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Synthesis

What we know and do not know about reciprocal pathways of environmental change and migration: lessons from Ethiopia

Kathleen Hermans^{1,2} , Charlotte Wiederkehr^{2,3} , Juliane Groth^{2,4}  and Patrick Sakdapolrak⁵ 

ABSTRACT. Linkages between environmental change and migration can be reciprocal: declining environmental conditions can trigger people to leave a place, while the movement of people to certain places can have implications for the natural environment and may enhance conflict risks. Although a growing body of research has enriched our knowledge on these two main directions of influence, including the role of conflict, research on dynamic linkages between environmental out-migration and degradation through in-migration is virtually lacking. To fill this gap, we have developed a conceptual framework and have outlined specific pathways of environmental change, migration, immobility, and resource use conflicts. We focus on reciprocal linkages to understand the mechanisms through which environmental change contributes to out-migration and how in-migration, in turn, may contribute to changes in the environment and resource use conflicts. The framework and corresponding pathways are based on our empirical research on resource-dependent rural communities in Ethiopia, which we have embedded in a broader Global South perspective. We identified the following four specific pathways of change: first, environmental change increases migration needs, primarily through declining agricultural production and food insecurity, with financial means and migration experiences being key factors enabling migration. Second, environmental change increases migration needs but hampers migration abilities through care responsibilities and lack of financial resources. This lack inhibits migration and leads to involuntary immobility. Third, migration to rural areas triggers land use change and deforestation through livelihood transitions and adopted land management in receiving areas. Forth, blaming migrants for perceived resource degradation contributes to resource disputes and violence between migrants and the local population. We conclude with future directions for identifying and understanding reciprocal environment-migration linkages and priorities for research.

Key Words: *conflict; environmental change; Ethiopia; migration; reciprocal linkages*

INTRODUCTION

Linkages between environmental change and various forms of migration can be reciprocal: declining environmental conditions can push people to leave a place (Black et al. 2011), while the movement of people to certain places can have severe implications for the environment (Radel et al. 2019). Environmental change has recently received considerable attention in explaining out-migration. It is particularly the influence of climate change on out-migration that has been studied intensively within the past two decades (Cattaneo et al. 2019, Pigué 2022). Specifically, there is a growing recognition that climate-related migration is multi-causal, context-specific, and typically driven by factors operating at various scales (Hunter et al. 2015, Borderon et al. 2019, Cattaneo et al. 2019, Hermans and Ide 2019, Cundill et al. 2021, Hermans and McLeman 2021), and actual engagement in migration may differ substantially within and between households (Hoffmann et al. 2022). Environmental migration outcomes, hence, range from voluntary migration to involuntary displacement and cover various forms of immobility, as such reflecting varying levels of agency (Hugo 2011, Afifi et al. 2016, Ayeb-Karlsson et al. 2020, Van Praag 2021).

People's motives for migration and types of movement can be manifold; the same applies to the impacts it has on the natural environment. Overall, the movement of people to certain places (hereafter referred to as in-migration) can have multiple implications in destination areas, including changes in

environmental conditions and resource use dynamics. For example, in many tropical forest frontier regions, the arrival of domestic settlers has contributed to deforestation and forest degradation in the past (Geist and Lambin 2002, Bilsborrow et al. 2004, Barbieri et al. 2009, Hermans-Neumann et al. 2016). Such findings are contradicted by other case studies that show that the impact is context-specific and depends on a variety of direct and indirect demographic, political, economic, social, and institutional factors operating at various scales (Caviglia-Harris et al. 2013, van der Geest et al. 2016, Jones et al. 2018). In addition, several scholars suggest that (environment-induced) migration enhances conflict risks at destinations, primarily through increasing demographic pressure and natural resource scarcity (e.g., Homer-Dixon 1999, Kelley et al. 2015), a claim that is highly contested by many others (e.g., Theisen 2008, Koubi et al. 2014, Seter et al. 2018).

Taken together, a growing body of research has significantly enriched our knowledge of the two main directions of influence, including the role of conflict. Yet, research on dynamic linkages between environmental out-migration and degradation through in-migration is virtually lacking. This hampers our understanding of the complex dynamics between socioeconomic and environmental factors. This is particularly concerning because migration can be a key variable that interacts with multiple socioeconomic and ecological system factors across multiple levels and directions (Jokisch et al. 2019).

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Consequently, we expect cross-level dynamics to play a role when considering interactions between migration and the environment. However, it remains unclear if and how environmental change and migration may reinforce each other, potentially leading to unintended social or environmental dynamics and undermining ecological and social sustainability.

Here, we present a conceptual framework including specific pathways of environmental change, migration, immobility, and resource use conflicts. We focus on bi-directional linkages to understand if and how environmental change and migration can reinforce each other and lead to a positive feedback loop. The framework and its corresponding pathways are based on our empirical research on resource-dependent rural communities in Ethiopia (Fig. 1), accumulated over the past years under the umbrella of the MigSoKo project, which we have embedded in a wider Global South perspective. Our study aims to illustrate feedback mechanisms through which environmental change contributes to migration, either by triggering or impeding it, and how consequent in-migration may contribute to changes in the (natural) environment and conflicts surrounding the use of natural resources. Thereby, we primarily focus on rural-rural migration, an aspect that is vastly underrepresented in environment-migration studies. Our work shall serve as the first novel attempt to conceptualize and discuss reciprocal linkages between environmental change, migration, and resource use conflicts based on a set of individual empirical studies.

