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Review

'We Herders Are Often Chased About by Drought': A Systems Analysis of Natural Resource Degradation Within the Climate–(Im)mobility–Violence–Health Nexus in Sahel

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Abstract: This study applies a systems analysis to further our understanding of the many pathways linking climate stress to human (im)mobility and interpersonal violence via natural resource stress within eight countries (Burkina Faso, Chad, Mali, Mauritania, Niger, Nigeria, Senegal, and Sudan) across the Sahel region. To illustrate the multiple pathways within the climate–(im)mobility–violence–health nexus, contextual and conceptual systems maps were drawn out based on secondary qualitative data from 24 peer-reviewed journal articles selected from a search result of 394 publications. Even though the geography, environment, socio-political context, traditions, and cultural history were highly diverse, the overarching factors that determined people's (im)mobility and health outcomes, in association with natural resource stress and violence, were very similar. These vulnerability pathways included gendered immobility, interpersonal conflict, and lack of social protection, which provide important lessons and offer tangible opportunities for policy interventions. The vulnerability pathways often eroded access to natural resources and positive (im)mobility and (mental) health outcomes, which ended up entrapping people in extended cycles of violence and exploitation—especially certain intersectional positions and disadvantaged groups (whether within a household, society, or country).

Keywords: climate change; conflict; immobility; mental health; migration; natural resources; violence

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1. Introduction: The Climate–(Im)mobility–Violence Nexus in the Sahel

Human (im)mobility is often organised around the space, time, and reasons behind people's movements (or inability to move) [1–3]. For example, people may choose to move (seasonally or permanently), they may be forced to migrate, resettle, and return, or they may end up displaced, immobile, or 'trapped' [1,2,4–9]. In this article, the concept '(im)mobility' is used to highlight the flexible and transformative character of diverse mobility and immobility patterns and outcomes (see [9,10]). These include (in)voluntary migration (seasonal, temporary, and permanent), displacement, immobility, and 'trapped' populations. Lately, more and more human mobility scholars have argued for this more inclusive term as (1) a migration and mobility bias has resulted in an immobility research gap [4,11,12], (2) displacement, for example, may include mobility as well as immobility

layers [2,13], and (3) migration, mobility, and immobility experiences are subjective and keep shifting over time [14–16]. In this way, mobility can lead to immobility, and vice versa, as most (im)mobility outcomes are temporary rather than permanent. The drivers or factors behind human mobility tend to be highly diverse. People can be driven by the desire to improve their economic and livelihood security; they may move towards social networks or flee conflict and persecution [1–3]. In this way, migration flows are shaped and formed by macro, meso and/or micro factors [1,17,18]. This (im)mobility characterisation can be applied by (and to) people on the move, by their governments of origin, or by destination countries. In some incidences, several labels can be associated with a moving population, such as in the case of the 2015 Syria movements, where people were labelled both economic migrants and refugees [19–23].

In the current environmental migration literature, relatively little attention has been given to the different mechanisms linking natural resource degradation to human (im)mobility. This serves as a justification for why this article aims to better investigate these dynamics. For example, the overall environmental migration literature often refers to 'climate change' as the main reason for why people are forced to move or have ended up 'trapped'. However, when we go deeper into the narratives behind these environmental changes, we sometimes see how people may be alluding to specific natural resource loss or degradation, some of which may be climate change-related while others are more governance or resource management-related. People experiencing environmentally induced (im)mobility also often specifically draw attention to how it was the water, soil, or land resource loss that pushed them to move. This often occurs through impacts upon livelihood or financial sustainability, such as in the context of fishermen experiencing reduced catch due to water temperatures or bacteria changes, or farmers reduced harvest due to soil decline [24,25].

This article therefore seeks to investigate these dynamics within a Sahelian literature context, or more precisely within a sample of eight countries. Various authors have defined the geographic dimensions of the Sahel region differently. Commonly, the Sahel comprises the region stretching from Senegal on the Atlantic coast, through parts of Mauritania, Mali, Burkina Faso, Niger, Nigeria, Chad, and Sudan, to Eritrea on the Red Sea coast; see, for example, [26]. The study will help elucidate some of the pathways that people may be forced to take in relation to (im)mobility because of the impact of climate stress on natural resources, which oftentimes overlapped with interpersonal violence, social tensions, or conflict. In this article, we use the phrase 'climate stress' to refer to the deleterious impacts of 'climate change' and variability. The analysis is part of a wider research effort led by the International Resource Panel (IRP), hosted by the UN Environment Programme (UNEP), that investigated complex adaptive systems within the context of natural resources and human (im)mobility (see [27]). For further information, see also the case study analysis based on empirical data in Bangladesh and the Philippines and commentary on using a systems approach to investigate human (im)mobility and natural resource loss (e.g., [28,29]).

The literature analysis shows the centrality of decreased wellbeing to many of these pathways and suggests possible policy entry points to decouple the impacts of climate stress (be it from climate change or climate variability) with movement. This article follows a conceptualisation of placing the climate–(im)mobility–violence as well as the climate–violence–health nexus "*within a systems analysis that investigates these correlations as a network of factors whereof some are immediately tied to the environment while others are seemingly non-environmental or social, political, legal, financial, and psychological factors*" (see [30]). In this way, we pay attention to the wider human-made and societal relations that may increase the risks for certain intersectional positions to experience (im)mobility pathways that include interpersonal violence that negatively impact their health and wellbeing.

Livelihood loss is a common mobility driver where people may migrate away from insecure, natural resource-dependent livelihoods in rural areas (such as farming and fishing) in search of alternative urban livelihoods in the cities that are less vulnerable to climatic impacts. In some instances, the livelihood unsustainability may be environmentally induced and/or associated with natural resource degradation, but research also shows how resource management, governance, and social protection are important sustainability factors [1,24,31–34]. Adding to this, local resource management sometimes offers important sustainability strategies that include resistance from below to exploitative power dynamics, such as hindering land grabbing or regaining control over livelihood or natural resource use constraints, i.e., fishing quotas or agricultural land and water use [35,36].

