamics and social inequalities (in mobility decision-making, access to and control over natural resources). Firstly, the role of governments has been downplayed as they affect people's needs, aspirations, and abilities to migrate, for example in setting either permissive or stringent migration policies. Martin (2012) proposes that legal and institutional responses shape patterns of mobility in response to slow onset events, arguing that immigration policies and the relative level of governance play a crucial role in affecting individual responses to natural hazards and conflicts. A study for the European Union (Barbas et al. 2018) noted that droughts and land degradation are relevant to out-migration from rural areas, but that the final population response depends on people's ability to adapt to new conditions, institutional capacity and the effectiveness of natural resource management and sustainable development policies. Natural resources, and the systems of natural resource governance, access and benefit sharing in use, underpin many of the dynamics of what is often (perhaps misleadingly) labelled 'environmental migration', but also that which has been called 'economic migration'.

Secondly, current studies often focus on the household level, sometimes to the detriment of intra-household dynamics and social inequalities over entitlements to natural resources. For instance, only a handful of studies within the environmental migration sphere have broached the issue of gender and (im)mobility (Chindarkar 2012; Eastin 2018; Gray and Mueller 2012; Gioli and Milan 2018; Ayeb-Karlsson 2021; Van der Geest 2009). Gray and Mueller (2012) conducted a longitudinal study of the Ethiopia highlands during period of drought showing that men's labour migration increases with drought but that marriage-related moves by women decrease. By contrast, Joarder and Miller (2013) argue that in Bangladesh it is women who are the more likely to migrate temporarily as a survival strategy in the face of environmental challenges. Gendered immobility has also been investigated in Bangladesh where women are often left behind in rural villages or urban informal settlements while men move away from natural resource stress (Bhatta et al. 2015; Ayeb-Karlsson 2021). A study in the Philippines argued that at an individual level the most likely to prepare to migrate are young, connected, more educated men whereas older people are less likely to migrate, regardless of income level (Bohra-Mishra et al. 2017). Myrntinen (2017) notes the differential impact that environmentally induced migration has on gender relationships but argues that much of the analysis has tended to be based on relatively simplistic stereotypes. Gioli and Milan (2018) argue that migration

is in many contexts strongly defined by gender roles and propose that a feminist political ecology framework is a useful way of analysing the intersections between knowledge, power and practice.

While the literature on gender and migration and environmental change is scarce, the literature explicitly discussing gendered links to natural resources, and how these affect (im)mobility dynamics is even more negligible. In examining large scale land acquisitions, many studies treat the household as a homogenous unit that pools resources, with members uniformly affected by land loss. As Nyantakyi-Frimpong and Bezner Kerr (2017: 422) remark, there are few attempts to "[break] open the black box of the household to examine whether and how emerging land deals (re) produce social differentiation or gendered struggles over resource access and control." Seeing gender as a mediating factor throughout the migration process (from decision-making to outcomes) may provide more nuanced evidence to develop better and more inclusive sustainability policies.

## The natural resource impacts of mobility

The role of natural resources in triggering displacement or facilitating and encouraging migration—either for necessity or opportunity—has an important bearing on the mobility forms, but also on the impacts of those movements (Brown and McLeman 2013). This is not a linear or teleological process, in which migration 'ends' upon arrival. The impacts of mobility feedback and affect natural resources of migrants, societies of origin as well as destination.

Much of the concern about human mobility as a negative force has been articulated in terms of its potential impact on peace and security. Natural resources are commonly cited as a mediating pathway towards violence in much of the literature that is focused on the links between climate change, migration, and conflict (Adger et al. 2014; Kelley et al. 2015; Aremu and Abraham 2020). Empirical studies investigating this area focus on migration leading to social tensions with host populations over limited or depleting natural resources or conflicts over competing livelihoods. For example, Mbonile (2005) writes how in-migration to the Pangani River Basin in Northeast Tanzania, partially in search of water, has led to intensive water conflicts between pastoralists and farmers and has increased overall demand for water, affecting water availability in downstream areas. Ecological decline in Northern Nigeria is driving herders to embark on a north–south migration in search of forage and water for their cattle. However, continuous clashes are occurring between migrating herdsmen and destination populations for various reasons including competition over scarce natural resources (Aremu and Abramham 2020).