RECIPROCAL LINKAGES BETWEEN ENVIRONMENTAL CHANGE, MIGRATION, AND RESOURCE USE CONFLICTS: A FRAMEWORK

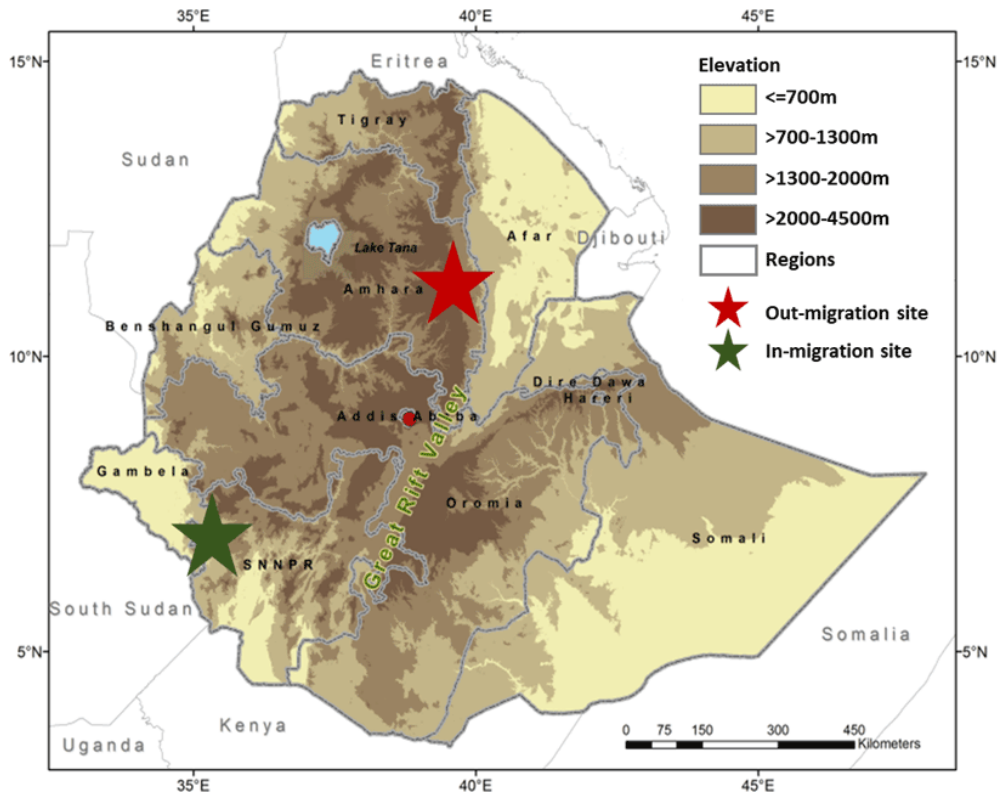
Our framework draws on our empirical research carried out in rural communities in Ethiopia, complemented by two synthesis studies focused on the larger Global South (i.e., motivated by the availability of data, see Appendix 1). These individual studies have applied diverse quantitative and qualitative methods to understand specific aspects of the linkages between environmental change and migration. Five of these studies have analyzed how environmental change, particularly increasing rainfall variability, drought, and land degradation, have shaped migration and immobility in the Ethiopian highlands and elsewhere in Sub-Saharan Africa. In turn, two studies have analyzed how in-migration contributes to environmental change, mainly deforestation and resource use conflicts in Southwest Ethiopia and beyond. These studies have in common their focus on rural subsistence-based and smallholder communities, either migrant-sending or receiving communities, that are highly dependent on natural resources, such as grassland, soil, forest products, and water. Among all but one study, the units of analysis were individuals or households. Detailed information on the specific methods employed, including the data types utilized, is provided in Appendix 1.

We use a social-ecological systems (SES) perspective to develop our framework, which is particularly apt to examine the nexus between environmental change and societal dynamics (Fischer et al. 2015, Partelow 2018). The systemic perspective allows us to account for the inherent complexity of socioeconomic, political, and ecological factors, as identified in our empirical research. It further enables us to explicitly address nonlinear relationships and feedbacks between humans and the biosphere, including

learning and adaptation processes in the social system in response to modifications of the ecological system (Binder et al. 2013, Hamann et al. 2018). As such, the SES perspective is key for acknowledging that reciprocal environment-migration dynamics are typically complex, diverse, and context-specific (Radel et al. 2019, Cundill et al. 2021). SES frameworks that capture the links between micro-level interactions and emerging macro-level structures and processes that determine SES behavior, including specific pathways of change, are scarce (Schlüter et al. 2019). We address this gap by considering causal linkages between humans and ecological entities in the identified pathways, emphasizing the role of agency. Here, we specifically address three levels: macro (i.e., regional to national), meso (i.e., community or any social group), and micro (i.e., individual or household). In doing so, we address a significant research gap in SES research, namely to integrate micro-level interactions and human agency with meso-level and macro-level processes and conditions that determine SES behavior (Hamann et al. 2018, Borderon et al. 2019, Schlüter et al. 2019).

Figure 2 depicts the linkages between environmental change, migration, and resource use conflicts based on insights from our own research. This empirically underpinned framework serves as a starting point for generating a generic understanding of potential reciprocal environment-migration linkages based on a specific social-ecological context, here Ethiopia. Overall, we show that reciprocal linkages between environmental change and migration clearly exist in the studied rural communities in Ethiopia, which are mediated by various factors occurring at the micro, meso, and macro level (Table 1). These factors cover biophysical, socioeconomic, and institutional aspects. Remarkably, although not surprisingly, our research revealed that most identified factors can act in opposite directions. Hence, they can trigger or accelerate changes, just as they can hamper or slow them down. For example, in northern Ethiopia, unfavorable environmental conditions for agriculture, including increased drought frequency, unreliable rainfall, and advanced land degradation, can increase migration needs and aspirations by undermining the viability of agricultural livelihoods. However, these conditions also tend to lower migration abilities by decreasing agricultural income and hence, financial resources required for migration. Conversely, favorable environmental conditions, such as relatively stable rainfall during the cropping season in “a good year,” can decrease migration needs and aspirations and enable migration via agricultural income (for more details, see below the description of pathways A and B). The precise impact mechanisms significantly depend on a variety of additional mediating factors at the macro, meso, and micro level (for more details, see also Wiederkehr et al. 2019). For instance, different levels of risk perceptions, place attachment, and migration experiences play a significant role in migration decisions and are sometimes closely interrelated. Specifically, migration experience increases people’s abilities to migrate, for example, by providing helpful information and lowering risks and costs associated with migration. In addition, aspirations to move are shaped by people’s perception of environmental risks and typically are limited in cases of strong attachment to their place of origin for social or cultural reasons. In turn, agricultural policies encouraging certain farming practices, such as cash crop production in southern Ethiopia, multiple conflicting formal and