A deeper investigation of the many ways that natural resources enable (or disable) people's (im)mobility outcomes can support more targeted regional, national, and local policy interventions. This study aims to investigate when migration serves as an adaptation strategy to natural resource degradation by increasing local resources through remittances and external funds, but it also looks at erosive coping pathways resulting in exploitation and harm. The wider network of social, psychological, and ecological contexts that mediate these pathways aligns with the nature of complex adaptive systems (in a way that they are unpredictable, non-linear, and co-evolving). A systems approach has in the past been used to study diverse complex climate–(im)mobility–violence–health linkages (see, for example, [30,37–40]). In this article, we understand systems to be people and nature being inextricably linked, so that the social and environmental linkages in tandem exert strong influence over outcomes. We are aware of numerous schools of thought with such a systems approach, including social-ecological systems (SES), complex adaptive systems (CAS), coupled human and natural systems (CHANS), and coupled or complex human-environment systems (CHES). Rather than wading into the debates regarding their critiques and differences in order to stand with a single school of thought, we prefer to emphasise the similarities, connecting with them all through our definition which draws on them all. In line with this, the social component in this article includes actors, institutions, cultures and livelihoods (including economies). This approach complements conceptualisations used within political ecology and human ecology which tend to critically evaluate nature- society relations and intertwinings, its power structures, and (natural) resource access and distributions to identify injustices, inequities, and disparities of costs and benefits.

A growing body of literature is linking natural resource degradation to conflict through intermediate economic, political, and social processes, including food and income insecurity as well as forced population movements [21,41–47]. The 2015 Syria scenario has received particular attention as some scholars proposed that drought-induced resource degradation and so-called 'mass migration' were behind the conflict [21,46]. However, more critical assessments of the Syria case (and other natural resource scarcity and conflict relations) urge for more caution. The fear is that weakly founded arguments and simplistic linear connections are used to blame the so-called 'climate crisis' for poor political governance and resource management while portraying migration as a security issue and problem [22,23,48–54]. More critical human (im)mobility scholars rather raise concerns around the post-colonial and racial undertones that surround the 'climate refugees', 'environmental migrants', and 'trapped figures' [9,55–58]. This systems analysis takes a more holistic approach to understanding the pathways between natural resources and the climate–(im)mobility–violence–health nexus in the Sahel based on the literature.

2. Capturing Climate–(Im)mobility–Violence–Health and Natural Resource Pathways in the Sahel

This systems analysis draws on secondary data compiled through a review of the literature spanning eight countries in the Sahel region (Burkina Faso, Chad, Mali, Mauritania, Niger, Nigeria, Senegal, and Sudan). The early mock searches guided the selection of countries as the study seeks to analyse secondary data through a literature review [30,59,60]. These mock searches also determined the selection of databases where we decided to go with Web of Science rather than Google Scholar or Scopus to name a few alternative databases. This was because Web of Science was the databased that generated the most suitable search results (English peer reviewed journal articles in the selected topic area). However, we also tried to include countries that are not as commonly investigated within the existing climate change literature body in an effort to fill existing geographical and socio-cultural gaps in the research area. Qualitative data are drawn from publications referring to natural resource stress, climatic changes, and (im)mobility in the Sahel region, published between 1999 and 2021. The review used the Web of Science database to search for and retrieve English peer-reviewed journal articles for screening, as it broadly covers literature from the fields of life science and natural science that cover issues relating to natural resource stress. Eight countries from the region were included, namely: Burkina Faso, Chad, Mali, Mauritania, Niger, Nigeria, Senegal, and Sudan. Articles were selected that referred to natural resources, climatic changes, and (im)mobility experiences. Regarding natural resources, the search includes land and soil decline, food (in)security, water (in)security, and agricultural degradation. Regarding climatic changes, the search terms included acute (such as floods, dust storms, and wildfires) and slow-onset (such as drought, salinification, and desertification) environmental stressors. Themes of conflict, violence, and exploitation are also included. These were used to capture issues of natural resource-linked social tensions claimed to occur in the context of climatic stress and potentially influencing (im)mobility and mental health patterns. Texts were excluded that did not relate specifically to natural resource impacts, climatic changes, human (im)mobility, or that were based outside of the selected countries. 394 publications in total were identified through the literature search, of which 24 (published between 1999 and 2021) met the inclusion criteria (see Table 1). We decided to quality control the selected publications by limiting the inclusion criteria to peer-reviewed journal articles only. Study selection was guided by the choice of search terms (see Table 2).

Table 1. Overview of the study selection.

	Authors and Year of Publication	Country Focus	Environmental Stressors	Resource Elements	(Im)mobility Elements
1	**Afifi 2011 [61]**	Niger	Drought	Food shortages Water shortages Soil degradation Livestock death Fishing failures	Restricted mobility of Fulani herders Farmers moving north Herder–farmer conflict International migration, deportation, and voluntary return Women/elderly/children remain—labour burden
2	**Akinyemi and Olaniyan 2017 [62]**	Nigeria	Drought	Cattle-sensitive resource scarcity (grass) Resource-related conflict: water pollution, crop damage/theft Water scarcity/competition Cattle theft/poisoning Poverty	Pastoral migration Herder–farmer conflict