However, McLeman et al. (2018) note that natural resource-related migration can be linked to political instability, but the security literature warns us to be careful of overly simplistic cause-effect assumptions. Similarly Dalby (2002) noted that deterministic claims about the relationship between environmental change, instability and migration are implausible given that conflict and mobility are complex socio-ecological phenomena. In fact, Nicholson (2014) warns that any ongoing substantive search for a causal relationship could be a ‘blind alley’ which fails to analyse the assumptions implicit in any such search and, in so doing, allows the results to be politically manipulated.

Migration and displacement are often described, and treated, as a function of vulnerability—an indicator of the limits of adaptation (Warner and Afifi 2014). In the context of climate change, Adger et al. (2009) note that adaptation is formed and constrained by social factors such as cultural values, knowledge, and attitudes to risk. These form ‘societal limits’ to adaptation but these are limits that are mutable. For example, many policy interventions explicitly try to encourage adaptation measures in areas of origin as a way of reducing migration pressures on destinations (including pressures on natural resources, infrastructure, and services) (Gemenne and Blocher 2017).

Over the past decade a narrative emerged that described migration, rather than being a symptom of a failure to adapt or a threat to political stability as an effective form of adaptation (Black et al. 2011a, b, 2013a; Hunter et al. 2015). After all, migration is one of the oldest and most widely used strategies to maintain livelihoods in response to social, environmental and natural resource changes (Adger et al. 2015)—pastoralist societies, reliant upon biological (flora/grassland) resources, are just one example of this.

In many societies, seasonal labour migration has been a livelihood strategy for generations that follows natural resource rhythms (e.g. the timing of planting and harvesting or fish reproduction) (Kniveton et al. 2008; Zickgraf 2018b). This approach underpins the common usage of the New Economics of Labour Migration (NELM) theory, in which migration represents a livelihood diversification and insurance strategy, sheltering the migrant-sending household from adverse changes including those that are natural resources induced (Stark and Bloom 1985). The option of such adaptation is, however, denied to those who lack mobility options, leading to the prospect of increased numbers of people ‘trapped’ in risky places and situations (Black et al. 2011a, b; Black and Collyer 2014; Adger et al. 2015), or for those unwilling to move (Zickgraf 2018a).

Human mobility can have significant impacts on natural resources in the areas from which the migrants depart, but what those impacts are vary from one context to another based on multi-scalar socio-economic, environmental, political and demographic interactions. On one

hand, out-migration can decrease pressure on local natural resources. Temporary out-migration is already a coping strategy for populations living in areas affected by environmental stress, enabling mobile people to search for non-natural resource dependant work externally. It both allows people to remit money home as well as to reduce the overall number of people depending on land and water resources for food security (Brown 2008; Sakdapolrak et al. 2016). A study of eight case studies in Asia, Africa and Central America,<sup>6</sup> for example, assessed a wide range of rainfall related climatic events, such as floods, drought, seasonal shifts, noted that out-migration can be a successful temporary adaptation strategy (Afifi et al. 2014).

The literature favors more economic dimensions of the environment-migration nexus, primarily by seeing how financial remittances can decrease reliance on local, rural, natural-resource based livelihoods. Yet, out-migration can also help to increase social resilience and benefit natural resources in the origin areas by transferring skills, knowledge, technology, or ‘social remittances’ (Levitt 1998; Levitt and Lamba-Nieves 2011; Scheffran et al. 2012; Brown and Wittbold 2018). Migrants, therefore, can help drive adaptation to environmental change and protect natural resources within socio-ecological systems in less material ways. For instance, the movement of migrants can build and extend social networks that facilitate future migration, continuing the chain of migration from place to place (Brown and McLeman 2013), and helping to escape the perils associated with involuntarily immobile and displaced populations.

However, this more optimistic reading of migration as adaptation is not without critique. First, by narrowing the focus on migration as an adaptive response to environmental and natural resources risks, it ignores the major impacts of other forms of migration. Second, it does not address the other ways that people and societies deal with change, such as resilience building. Third, migration as adaptation has been interpreted in a way which justifies neoliberal migration policies (Sakdapolrak et al. 2016).