Fig. 1. Location map of the out-migration study site and the in-migration study site based on elevation data obtained from the Shuttle Radar Topography Mission (SRTM) at 250-m resolution (Farr et al. 2007).



informal land tenure arrangements, and lacking land rights, have been shown to accelerate pressure on natural resources, especially forests, in rural receiving areas. Together with micro-level farming practices and resource access restrictions for selected population groups, this can fuel deforestation in rural receiving areas (see pathway C). We have looked at selected feedbacks between the environmental and social systems to fill the blind spots in understanding environment-migration linkages, including the role of institutions. The novelty lies in its explicit focus on rural areas, for both sending and receiving areas, to identify potential feedbacks between them.

PATHWAYS OF SOCIAL-ECOLOGICAL SYSTEM CHANGE

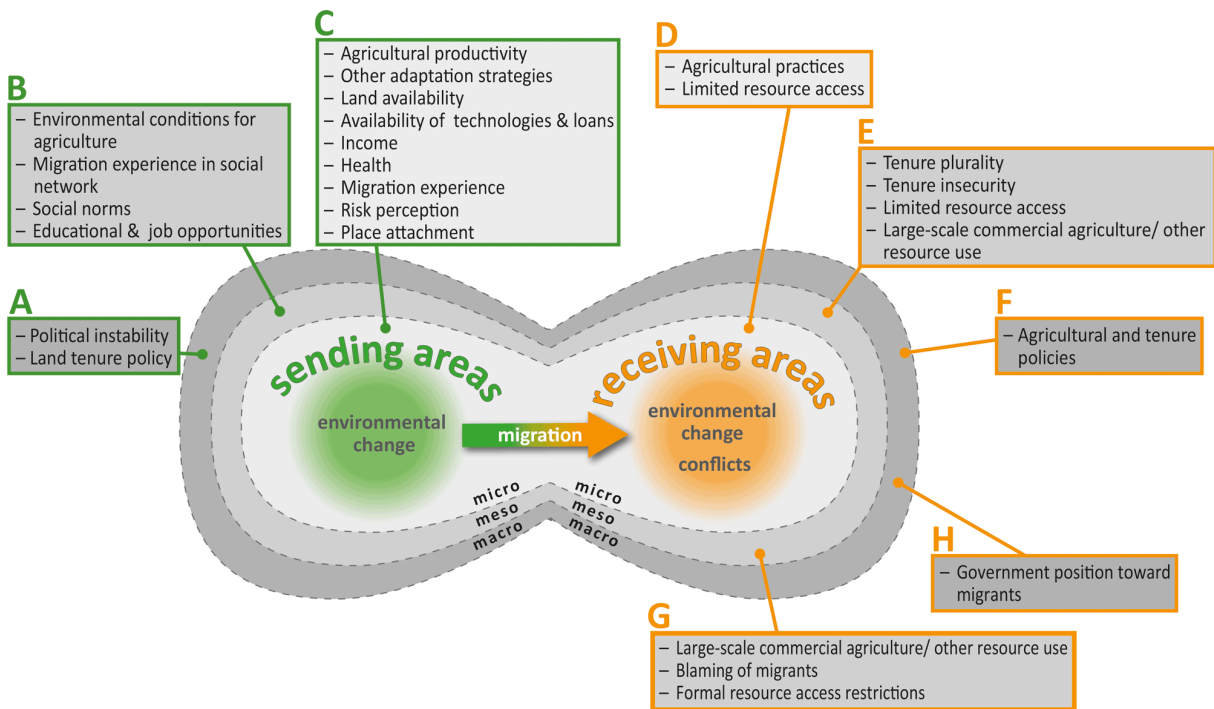
In the following, we outline four pathways that describe the impact of environmental change on migration, and vice versa, mediated through different contexts and mechanisms. As such, they illustrate the linkages explaining reciprocal environment-migration dynamics. These pathways were derived from our above framework and are exemplary based on our empirical research. We consider multi-level factors that enable or amplify processes of environmental change and migration and those that might undermine these. We start by describing two pathways that address out-migration, and the lack thereof, in the context of increasing climate variability, drought, and land degradation. Here, we draw on the concepts of migration ability (i.e., a person's willingness to move), migration aspiration (i.e., a person's

motivation to move), and migration need (i.e., the level of pressure on a person to move), based on Carling (2002), Black and Collyer (2014), and Carling and Schewel (2018). Both pathways are based on our empirical insights from the South Wollo Zone in the northern Ethiopian highlands and results from a meta-study with a geographic focus on Sub-Saharan Africa (SSA). We then describe two pathways that address social-ecological consequences of rural in-migration, thereby focusing on deforestation and natural resource use conflicts. These two pathways draw on our findings from the Bench Maji Zone in Southern Ethiopia, which in the past had attracted significant migrants from the northern highlands (as represented in the former two pathways), as well as on results from a meta-study with a larger Global South perspective (Table 1).