Table 1. *Cont.*

	Authors and Year of Publication	Country Focus	Environmental Stressors	Resource Elements	(Im)mobility Elements
3	**Ayeb-Karlsson et al., 2019 [63]**	Senegal	Rainfall variability High temperatures Soil salinization Strong wind events Flash flooding Storm surges	Agricultural failures Food shortages	Immobility in unsafe spaces/places with limited adaptation options Migration to urban slum areas Women: gendered immobility Livelihood change
4	**Brottem 2014 [64]**	Mali	Drought Rainfall variability	Resource competition Crop damage	Livestock (im)mobility Herder–farmer conflict Herder settlement Government policy: grazing zones, livestock corridors Territorial issues
5	**Djoudi and Brockhaus 2011 [65]**	Mali	Desertification	Water shortages Arable land loss Food insecurity	Men: seasonal/non-seasonal migration Women: gendered immobility/vulnerability; increased labour burden (women); illegal charcoal production; socially restricted mobility; opportunity for empowerment
6	**Drees and Liehr 2015 [66]**	Senegal, Mali	Rainfall change	Agricultural success/failure	Changing patterns of migration: duration, destination Environmental change: lower impact on migration than socio-economic conditions
7	**Ele 2020 [67]**	Nigeria	Drought Desertification	Water shortages Lake Chad shrinkage Land scarcity Famine Decreased grazing vegetation	Migration for alternative livelihoods Forced herder migration Herder–farmer conflict Government policy: anti-open grazing laws, annexation of land, ranch establishment, grazing routes/reserves Inter-country migration; porous borders; illegal cross-border movement
8	**Freeman 2017 [68]**	Niger, Senegal, Mali	Drought Erratic rainfall Erratic temperatures Flooding	Lake Chad shrinkage Water/pasture competition	Social/political/demographic/economic context = intervening variables for migration decision Pastoral migration, herder–farmer conflict Tuareg (im)mobility + rebellion Conflict: small-scale regional conflict, insurgent groups International emigrants finance local development
9	**Gueye et al., 2015 [69]**	Senegal	Drought Reduced rainfall	Agricultural failures Water shortages Food shortages Crop loss Field loss, wind erosion Reduced (cattle) fertility	Increased mobility Migration for employment Rapid urbanisation, consolidation of new cities Informal/illegal settlements Dense urban populations: flood vulnerability Home ties Cities hub of international departure/return

Table 1. *Cont.*

	Authors and Year of Publication	Country Focus	Environmental Stressors	Resource Elements	(Im)mobility Elements
10	**Henry et al., 2004 (a) [70]**	Burkina Faso	Reduced rainfall	Land degradation	Limited mobility—trapped in unfavourable areas Emigration to Côte D'Ivoire—coffee/cocoa plantations Ties to villages of origin/family networks
11	**Henry et al., 2004 (b) [71]**	Burkina Faso	Reduced rainfall	Agricultural failures Water shortages	Migration behaviour dependent on individual characteristics: education, ethnicity Rural–rural/short term migration Long-distance movement restricted by environmental stress Gendered mobility Alternative livelihoods in risky environments
12	**Howorth and O'Keefe 1999 [72]**	Burkina Faso	Drought	Disappearance of forest/savanna zones Soil loss Lowered water table Adoption of local farming practises New resource–use patterns for shared livelihood subsistence	Widespread Fulani pastoralist migration to sedentary Mossi areas Trade, exchange, cooperation, negotiation Assimilation + integration into social system
13	**Ibnouf 2011 [73]**	Sudan	Drought Desertification	Food insecurity Livelihood diversification–household garden plots	Gendered (im)mobility Unreliable remittances Women: increased labour burden
14	**Kamta et al., 2020 [74]**	Nigeria	Desertification Water shortages	Low agricultural productivity Loss of animals Food insecurity Water insecurity	High environmental resource dependence → vulnerability to conflict → early migration Primary cause of forced displacement = Boko Haram insurgency
15	**Kielland and Kebede 2020 [75]**	Senegal	Drought Irregular rainfall	Agricultural failures Animal diseases Insect (locust) attacks	Child mobility Living away from home as talibés = adaptation response Bonds of reciprocity with distant employers/households
16	**Madu and Nwankwo 2021 [76]**	Nigeria	Desertification Drought Rainfall variability	Food insecurity Destruction of crops by herds	Herder–farmer conflict Population pressures in southern region
17	**Morand et al., 2012 [77]**	Mali	Rainfall variability	Water insecurity Decline in fish abundance	(Adaptation of floodplain fishers) Disruption to seasonal fishing migrations Lack of flexibility to modify routes = trapped + immobile populations Permanent emigration Livelihood change
18	**Nawrotzki et al., 2016 [78]**	Burkina Faso, Senegal	Heatwaves Drought	Agricultural failure Food insecurity	Migration as income diversification Drought limits international mobility Increased rainfall increases international outmigration

Table 1. *Cont.*

	Authors and Year of Publication	Country Focus	Environmental Stressors	Resource Elements	(Im)mobility Elements
19	**Olaniyan and Okeke-Uzodike 2015 [79]**	Nigeria	Rainfall variability	Decreased grazing resources Cattle death Land ownership disputes Killing of cattle by local farmers Crop destruction by cattle	Increase in flow of migrants Herder–farmer conflict Lack of integration into host communities
20	**Onwutuebe 2019 [80]**	Nigeria	Drought Rainfall variability	Decreased farm yields Food insecurity Water insecurity Land grabbing	Men: migration for alternative livelihoods Women: gendered immobility; increased vulnerability; increased labour burden
21	**Owonikoko and Momodu 2020 [81]**	Niger, Chad, Nigeria	Reduced rainfall Drought Lake Chad shrinkage Desertification	Unsustainable exploitation of lake resources Water insecurity Fishing, farming, hunting, herding Arable land shortages Livelihood loss Competition for water resources	Switch to criminal activities: cattle rustling, trafficking Radicalisation/recruitment by Boko Haram Rural–urban migration Urban social crises Seasonal to permanent movement of pastoralists Herder–farmer conflict Cross-border movement to follow lake shores
22	**Sanfo et al., 2017 [82]**	Burkina Faso	Reduced rainfall Drought Heatwaves Crop parasites	Land degradation Reduced soil productivity Reduced crop yields Food insecurity Child malnutrition Reduced land availability Land tenure insecurity Deforestation	Temporary + permanent migration Family reunification Immobility: poverty constrains migration Trapped populations in food-insecure regions
23	**Scheffran et al., 2012 [83]**	Senegal, Mauritania, Mali	Drought Irregular rainfall	Water insecurity	Circular/seasonal migration Nomadic pastoralism/transhumance Gendered mobility Remittances: household income; emigrant financing local development projects Return of international migrants Strong migrant links with areas of origin
24	**Seiyefa 2019 [84]**	Mali	Rainfall decline Drought	Water insecurity Cropland erosion Livelihood loss Resource competition/capture	Switch to criminal activities: smuggling, trafficking, kidnapping, illegal migration Opportunistic recruitment to terrorist networks, e.g., Al Qaeda Marginalisation and migration of weaker groups
25	**Traore and Owiyo 2013 [85]**	Burkina Faso	Drought Locust invasions	Lack of good pastures Natural resource competition/conflict Crop failure Livestock weakness/death Water insecurity Food insecurity	Decreasing reliance on transhumance as a coping measure Immobility increases vulnerability in drought Shift from nomadic herding to crop and livestock keeping Migration for alternative livelihoods Disrupted family cohesion

Table 2. Inclusion and exclusion criteria.