Out-migration is not necessarily beneficial for natural resources in areas of origin. In the Global South, large rural to urban migration coupled with falling birth rates is affecting the distribution of populations (Schaeffer 2017) and of natural resource use and management. McLeman et al. (2018) note that migration is also contributing to socio-economic inequality in sending areas, as it is most available to those with the maximum social, personal and financial capital to move and, therefore, the benefits of migration are unequally distributed. While out-migration can indeed decrease local pressures on natural resources,

<sup>6</sup> Guatemala, Peru, Ghana, Tanzania, Bangladesh, India, Thailand and Vietnam

but it is also often members of the active labour force who migrate leaving a labour shortage in origin areas. One study noted that seasonal migration out of northern Ghana led to maladaptive outcomes. When migrants failed to return home from the south in time for the start of the farming season, it left the community of origin with a labor shortage that led to reduced crop yield and ultimately resulted in local food insecurity (Antwi-Agyei et al. 2018).

For destinations, too, findings are mixed. In-migration can put pressure on local natural resources, particularly when governance systems are weakened or fragile. Bryceson and Massinga (2002) describe how in Mecúfi district of northern Mozambique in-migration of people to coastal areas following the civil war increased the strain on coastal resources and introduced new systems of governance that merged with some of the traditional forms of natural resource management. In-migration in Ethiopia has been linked to land degradation in destination regions (Hermans-Neumann et al. 2017). Indeed, experience shows that managing in-migration can be a challenge at all scales. Owen and Kemp (2017) describe how many extractive companies lack the social management structures to deal with the ‘natural resource rush’ to large commercial mining sites.

McLeman et al. (2018) and de Haas (2010) both argue, respectively, that there is no overall consensus on whether migration is ‘good’ or ‘bad’ and that the empirical evidence does not strongly support either an overwhelmingly positive or a resolutely negative assessment of its impacts. Black et al. (2011a, b) contest the conventional narratives that place migration in a negative light, arguing instead that migration will offer opportunities as well as challenges, which the literature reviewed supports. The greatest risks may be borne by those who are unable to relocate as people may be rendered even more vulnerable if politicians impose inappropriate policies designed to stop or ‘solve’ migration. Ayeb-Karlsson et al. (2018) also raise caution for how forced relocation or resettlement of ‘trapped’ populations and new-settlers could be misused for political and financial gains including land- and green grabbing or unethical natural resource redistribution. The specific drivers and forms of movements determine the balance of these impacts on natural resources and, through those, sustainable development, politics, security, for instance. Ultimately, this has a bearing on whether migration is viewed as a net positive or a net negative phenomenon (Black et al. 2011a, b).

## Discussion: resources and mobility as a complex adaptive system

With all the variation apparent across empirical studies reviewed, it is clear that the research agenda has moved beyond linear theories of environmental ‘push’ or

economic ‘pull’ towards a greater appreciation for context and non-linear relations at all levels (Hunter et al. 2015; McLeman and Gemenne 2018). Natural resource-related drivers are just some of many factors influencing mobility decisions, increasing migration in some cases and reducing it in others, leading to a variety of mobility patterns and impacts on migrants, origin, and destination area (Kniveton et al. 2008; Foresight 2011).

Rather than to oversimplify the relationship between natural resources and human mobility, we suggest embracing it. We advocate for a systems approach used by scholars in the past to, for example, investigate the linkages between climate change and wellbeing (Berry et al. 2018; Hayward and Ayeb-Karlsson 2021). System investigations, specifically thinking in terms of socio-ecological systems (SES)—by which we mean ‘an ecological system intricately linked with and affected by one or more social systems’ (Anderies et al. 2013) and, by definition, vice versa offer a way of linking and representing the numerous findings that arise from empirical, localized case studies.

A more complex, systemic approach allows us to better understand non-linearities in the relationship between natural resource use and management and human mobility. The confluence between the two can, in fact, be conceptually thought of as sharing the properties of a *complex evolving socio-ecological system* (Allen 1990, 2001) operating at different temporal, spatial and social scales, involving multi-directional feedbacks, multilevel interactions, inevitable uncertainty, and displaying emergent properties (Gunderson and Holling 2002; Mayumi and Giampietro 2006; Rammel et al. 2007; Berkes et al. 2008; Kniveton et al. 2012). In this framing, migration systems can and should be considered as a subsystem within wider SESs operating on various different geographical and temporal scales, as well as one that influences and is influenced by them. The same logic applies to understandings of natural resources.