Pathway A: Environmental change increases migration need, whereas financial means and migration experiences are key drivers enabling migration

For the northern Ethiopian highlands, our research has shown that soil degradation and increasing rainfall variability limit smallholder agricultural production (Hermans and Garbe 2019, Groth et al. 2020, 2021). Reduced agricultural production, resulting in income losses and food shortages, urges farmers to search for income sources outside agriculture, such as daily labor (e.g., construction work), cultivating eucalyptus trees, or running a small enterprise (e.g., tailoring, running a cafeteria, or pottery). Groth et al. (2020) have shown that households that are successful

Fig. 2. Reciprocal linkages between environmental change, migration, resource use conflicts, and their multi-level mediating factors.



in income diversification through applying at least one of these activities are more likely to migrate than households with restricted agricultural incomes as a consequence of adverse environmental conditions. In other words, households with a minimum of economic resources, for example, originating from non-agricultural incomes, are more likely to be able to migrate than households without income diversification options. This is mainly because migration comes with financial costs. A second important factor enabling migration, as observed in our research, is the migration experience in one's own household. Sharing migration experiences among those who have left and those who have not (yet) shapes expectations and risk perceptions associated with migration. Our research demonstrates that being part of a social network with migration experience has a tangible influence in overcoming practical hurdles related to migration, including assistance in finding suitable employment and housing. Additionally, these networks can extend their influence by facilitating the identification of safe migration routes and connecting individuals with supportive individuals or organizations. The observations of improved lifestyles, such as better clothes and mobile phones, among migrated siblings or friends further strengthen the desire to migrate among young people. Notably, the narratives and perceptions conveyed by returnees also significantly impact migration, highlighting how migrant networks not only affect the ability to migrate but also shape migration aspirations. Taken together, this pathway illustrates that household resources, especially financial means and access to migration experiences, are key factors enabling and stimulating migration. Moreover, this pathway underpins the crucial role of migration aspiration in addition to migration need

and ability to shape migration processes. Although alternative income sources tend to alleviate the need to migrate in the context of environmental change, people might still decide to migrate, among other things, because of positive migration experiences within their own households or educational and professional opportunities at destination areas (see also Wiederkehr et al. 2019).

Pathway B: Environmental change increases migration need but hampers migration ability through care responsibilities and lack of financial resources

The starting point for this pathway is the same as for the former: increasing land degradation and rainfall variability in combination with factors related to the limited availability of technologies, loans, and land, pressure agricultural production. In northern Ethiopia, this typically adversely affects household income and food security. The consequent need for income sources outside agriculture makes farmers search for alternative job opportunities, for example, daily labor as construction workers. Yet, in the rural northern Ethiopian highlands, such job opportunities are rare and not accessible for everyone, which increases the need to migrate to secure household incomes elsewhere. However, and as indicated in the former pathway, migration is often costly and requires a minimum of economic resources to realize it. In northern Ethiopia, our research has revealed that households without access to non-farming income and income diversification typically lack these economic resources (Groth et al. 2020). This lack, in turn, inhibits migration and leads to involuntary immobility, and hence, so-called "trapped populations." The lack of resources undermines the ability of people to leave. Besides economic resources, gender roles

Table 1. Short description of each identified influence factor as illustrated in Figure 2, based on our empirical research as listed in Appendix 1. Influence factors are presented individually to allow for a systematic overview. In reality, most indicated influence factors typically interact, leading to a particular outcome (potentially resulting in the outlined pathways).

Influence factor	Description
SENDING AREAS	
Macro level	
Political instability	Political instability can increase migration needs and aspirations while decreasing migration abilities.
Land tenure policy	Depending on the specific policies, land tenure can either increase or decrease migration needs and aspirations (e.g., if land can be purchased in a given area, or if land property at the place of origin is lost in case of moving).
Meso level	
Environmental conditions for agriculture	Unfavorable environmental conditions for agriculture can increase migration needs and aspirations by undermining the viability of agricultural livelihoods. However, they also tend to lower migration abilities by decreasing agricultural income. Conversely, favorable environmental conditions can decrease migration needs and aspirations and enable migration via agricultural income (see also agricultural productivity).
Migration experience in social network	Migration experience in the social network increases migration abilities of people by facilitating movement (e.g., by providing helpful information and lowering associated risks and costs).
Social norms	Social norms can contribute to higher or lower migration aspirations (depending on whether migration is connoted positively or negatively). They can also reduce migration abilities (e.g., when women are primarily assigned the role of domestic caregivers).
Educational & job opportunities	Educational and job opportunities can increase migration abilities (e.g., via income sources outside of agriculture at the area of origin) and migration aspirations (e.g., if better opportunities are available at the destination). In contrast, under sufficient agricultural production, an increase in non-farm activities can reduce migration because of a lower migration need and because people might have little migration aspirations when they have a job.
Micro level	
Agricultural productivity	Low or decreasing agricultural productivity tends to increase migration needs and aspirations. However, it can also reduce people's migration abilities because of lacking financial income from agriculture. High agricultural productivity tends to have the opposite effect (see also environmental conditions for agriculture).
Other adaptation strategies	Other strategies for adaptation can reduce migration needs and increase migration abilities (e.g., by enhancing agricultural productivity or providing food or income from other sources).
Land availability	Lacking availability of land contributes to migration aspirations and increasing migration needs when people struggle to provide for their household. Available land, in turn, can have the opposite effect but, at the same time, increase migration abilities.
Availability of technologies & loans	Technologies and loans can reduce migration needs and increase migration abilities at the same time (e.g., by facilitating in-situ agricultural adaptation or by making financial resources available).
Income	Income essentially determines people's ability to stay put and migrate (especially across longer distances). Higher income levels simultaneously contribute to higher migration abilities and lower migration needs (and vice versa).
Health	Health essentially determines people's ability to stay put and to migrate. A better health status contributes to higher migration abilities (and vice versa). In contrast, increasing health problems (due to, e.g. food insecurity and water scarcity) increase the need to migrate (and vice versa).
Migration experience within the household	Available migration experience in a household increases the migration abilities of household members by facilitating movement (e.g., by providing helpful information and lowering associated risks and costs).
Risk perception	The subjective perception of environmental risks can increase people's aspirations to migrate.
Place attachment	A strong attachment to their place of origin for social or cultural reasons lowers people's aspirations to move.
RECEIVING AREAS	
Macro level	
Agricultural and tenure policies	National policies can contribute to deforestation if they promote the expansion of small-scale or large-scale commercial agriculture in a given area (e.g., by encouraging cash crop production, land-intensive farming practices, or facilitating land transfers to private investors) or land use management practices that are ecologically not sustainable in the local contexts.
Government position toward migrants	Depending on the respective context, both an adverse and a supportive government position toward migrants at the destination can contribute to resource conflicts (either by increasing their marginalization or by provoking envy and resentment among other local groups that feel disadvantaged).
Meso level	
Tenure insecurity	Lacking secure and formal land rights because of tenure plurality (i.e., multiple and potentially conflicting formal and informal tenure arrangements) can contribute to environmental change. For instance, forest clearing can become a common strategy to claim land needed to sustain agricultural livelihoods in rural receiving areas.