	Included	Excluded
Problem	Natural resource pressures Climatic changes (and subsequent environmental stressors)	Publications not relating to climatic changes and subsequent environmental stressors
Population	Populations within selected Sahelian countries (Senegal, Mauritania, Mali, Burkina Faso, Niger, Nigeria, Chad, and Sudan)	Populations outside of selected Sahelian countries
Interest	Human (im)mobility and proximal determinants of migration such as livelihoods and conflict	Journal articles not referring explicitly to natural resources or related determinants of human migration
Context	The Sahel region (a semi-arid region of high climate vulnerability characterised by high rainfall variability and periods of drought)	Countries outside of the selected Sahelian countries
Publication details	Peer-reviewed journal articles in English published before 10 January 2021	Non-peer-reviewed material or journal articles published in languages other than English or published after 10 January 2021
Search terms	*(Senegal OR Mauritania OR Mali OR Burkina Faso OR Niger OR Nigeria OR Chad OR Sudan)* ***AND*** *(climat* change OR environmental (shock OR stress OR impact OR stressor) OR natural (disaster OR hazard) OR heat OR heatwave OR heat stress OR drought OR flood OR salinification OR salinity OR salinization OR rainfall variability OR aridity OR desertification OR wildfire OR bush fire OR dust storm)* ***AND*** *(resources OR food OR water insecurity OR finance* OR econom* OR livelihood OR livestock OR famine OR agriculture OR soil (erosion OR degradation) OR land degradation OR pasture OR cropland OR crop diseases OR conflict OR traffick* OR gold mining OR exploit*)* ***AND*** *(migrat* OR *migrant OR refugee OR mobility OR immobility OR displacement OR displaced OR relocation OR resettlement OR trapped OR IDP OR non-migra* OR stay behind OR population movement OR nomad)*	
Database	Web of Science	

To identify the pathways linking natural resource degradation and the climate–(im)mobility–violence–health nexus, a qualitative thematic narrative analysis was carried out [60,86]. Systems diagrams were drawn to illustrate the contextual and conceptual relationships. Three thematic pathways emerged, namely (1) *Gendered Entrapment*, (2) *Interpersonal Violence and Conflict*, as well as (3) *Legal and Social Protection* linking the diverse natural resources to different (im)mobility outcomes. The narratives were analysed in detail to understand how each factor within the pathways related to one another. These pathways, around which the result section is structured, illustrate the many ways that access and availability to natural resources can alter people's vulnerability to climatic stress [39,40]. They can positively as well as negatively impact their (im)mobility outcomes, whether resulting in eroding their (mental) health or entrapping them in cycles of violence and conflict.

3. Identified Pathways Between Climate–(Im)mobility–Violence–Health and Natural Resource Degradation in the Sahel

The literature sample illustrates a wide range of factors regulating the pathways between natural resource degradation and the climate–(im)mobility–violence–health nexus in the Sahel region. These factors interact in complex ways, out of which three key pathways can be identified. In some ways, the pathways overlapped and interacted with one another (as seen in Figure 1), and the factors together shaped the

climate–(im)mobility–violence–health nexus. How various populations are susceptible to becoming either mobile or immobile is impacted differently by natural resource stress. These variable mobility impacts fall on certain marginalised groups according to intersectional positions such as age, gender, health conditions and disability, livelihood and marital or migration status, and religion.

Even though the literature exposes strong pathways linking natural resource stress with human (im)mobility in the Sahel, mono-causal interpretations of the issue must be avoided. Any influence of access to natural resources on migration decisions occurs in specific socio-economic, political, and demographic contexts that strongly influence (im)mobility patterns. To view migration or entrapment solely through the lens of climatic or environmental risk would be to ignore crucial social, political, financial, psychological, and emotional factors, reducing and oversimplifying the issue to a cause-effect phenomenon. For example, Drees and Liehr [66] observe that socio-economic and political conditions impact mobility patterns more than changing environmental conditions in the Sahel region.

1. *The Gendered Entrapment Pathway: Natural resource strains, gendered (im)mobility, and food insecurity*

The literature broadly supports that livelihoods in the Sahel are dependent on rain-fed agriculture, which is vulnerable to the effects of drought. Drought decreases agricultural productivity and exacerbates food insecurity [61,63,67–69,73,78,80,82,83,85]. Male outward migration is a common coping strategy, where men move away in search of seasonal or permanent work in distant destinations, using remittances to diversify the household income [61,65,71,73,80,85]. However, remittances from male relatives are often unreliable sources of income, as migrant employment tends toward marginal, low-income jobs with variable earnings. This places a greater responsibility on women to ensure economic stability and food security for their families [61,73].

Male out-migration can lead to an increase in the percentage of female-headed households. Male departure frequently leaves women with a greater burden of tasks, both within the household (food production) and outside (e.g., new tasks such as livestock herding and charcoal production). Women also engage in tasks that restore environmental conditions, such as planting trees and digging water reservoirs. This increased work burden, comprising domestic, caring, and agricultural tasks, leaves women with an intensified workload, shaped by both gender roles and resource (in)security [61,65,73,80].

The gendered double work burden not only undermines women's ability to adapt to resource stresses but undermines food security, as farms headed by women reportedly achieve lower yields than male-led farms. Gender norms restrict women's social mobility as well as physical mobility. Women's access to natural resources, assets, and decision-making is limited, which, alongside gendered barriers to market access, increases their financial insecurity [65,73,80]. Women may also end up 'trapped' in positions of vulnerability as their attachments to the domestic sphere undermine their ability to switch occupations as an adaptive response to adverse climatic conditions. In addition to occupational immobility, the absence of a male relative can undermine women's land tenure security, as a dead or an absent husband can leave women more vulnerable to land grabbing. Unreliable remittances from male relatives can exacerbate such positions of uncertainty [61,63,80].