Human mobility, in its various forms, is just one of many parts of a spectrum of possible responses to change and opportunity in the system (Warner 2010). Such an approach would capture human mobility as well as ecosystems and their associated natural resource services as multi-causal, complex, adaptive phenomena and would require us to consider a broad range of interconnected attributes acting within and between them. By their nature, therefore, they cannot be understood through reductionist analysis of their constituents, because it is the interplay *between* their components that give them the dynamism (with constant evolution and high variation) that we observe.

Though case studies reviewed tend to focus on migrants or societies of origin or destination, from a systems approach, impacts on migrants and societies of origin or destination



must be seen as interactive rather than taken in isolation of one another. In terms of natural resources, the depletion or overuse in destination areas could stimulate further migration, while ‘successful’ migration can allow family members to stay in areas of origin by decreasing their dependence on local natural resources or enabling non-migrants to invest in natural resource beneficial infrastructure such as irrigation systems. Ill-equipped or under-prepared destination areas may limit the adaptive potential of migration and sustainable development by hindering migrants’ abilities to secure and send remittances, as well as to improve their own and their social network’s wellbeing. Issova et al. (2020) argue that viewing migration resulting from relationships to natural resources through the prism of the Sustainable Development Goals provides the sort of interdisciplinary, comprehensive approach that enables a balanced view of the impacts of migration.

Aside from policy recommendations including more prudent practical measures like ‘future’ or ‘climate proofing’ infrastructure in areas of particular concern like Asia and the Pacific (Édes & Gemenne 2015), natural resource management and governance systems and frameworks need to be able to deal with different temporal, social and spatial aspects, nested hierarchies and the multidimensional interactions and emergent properties of a dynamic system (Rammel et al. 2007). Future sustainable development targeted policy frameworks must have the capacity to deal with these inherent complexities and uncertainties, including shifting human (im)mobility dynamics (Martin 2012). In fact, intertwined human and natural systems inherently operate far from any static or equilibrium conditions (often conceived as a ‘Panarchy’: (Gunderson and Holling 2002) and are immutably dynamic and non-linear (Miller and Page 2007). Therefore, adopting an SES approach and understanding, with its associated focus on complexity and adaptation, explicitly allows one to reframe human and ecological factors in a process of ‘coevolution’, wherein migration can be an important diagnostic of stress or positive adaptation.

## Conclusions

The degradation and diminishment of natural resources is likely to grow and to shape the mobility landscape in the coming decades, despite a distinct lack of clarity regarding the scale and speed of these trends. The role of natural resources, however, is often obscured within ‘environmental migration’ literature and debates, overshadowed by concern over global environmental change and climate change. After a review of relevant literature, we articulated three primary streams of study when it comes to how natural resources interact with human (im)mobility: natural resources’ role in the migration decision-making

process, in shaping mobility dynamics in time and space, and, subsequently, how they are impacted by movement. Literature tends to treat these as separate areas of scientific inquiry, with most attention given to the former. Natural resource availability and use, populations’ livelihood dependence, and natural resource management, are most frequently analysed as intermediaries within the climate change-migration nexus. Fewer case studies have specifically given attention to the ways that natural resource bases and their management, such as mining operations or land grabbing, affect and are affected by human mobility.

The scientific corpus shows that the links between natural resources and human mobility are complex, running in many directions with multiple possible pathways, intermediate stages and resultant outcomes. Appropriate policy responses require these relationships are better understood. We still do not really understand how different policies and programme initiatives influence the potential for natural resource-induced (im)mobility, and what best practices we should profile and mainstream. Part of the governance challenge in dealing with the natural resources is that they suffer from significant fragmentation of actors both vertically and horizontally. Natural resource management often move between local, national and international levels and are rarely dealt with as a single issue but rather addressed by multiple initiatives in different ways.

To move beyond discreet case studies produced in localized contexts, we suggest a systems approach. The multiplicity of linkages and feedbacks between natural resources and migration across different spatial, temporal and social scales lends itself to a complex adaptive (sub)system (CAS) framing within larger socio-ecological systems. As a CAS, the outcomes of migration and natural resources linkages are highly non-linear and can be emergent: the sustainable management of them, therefore, requires flexible, robust and equitable approaches. Ultimately, policy makers need to address both sides of the natural resource-migration nexus: implement adaptation strategies that allow people to remain where they currently are, and identify migration and social protection measures that safeguard people’s livelihoods, lives and wellbeing when unable to stay.

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