(con'd)

Large-scale commercial agriculture / other resource use	Large-scale commercial agriculture or other resource-use activities (e.g., industrial logging) can contribute to both deforestation and resource conflict by reducing the forest product availability for local subsistence users or smallholders and adding pressure on the natural resource base in a given area.
Blaming of migrants	Blaming migrants for using natural resources unsustainably and degrading them can contribute to resource conflict involving migrants, especially in contexts where local livelihoods are highly resource-dependent.
Formal resource access restrictions	Depending on the context, formal (i.e., state-sanctioned) resource access restrictions can contribute to resource conflicts, e.g., when there are limited resource use possibilities for certain local groups in an area, and restrictions are perceived as unfair.
 Micro level	
Agricultural practices	Certain agricultural practices, primarily expanding agricultural land for food production, contribute to deforestation.
Limited resource access	Exclusion of specific households in forest resource management (due to language barriers) and, hence, limited access to forest resources contributes to deforestation by incentivizing the uptake of agricultural activities.

and associated social norms largely determine at the micro level whether people migrate or stay put (Hermans and Garbe 2019, Groth et al. 2020). Many farmers are committed to staying in their village because of their responsibility to support their own families, particularly in raising and educating their children. In rural northern Ethiopia, as in many rural resource-dependent communities, it is primarily the women who have restricted abilities to leave because of primary domestic care responsibilities. Despite the need to generate additional income for their family, these women often stay. Additionally, limited health conditions and old age emerged as another critical factor that hindered farmers from pursuing migration. These findings are also reflected by Wiederkehr et al. (2018), who show that rural households in SSA typically apply a variety of strategies to deal with environmental changes. Migration is common; however, it is not the most preferred nor accessible strategy for most affected households. Based on a meta-analytical approach, the authors concluded that nearly one out of four households in SSA drylands apply migration as adaptation. Most households try to adapt in situ, applying crop, livestock, soil and water management strategies primarily. Lack of financial resources is one of the most commonly mentioned barriers to adaptation, including migration.

Pathway C: Migration to rural areas triggers land use change and deforestation through livelihood transitions and adopted land management

Our research in Southwest Ethiopia, a hotspot of multi-ethnic in-migration, has shown that understanding environmental change as a consequence of rural in-migration requires accounting for a variety of micro, meso, and macro level factors rather than a straightforward cause-effect narrative (Groth et al. 2023). The Southwest of Ethiopia, characterized by environmental conditions being beneficial for agriculture, has experienced substantial in-migration of smallholder farmers in the past decades, amongst others, from the northern Ethiopian highlands. While the resulting population growth has undoubtedly increased the demand for agricultural land, land given to migrants by the national government has contributed to tenure plurality, that is, the coexistence of multiple land tenure systems or arrangements within the region, including the traditional forest tenure, the so-called kobbo system. This tenure plurality has led to tenure insecurity, meaning that individuals are uncertain about their rights and control over the land they occupy. As a result, this tenure insecurity fueled forest clearing to consolidate land claims.

In addition, the growing ethnic diversity resulting from in-migration, in combination with state-led changes in forest management institutions, has diminished the power of the local population. For example, using Amharic as the language for forest user group meetings presents a language-related barrier to accessing the forest, as it is fluently spoken by most migrants but not necessarily by locals. This language disparity may have contributed to the decline in forest activities among local households and likely impeded the effectiveness of forest management initiatives in the region. Consequently, the majority of the local population, which has traditionally largely depended on forest products, such as timber and honey, experiences increasing barriers to forest resources and a reduced forest cover nowadays. Besides, the local population perceives the migrants from the northern highlands, who have transferred their agricultural practices from the North to the South of the country and obtain comparably high agricultural yields, as successful agriculturalists. In addition, the expansion and intensification of agriculture is fuelled by agricultural and land tenure policies that promote the production of cash crops for national and international markets and facilitates the expansion of commercial agricultural projects. Local extension programs, such as those found in the Ethiopian highlands (where the migrant originates), encourage practices like intensive ploughing, adopting better seed varieties, and utilizing inorganic fertilizers and pesticides. However, these activities, while already prevalent in the region, contribute to deforestation and degradation of soil and forests. A land proclamation, for example, privileged state-led land transfers to private investors and contributed to reduced forest availability for the rural population. Taken together, these developments have provoked a livelihood transition of the local population from primarily forest users toward agriculturalists, which has aggravated deforestation. In short, in-migration of smallholders to forest frontiers has contributed to deforestation by increasing the demand for agricultural land and the adoption and diffusion of agricultural techniques among the forest-based local population. Yet, these processes are strongly mediated by multiple macro, meso, and micro factors.