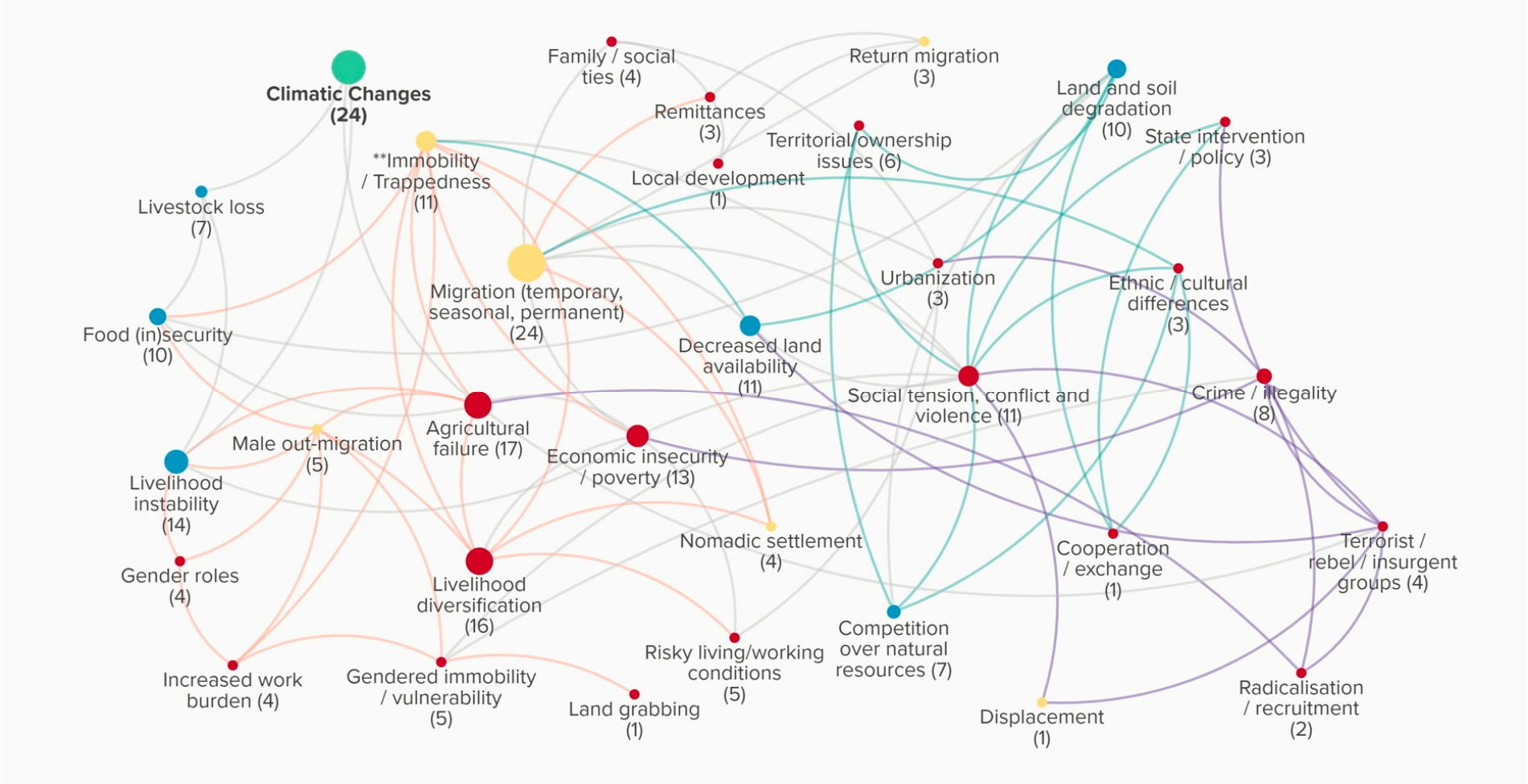

Figure 1. Systems map of the natural resource degradation and climate–(im)mobility–violence–health nexus in the Sahel. The systems map drawn out of the literature review identified connections between natural resource degradation and the climate–(im)mobility–violence–health nexus in the context of eight countries in the Sahel. In this figure, green represents the environmental impacts, blue represents natural resource-based factors, red is human and social factors, yellow outlines the (im)mobility outcomes, and finally purple is health and wellbeing factors. The numbers indicate how many out of the 24 selected journal articles made this specific link (authors own creation, cite as Ayeb-Karlsson et al.).

Text Extract 1

> /. . . / my life is different now; my husband travelled to town for work, irregular remittances from him aren't enough /. . . / I am too overloaded, but what can I do, it is obligatory for my family ([73]: 221).

However, although male outmigration and female immobility are sources of vulnerability for women, there might be long-term positives of these gendered patterns of migration. Male absence could be an opportunity for women's empowerment, shifting gender relations and strengthening women's decision-making [65,73].

Conversely, natural resource degradation can restrict human mobility in the Sahel; whilst acting as push factors, water scarcity and natural resource loss can also create 'trapped' populations in climatically and socially vulnerable regions [63,70]. As a response to declining agricultural yields and subsequent economic strain, farmers invest less in farmland management, becoming 'trapped' in cycles of insecurity involving food and finances. These conditions of insecurity act as barriers to adaptive migration, especially in regions where levels of malnutrition and food insecurity remain high [71,78,82].

Text Extract 2

> The problems of food shortages mean that we have very little to invest when we need to think of how to deal with dryer or wetter conditions. /. . . / The special seeds are very expensive ([63]: 1591).

Climatic stressors also seem to alter the type of migration that people tend to undertake. In Burkina Faso, for example, conditions of drought may increase the likelihood of short-term moves, whereas people living in better-watered areas are more likely to migrate abroad and for longer periods [70,78].

Similar patterns of immobility are experienced by delta fishermen in Mali. Morand et al. [77] showed how fishing migration routes and settlements are not easily moveable, creating 'trapped' and immobile populations who struggle between high population densities and high relocation costs. This immobility drives fishermen to more drastic adaptive strategies, such as abandoning fishing entirely and switching to other activities or permanent emigration from delta areas.

Lastly, transhumance appears to be diminishing as an adaptive strategy in herders, with increased reliance on permanent migration. Natural resource strain, droughts, and failed rains are having deleterious impacts on the quality of grazing pastures, which makes transhumance a less viable coping measure [67,79,85]. This restricts herders' mobility and increases their vulnerability to extreme droughts, a trend that is exacerbated by competition over land resources [61,85]. Permanent settlement or lengthened stays are common responses from nomadic herders in Mali, Niger, and Nigeria, who are also diversifying their livelihoods from managing solely cattle to a combination of crops and livestock. Herders are actively encouraged to settle in established ranches by anti-open grazing policies and annexation of land by the government, which can create conflict and tension over land ownership [64,67,81].

2. *The Interpersonal Violence and Conflict Pathway: Land degradation, natural resource competition, and Herder–Farmer tensions*

A prominent migration-conflict pathway arises where natural resource strains act as push factors for long-distance migration of cattle herders, especially in Nigeria, Niger, and Mali. In conditions of drought, desertification, erratic rainfall, decreased grazing resources, and cattle death (especially in dry seasons), herders are forced to seek alternative grazing spaces in wetter regions [61,62,67,72,79,81].

Text Extract 3

> We herders are often chased about by drought. It is often said that pastoral farmers have no home. We do have homes, but our profession forces us to move when we are confronted with drought ([62]: 11).

The resulting social dynamics between indigenous and immigrant populations can be positive, with cooperation, negotiation, and inter-ethnic exchange of skills and gifts. The cooperation (such as the exchange of farming and cultural practises) can help these societies to build resilient subsistence with new natural resource-use patterns. However, herder–farmer conflict over natural resources is a common result of this migration pattern in host areas: theft of crops, cattle damaging farmland or polluting water, locals killing cattle, and competition for water and land all create tensions that spur conflict [61,62,64,79].

Text Extract 4

> The crux of the matter is that the cattle would enter and destroy crops in the farms. The farmers retaliate by attacking or killing the animals. This would lead to clashes and in most cases, resulting in loss of human lives and properties. It is a frequent problem. It happens regularly ([79]: 33).

Alongside natural resources, conflicting positions between herders and farmers can be brought about by differences in culture and identity. When new populations of pastoral herders arrive en masse in an area, they can often remain itinerant and separated from the host society. A lack of integration can exacerbate misunderstandings between these groups. One example is the perceptions held by farmers that herders are indifferent to hosts' customs and values [76,79]. Ethnic differences can also create divisions and perceived threats between herder groups, with some claiming more entitlement to land than others. For example, in Nigeria, members of the Fulani *Ibile* distinguish themselves as separate and more established from the more newly arrived Fulani *Bororo* migrants, a position that is shared by some locals.

Text Extract 5

> At present, we have two types of Fulani here, the Ibile and Bororo. We have been living peacefully with the Ibile long ago before the arrival of Bororo group of herders. The Bororo have been a cog in the wheel of progress in this land and that is responsible for the incessant clashes between the two parties [farmers and herders] ([79]: 33).

Underlying deprivation and frustration in these areas drives further conflict between herders and farmers. Civil crimes such as theft, rape, and harassment feed violence, which leads to death, lost homes, destroyed property, and damaged land. This results in further poverty and food insecurity [62,67,76,81]. Madu and Nwankwo [76] found that the issue of food security is a particularly central concern in Nigeria, as the clashes tend to occur in major food-producing regions.

Government policy attempts to address such issues of land rights and ownership in resource-scarce contexts by creating corridors for livestock passage and herder grazing zones. Official boundary formation can be seen unfavourably by farmers as a way to strengthen the land rights of herders or accepted as a legitimate way to maintain supremacy over herders by enforcing the host-stranger relationship. Either way, conflict management strategies themselves can produce territorial issues, as with a proposed transhumance corridor in western Mali [64,67].

Text Extract 6

> We need a corridor. But it is false to say that the corridor is for everyone just because everyone has livestock. There are peasants and there are herders. It is

> the peasants who will lose land because of the corridor and that is unacceptable (Brottem, 2014 [64]: 651).

As mentioned by Ele, M.N. [67], policies involving herder settlement are controversial as land must be made available for settlement, and both farmers and herders are unwilling to give up land. Akinyemi and Olaniyan [62] showed that when such attempts at conflict management and mediation fail, social groups can lose confidence in systems of governance and abandon mediation processes in favour of self-defence. The issue is further complicated by the fact that inter-country transhumance in the region is enabled by relatively porous borders: although inter-country movement in the Economic Community of West African States (ECOWAS) requires special certification, illegal cross-border movement of cattle occurs commonly, according to [67], leading to further conflict.

3. *The Legal and Social Protection Pathway: Natural resource loss, illegal activities, and social safety*

Drought has dramatic impacts on rural landscapes, which creates instability for farmers: soil and wind erosion precipitate crop and field loss, reduced crop fertility, and livestock failures [61,67,69,74,79,80,82,84,85]. These agricultural failures can often result in social processes involving crime and illegal activities. For instance, migration from rural areas to cities, as a coping strategy for climate insecurity, leads to rapid urbanisation. These rapid demographic shifts, without government preparation or planning, create highly dense urban populations where informal and illegal settlements are common, such as slum areas that are prone to flash flooding [63,69]. A lack of work opportunities for migrants drives unemployment, which fuels urban social crises, with criminality being used as a poverty coping mechanism. Child mobility also involves social safety issues: according to one study in Senegal, children from drought-shocked households are more likely to live away from home as a strategy to diversify social networks and gain new skill sets. One example is the pursuit of Quranic studies by young boys who live away as talibés, but this environment frequently involves begging in the streets and other risky activities [75,81].