Pathway D: Blaming of migrants for perceived resource degradation contributes to resource disputes and violence between migrants and local groups

Our research has demonstrated the potential for resource conflicts in migrant-receiving areas where local groups perceive the degradation of natural resources upon which they depend for

sustaining their livelihoods and blame the resource use practices of migrants for this. Such tendencies have been observed in the lowland tropical forest in southwest Ethiopia, where the local population traditionally depend on forest products, such as honey or wild coffee. Unlike the locals, migrants from the northern highlands use the forest mainly as a source of timber and fuelwood and are increasingly blamed for forest clearing. This situation has led to violent disputes over land use rights between migrants from northern Ethiopia and local groups, further exacerbating the complexities of the land tenure conflicts in the region (Groth et al. 2023). These tensions are partially related to the different resource use practices of agriculture-dependent migrants and forest-based local groups and the overall decrease of natural resources (see pathway C). In addition, a poorly executed land reform created in 2010, which allocated land claimed by local groups under their traditional tenure system to migrants, resulted in tenure plurality. Ultimately, these developments led to tensions and violent conflicts between local groups and immigrants, resulting in the temporary displacement of migrants from their homes. Moreover, current legal migration restrictions prevent migrants from outside the southern regions from obtaining formal land titles, which undermines their legitimacy vis-à-vis the local population and external investors and may exacerbate land tenure conflicts and marginalization of migrants. Furthermore, our research highlights that the potential for conflicts over resources in areas receiving migrants extends beyond Ethiopia. In our meta-analysis (Wiederkehr et al. 2022), which analyzes the factors contributing to natural resource-related conflicts in the Global South, we found that blaming migrants for allegedly degrading natural resources in the area contributes to such conflicts. This is exemplified by a case in Katiali, northern Ivory Coast, where a violent land dispute erupted during the 1970s and 80s between migrant herders and local farmers. The conflict arose because of an influx of pastoralists, driven by severe droughts in the Sahel, arriving in unprecedented numbers. Tensions and resource competition escalated over time in the context of among other things crop damage attributed to the pastoralists' cattle herds, disagreements over the ownership and use of land fertilized by these herds, and rising inter-ethnic hostilities in general. Crop damage remained mostly uncompensated and significantly impacted farmers' income, which explains why such accusations have the power to accelerate conflict, especially in cases of high resource dependence. Furthermore, Wiederkehr et al. (2022) highlight the significant impact of governmental actions on the dynamics between local communities and migrants, particularly in situations where there are limited possibilities for resource use and conflicting use interests. It becomes apparent that agricultural and land tenure policies, as well as economic forces play a pivotal role in shaping land degradation and escalating tensions in various rural regions across the Global South, extending beyond Ethiopia. Hence, the broader implications drawn from both the Ethiopian case study and the broader context of the Global South highlight the persistent patterns of resource conflicts that can arise in diverse regions because of migration and competing interests and practices surrounding resource utilization.

Concluding this, the two pathways yielding out-migration (pathways A and B) illustrate how environmental change, through the channel of agricultural production, shapes migration needs, abilities, and aspirations. Both pathways show that migration

needs of rural smallholder households have increased because of limited agricultural production as a consequence of adverse environmental conditions at the meso level, mainly land degradation and increasing rainfall variability. Yet, migration abilities and aspirations largely differ between households because of different micro-level socioeconomic factors, primarily financial resources and migration experience in one's own household, as well as social norms (here considered at the meso level). Taken together, this leads to varying migration outcomes, including involuntary immobility. Overall, both pathways show that migration is strongly mediated by the ability of a household to migrate rather than often cited so-called push factors. Further, our findings contradict the notion of the "poorest of the poor" who leave their home but rather hint at the opposite, as migration requires a certain level of household resources. For the other direction, pathways C and D show that inextricably linked social and political factors essentially shape causal linkages between in-migration, natural resource degradation and resource use conflicts. Pathway C underlines the key role of resource access, property, and exclusion, especially at the meso level, in driving resource use dynamics in rural receiving areas. Which interest groups, including migrants, are able to use and control certain resources and whose claims are legitimized by the state are decisive in this context. Not surprisingly, tenure regimes are particularly crucial here. Tenure plurality and insecurity can pave the way for forest clearing (here used as a proxy for environmental change), e.g., by smallholders and large-scale agricultural projects like in Southwest Ethiopia, or contribute to conflicting land claims, thereby enhancing tensions between different groups. Furthermore, economic activities at the meso level, such as large-scale commercial agriculture, often exacerbate existing conflicts of resource use interests and can contribute to the marginalization of certain user groups. Besides this, pathway D illustrates the conflictive and violent dynamics that can unfold when migrants are attributed the primary responsibility for perceived environmental degradation in a given area, especially in contexts where livelihoods are predominantly resource based. In many of the cases assessed in detail in Wiederkehr et al. (2022), this blaming reflects ethnic stereotypes and prejudices related to resource use practices and traditions, which differ between migrant and local groups, or envy and resentments, related to, for instance, government support for in-migration.

DISCUSSION

A growing body of research has shown how declining environmental conditions can contribute to out-migration, whereas in-migration can lead to modifications of the natural environment, including deforestation (Jokisch et al. 2019, Radel et al. 2019). Traditionally, however, these two processes have been studied independently, hence as two separate, unidirectional processes. Therefore, knowledge on dynamic linkages between environmental out-migration and degradation through in-migration is scarce. Against this background, the question arises if and how these two processes are linked, potentially leading to a positive feedback loop, and what factors from both the social and the ecological system at the micro, meso, and macro levels enable or support such a loop. Being entangled in a positive feedback loop means that a change in a given direction, for example, increasing environmental degradation, causes an additional change in the same direction, in our case, through the

migration process. As such, a positive feedback loop characterizes inherently unstable systems and undermines social-ecological sustainability.

In Ethiopia, we have looked at two distinct SES, which are coupled through migration. In the northern Ethiopian highlands, the environmental conditions for subsistence agriculture are by far less beneficial than in the southern region. This is because the adverse environmental change in the highlands is more pronounced and longer lasting, and population pressure and associated land scarcity are more severe than in the southern system. What both systems have in common, however, is the high dependency of the rural population on natural resources. Although we could not observe a positive feedback loop *per se* between these two SES based on our empirical research, it remains unknown at what level of environmental degradation in the southern in-migration system out-migration starts, hinting at the role of critical system thresholds. Rather than a feedback loop, we observe some critical pathways concerning environmental change, migration, and resource use conflicts that might disturb the self-regulating nature of the studied SES. Specifically, migration from the northern highlands to the South contributed to social-ecological conditions at the destination, including decreased access to natural resources and first indications of land degradation, which in the long run, threaten agricultural productivity (Groth et al. 2023). This, in principle, might increase migration need, potentially triggering migration to other regions.