Another adaptive mechanism to the livelihood loss involves violent competition for natural resources or even seeking illegal sources of income. In Mali, Djoudi and Brockhaus [65] showed how women whose male relatives had migrated away were sidelined to produce charcoal illegally, as they tended not to be included in the right power and social networks to obtain permits. Other criminal activities include smuggling illegal goods or services, drug trafficking, child trafficking, and recruitment for warlords. For marginalised and resource-poor groups, engaging in such activities is seen to provide an escape from economic hardship, including livelihood threats caused by climatic changes [81,84]. Furthermore, criminal and terrorist networks can exploit these contexts of economic and social fragility, using them for opportunistic recruitment. In the Lake Chad basin, where the shrinkage of the lake has caused livelihood loss, Boko Haram and Al Qaeda are reported to have used conditions of poverty and instability to radicalise and recruit new members [81,84].

> Text Extract 7
>
> A few days ago (referring to June 2015), Boko Haram militiamen came to our village, which is ten kilometers from Bourrah, and they told us to stop wasting our lives here and join them in the holy battle to save our faith and the lives of our families. They also said that Boko Haram is young people's only future /…/ [They] also told us that we would get paid from 600 USD to 800 USD a month if we joined them. It is a lot of money to us, if you consider that we cannot even make 70 USD a month from our work /…/ I was scared and I declined their offer, but many of my friends accepted ([81]: 1310).

Text Extract 8

> Some are dislodge by environmental issues in the Lake Chad Area./. . . /Going back to their areas is difficult because what drove them out is still there. Involvement in criminality in cities is usually coping mechanism for excruciating challenges they face with regard to sustaining their living in cities ([81]: 1311).

The insurgencies destabilise the agriculture sector by forcing displacement and creating conditions of fear for farmers. Fulani herders also resort to extremism and violence: herder–farmer conflicts have contributed to greater numbers of armed civilians and unregistered deadly weapons. Criminal groups appeal to people's economic vulnerability and grievances by offering financial incentives to join networks of violence [67,74,81]. Furthermore, inter-state conflicts over water use in the Lake Chad region have undermined a collective response to fight such insurgencies. For example, Owonikoko and Momodu [81] illustrated how conflict relationships between Nigeria and neighbouring Lake Chad countries meant that the early signs of threat from Boko Haram were ignored, giving the group opportunities to build their resource base, transit weapons between states, and plan heightened attacks. In this way, living with an increased dependence on natural resources may make societies more susceptible to conflict.

4. Discussion

This literature analysis showed that pre-existing vulnerabilities (social, financial, and natural resource-based) often were exaggerated by climatic stress and other societal shocks. Natural resource degradation strongly contributed to people's (im)mobility outcomes in the way that poverty and natural resource scarcity, for example, could determine people's (a group's or a society's) capacity to respond, escape the stress, and push them into vicious cycles of 'erosive coping' [39,87]. 'Erosive coping' has been used to refer to a situation where people are forced "*to dispose assets, undermine their nutrition and health, and generally erode their ability to survive*" [87] to deal with natural resource and livelihood shocks. These immediate responses to food and livelihood insecurity are often at the expense of people's risk-management capacity in the future [88–92]. A conceptual systems diagram was drawn out to illustrate the wider natural resource-eroding and enhancing social and economic factors that contributed to people's negative and positive (im)mobility outcomes (see Figure 2).

Interestingly, despite the diversity of traditions, cultural history, socio-political background, geography, natural resource context, and environment among the eight countries, some aligning pathways were observed within the complex systems dynamics. Three overarching factors that closely tied into people's natural resource and climate–(im)mobility–violence experiences were (1) *wellbeing*, (2) *debt*, and (3) *social protection*. These factors represent crucial areas of attention for future policy interventions.

The connections between people's *mental health or wellbeing*, violence, and natural resource decline, whether climate-related or not, is a research area that will require more attention. In recent years, a growing body of literature is placing mental health and wellbeing erosion in the centre of the study of climatic stress [13,30,38,59,60,86,93–101]. This represents an important contribution to a gap in the climate change literature, but its connection with different types of violence remains relatively unexplored, including its overlaps with modern slavery and human trafficking and exploitation. For some empirical investigations of climate change-related international movements and human (im)mobility in the context of the Philippines and modern slavery [102], and for research exploring trafficking and sexual exploitation of children in the Pacific in the context of cyclones and floods [30].

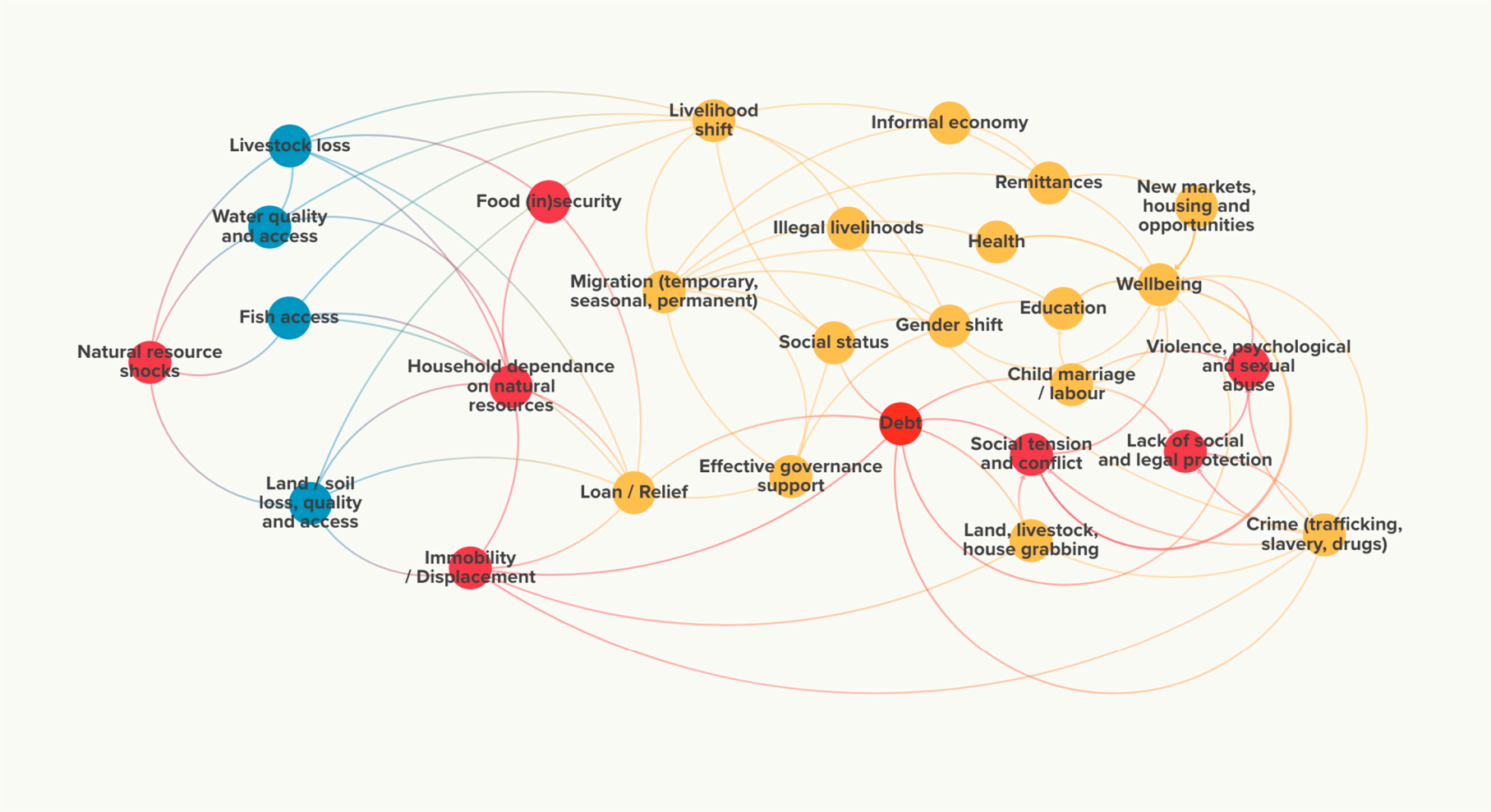

Figure 2. Illustrates a conceptualisation of the climate–(im)mobility–violence–health and natural resource nexus. The conceptual systems map summarises the pathways identified within the extended systems investigation in the Sahel, Bangladesh, and the Philippines. This includes investigating empirical data in two countries in Asia (Bangladesh and the Philippines) as well as secondary literature data in eight countries of the Sahel region. In this figure, red represents natural resource-stressing or eroding factors, blue represents natural resource-based factors, while yellow represents natural resource-enhancing factors (lead author's own creation, cite as Ayeb-Karlsson et al.).

The nuances in the narratives between *loans* and *debts* represent other policy intervention opportunities. It was explained how loans can support people to bounce back from natural resource loss (often crop and livestock related), while debt was associated with social tensions, coercion, and control and tended to be the beginning of a downward spiral that ended up forcing people to give up land and livestock. The setup of NGO microcredit and financing schemes is important here [36,103]. People often took out microcredit loans to be able to make agricultural investments during planting seasons, while planning to pay these back from the harvest profits. In the event of crop failure, many ended up in debt as they were unable to pay their instalments. The lack of flexibility within some of these financing schemes therefore pushed people to seek private loans or to sell and give up their land, livestock, and other assets. This increased people's vulnerability and could trigger forced migration, displacement, or entrapment. It also pushed people into exploitative and harmful labour contracts or to take up illegal income-generating activities.

Finally, *social protection* was identified as another policy area of opportunity. This relates both to the need for increased control and transparency of the governance processes upholding these legal frameworks, as well as the need to better protect certain intersectional identities and marginalised groups within societies. For example, it was observed how women and children often suffered more than men while pushed to move or when ending up 'trapped' due to natural resource strains [63,73,75,80]. Children who migrated to the cities due to food insecurity sometimes faced sexual predators and other types of violence, such as child labour or marriage, while radical extremist groups took advantage of the increased desperation among families experiencing natural resource degradation and poverty to recruit minors.

Women and girls who ended up 'trapped' in rural villages due to male out-migration similarly struggled financially, as remittances could be sporadic and unreliable while gender norms made it more difficult for them to access income-generating activities and/or education. In this way, the systems analysis illustrated how specific pathways tended to erode access to resources, wellbeing, development, and positive (im)mobility experiences. The systems network approach serves as an important research tool that can offer tangible insights into policy gaps, opportunities, and improvement.

It was interesting to see that in this context, certain pathways were more common in the literature than others. Clearly, the study cannot determine frequency as the analysis is based on published literature and conducted qualitatively. That said, to some extent, we can see how some pathways appeared more often than others in the body of literature. This can be observed in Figure 1 that includes the number of references that refer to certain systems' pathways. For example, five articles out of twenty-four outlined gendered connections such as male outmigration, gendered immobility, or gender roles as key factors associating natural resources with the climate–(im)mobility–violence–health nexus, while eleven articles referred to conflict and violence, and eight to crimes, many of which were associated with land and soil degradation. It will be important to continue exploring these connections empirically, and in some country contexts particularly, to enhance our understanding of their benefits and limitations to people.

5. Conclusions

This study showed how social, psychological, and societal factors often made it more difficult for certain intersectional positions and marginalised groups to recover from natural resource degradation. Some people even ended up 'trapped' in vicious cycles of violence, exploitation, and continuous wellbeing erosion. Women and children particularly were often forced to make lifelong sacrifices to their wellbeing and future opportunities. Disadvantaged groups (within a household, society, or country) also more frequently end

up locked into poverty positions. Policy frameworks must better focus on reducing social inequalities while protecting, empowering, and supporting marginalised groups. This study has illustrated how migration itself should not be framed as a problem. We must identify, isolate, and solve vulnerability factors within these larger systems and understand their links and pathways leading to negative (im)mobility outcomes and avoid making simple, linear, and direct climate–(im)mobility–conflict conclusions.

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