Furthermore, linking processes of environmental change, migration, and conflicts requires accounting for temporal offsets. Resource use conflicts after in-migration might occur with some delay rather than at the very moment of arrival at the destination (Wiederkehr et al. 2022). Similarly, except in extreme situations, climate change usually does not trigger migration right away. Instead, migration often starts once in-situ adaptation strategies cease to be effective (McLeman 2018). For example, during the Dust Bowl in the U.S. in the 1930s, over a hundred thousand people moved away from rural Oklahoma; however, only after a couple of years of poor harvests due to drought (McLeman et al. 2008). Similarly, extreme heat periods in Mexico have steadily increased migration away from the affected regions before migration increased nonlinearly only after three years of hot conditions (Nawrotzki and Bakhtsiyarava 2017). Together, the U. S. and Mexico studies illustrate the importance of time lags in understanding migration processes. Such time lags can be larger in SES characterized by reciprocal linkages because of the inherent complexity of such systems, something that ultimately needs to be considered in the study design.

It is important to underline that the migration-conflict linkage described in Pathway D is not to be understood as a universal conclusion but as one pattern that emerged from our research. Scholars working on resource conflicts as well as migration-conflict dynamics emphasize the broad range and cross-scale nature of mediating factors, which can contribute to tensions in receiving areas, including power relations in the host society or resource governance regimes, and how these might shift because of in-migration (e.g., Brzoska and Fröhlich 2016). Based on a review of climate change and conflict in East and West Africa, Seter et al. (2018) highlight that in-migration is not necessarily problematic but that the lack of well-established resource sharing

or conflict resolution mechanisms can enhance conflict risk where in-migrants and local groups had few previous relations and distinct ethnic backgrounds. Moreover, depending on how political institutions and elites respond to migrants, other social groups in this area likely perceive a higher or lower threat of resource competition (Esses et al. 1998, Barnett and Adger 2007). On the other hand, potential grievances of migrants and resulting conflict perceptions are found to be influenced by the pace of environmental change or hazard at the migrants' origin (Koubi et al. 2018).

Whether or not people move away from those regions to which they moved in the first place depends not only on the ecological conditions of the region but also on socioeconomic factors at the micro, meso, and macro level (e.g., Borderon et al. 2019). On a hypothetical basis, we expect resource conflicts to have a similar effect on out-migration as environmental degradation since the need and motivation for migration are likely to increase, thereby decreasing the level of agency in migration decisions. This implies a growing risk of involuntary migration and immobility and associated adverse effects. Further, people with restricted agency are more likely to move to or within degraded or conflict-prone areas because of a lack of choice, which likely entails adverse effects on those involved and potentially indicates a positive feedback loop. However, our research in Ethiopia has shown that the two studied SES (out-migration system in the northern highlands and in-migration system in the Southwest), although linked, are distinct regarding ecological, demographic, and governance conditions. This challenges the transfer of migration-enabling factors and barriers from one system to the other for concluding a potential positive feedback loop. It rather underlines the context-specific nature of migration processes, which limits the transferability of results and the leeway for predictions.

A key aspect shaping reciprocal linkages between environmental change and migration is place attachment, defined as the “emotional bonds which people develop with various places” (Lewicka 2011:219). Place attachment has been found to play a key role in the context of risk perception and migration decision making. In fact, a range of empirical studies from different parts of the world indicates that place attachment is one of the major factors at the micro level motivating people to remain in place (or at least the surroundings) even if environmental stress is experienced (e.g., Adams 2016, Khanian et al. 2019, Paul et al. 2020). This resonates with our empirical research, which has shown that, despite increasing rainfall variability and land degradation, especially elderly respondents in northern Ethiopia prefer to stay put because of their strong place attachment (Groth et al. 2020). Place attachment is the only influence factor we identified as having an exclusively “negative” effect when considering the linkages between environmental change and migration. Therefore, we suggest that, by incentivizing people to stay and increasing their tolerance of a certain level of stress generated by environmental degradation, place attachment counteracts other micro, meso, and macro factors that potentially contribute to a positive feedback loop. However, it is not well understood yet at which point environmental degradation or resource conflicts have such a detrimental impact that they “override” place attachment and, hence, the motivation to remain in place, pointing again to the role of critical thresholds in migration dynamics (see also Dandy et al. 2019).

In our study, we have looked at selected feedbacks between the environmental and social systems, namely those representing dynamic linkages between environmental out-migration and degradation through in-migration. Studying these reciprocal linkages is genuinely novel. The considered feedbacks reflect our empirical research focus and do not claim to be complete. In principle, a variety of environment-migration feedbacks potentially exists that was, however, beyond the scope of our research. Amongst others, these include the impacts of social and financial remittances, population decline, and associated loss of labor and knowledge (brain drain) in areas of origin, which may all influence natural resource use and out-migration behavior (Davis and Lopez-Carr 2010, Moran-Taylor and Taylor 2010, Greiner and Sakdapolrak 2013, López-Feldman and Chávez 2017, Ospina et al. 2019, Radel et al. 2019).

FUTURE RESEARCH DIRECTIONS FOR IDENTIFYING AND UNDERSTANDING RECIPROCAL ENVIRONMENT-MIGRATION LINKAGES

Our study forms the foundation for future research on the reciprocal linkages between environmental change, migration, and resource use conflicts. It illuminates the intricacies of these interactions and sheds light on agency at multiple levels (macro, meso, and micro). By employing this framework, we can advance our understanding of the bi-directional interplay between environmental change and migration dynamics. Building on our discussions, we have identified key recommendations for future research directions in identifying and comprehending reciprocal linkages and feedback loops in environment-migration systems. First, knowledge of the role of critical thresholds or tipping points in the emergence and development of positive feedback loops is virtually lacking. Non-linear relationships are an inherent characteristic of SES, and the importance of thresholds to understand the processes of in situ adaptation and migration in the context of environmental change has been stressed repeatedly (Bardsley and Hugo 2010, McLeman 2018, Adams and Kay 2019, Piguet 2022). Besides, a limited number of studies suggest that migratory responses to climate change are typically non-linear but change once a certain threshold is crossed (McLeman et al. 2008, Bohra-Mishra et al. 2014, Nawrotzki and Bakhtsiyarava 2017). However, empirical approaches for identifying and understanding critical threshold behavior and tipping points in feedback loops of environmental change and migration, including the consideration of place attachment and time lags in migration decisions, are lacking today.

Existing research on linkages between environmental change, migration, and resource use conflicts largely focuses on either migrant-sending or migrant-receiving locations but neglects reciprocal relationships. The concept of translocality has the potential to bridge this research gap as it describes “socio-spatial dynamics and processes of simultaneity and identity formation that transcend boundaries” (Greiner and Sakdapolrak 2013:373). As such, it may help capture the socioeconomic and ecological processes that shape migration and natural resource use in multiple connected locations, thereby integrating empirical insights from sending, transit, and receiving areas (Radel et al. 2019). Recently, this concept has been applied to understand the role of migration in land use change processes and livelihood transitions, as it is particularly promising because of its focus on institutions as key mediators (Eakin et al. 2014, Zimmerer et al.

2018). Yet, the concept requires an expanded emphasis on feedback loops to advance our understanding of how environmental change and resource conflicts can reinforce rural migration and vice versa across multiple levels and scales. In addition, research should be expanded toward investigating the environmental impact of out-migration in source areas, complementing the existing emphasis on the environmental effects of in-migration in destination areas. This would provide a more comprehensive understanding of the environmental consequences associated with migration processes.

For better understanding of feedback loops in SES, including trajectories of change and their implications for the environment and humans, the concept of red and green loops has been developed (Cumming et al. 2014). Red-loop systems describe societies where there is a significant disconnection from the local environment, with the share of income derived directly from ecosystems being low. A green loop characterizes feedbacks in societies where most people directly rely on natural resources, including agriculture and forests, such as in Ethiopia. Green-loop systems are characterized by direct feedback between human well-being and the degradation of the environment; a local equilibrium between resource use and human population is maintained and avoids long-term degradation of ecosystems (Cumming et al. 2014, Cumming and von Cramon-Taubadel 2018). A major challenge, especially against the background of a growing population, is to avoid poverty traps and an excessive degradation of local ecosystems, transitioning from a stable green loop to a green trap (Cumming et al. 2014, Hamann et al. 2018). The concept’s focus on resource dependence and sustainable development is promising but needs to be expanded for the role of migration to advance our understanding of how social-ecological processes in seemingly disparate, yet connected, locations can lead to feedback loops.

In our research, the linkages between migration and environmental change, on the one hand, and migration and resource conflicts, on the other, were targeted in separate analyses. Accordingly, potential dynamics between environmental change and resource conflicts have not been addressed in more detail here, and these processes are depicted as separate “outcomes” in Figure 2. However, existing evidence from the broader field of conflict studies and environmental peacebuilding indicates that these two can indeed influence or reinforce each other, which is likely also to have an impact on migration patterns in a given area (Buhaug and Uexkull 2021). Whereas resource cooperation can promote wider social cooperation between population groups while also strengthening the environment, conflict contributes to mis-coordination, short time horizons, or the absence of environmental policies (Ide 2019). Considering the scarce literature on environmental cooperation specifically addressing the context of in-migration, further research will be needed to grasp better how synergies between environmental cooperation and sustainable resource use can be enhanced in receiving areas.

Author Contributions:

KH: Writing - original draft, Conceptualization, Methodology, Funding acquisition.

CW: Conceptualization, Writing - review & editing.

JG: Conceptualization, Writing - review & editing.
PS: Conceptualization, Writing - review & editing.

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Data Availability:

All data used to create figures and tables were retrieved from the reviewed articles listed in Appendix 1. As such, the data used in this manuscript are accessible to everybody referring to the published articles.

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Reference	Geographic focus	Direction of influence	Thematic focus	Unit of analysis	Data	Method for data analysis
Groth et al., 2020	Northern Ethiopian highlands	EC ¹⁾ → M ²⁾	Identification of factors enabling migration in environmental change contexts	Households	Semi-structured household interviews (N=42), migrant interviews (N=5), focus group discussions (N=18), expert interviews (N=5)	Qualitative Comparative Analysis
Groth et al., 2021	Northern Ethiopian highlands	EC ¹⁾ → M ²⁾	Impacts of multi-level interactions of environmental and non-environmental factors on migration decisions	Households	Semi-structured household interviews (N=42), migrant interviews (N=5), focus group discussions (N=18), expert interviews (N=5)	Participatory Bayesian Network
Wiederkehr et al., 2019	Northern Ethiopian highlands	EC ¹⁾ → M ²⁾	Influence of nature's contribution to people (NCP) to migration needs, abilities and aspirations	Households and individuals	Scientific literature	Qualitative model development
Hermans and Garbe, 2019	Northern Ethiopian highlands	EC ¹⁾ → M ²⁾	Impact assessment of the 2015 drought on rural livelihoods and mobility	Households and individuals	Household survey (N=315), focus group discussions (N=8)	Descriptive statistics
Groth et al., 2023	Southwest Ethiopia	M ²⁾ → EC ¹⁾	Linkages of in-migration, resource use and livelihood changes of local communities	Households	Household survey (N=224), focus group discussions (N=3), expert interviews (N=12)	Random forest regression tree analysis
Wiederkehr et al., 2022	Global South	M ²⁾ → RUC ³⁾	Identification of factors leading to resource use conflicts in rural in-migration areas	Social groups	Scientific literature, grey literature	Qualitative Comparative Analysis
Wiederkehr et al., 2018	SSA drylands	EC ¹⁾ → M ²⁾	Identification of adaptation strategies in SSA drylands	Households	Scientific literature	Descriptive statistics

¹⁾ Environmental Change ²⁾ Migration ³⁾ Resource Use Conflict