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Re-assembling land degradation: toward a nature-society-inclusive soil erosion management strategy. A case of the Rwenzori region, Uganda

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Tackling land degradation, particularly soil erosion, remains a challenge due to the gap between science, policy, and practice which hampers the adoption of control measures by farmers. Bridging this gap requires understanding land degradation as an assemblage of the natural/biophysical and anthropogenic aspects; but also, rethinking epistemologies that level the grounds between scientists, policymakers, and farmers whose farm livelihoods are at-risk due to soil erosion. This study aimed to clarify how these requirements can be met through the lens of the recently proposed *hylomorphic framework*. This framework structures, in three steps, the procedure of bridging real-life experiences of farmers at risk of soil erosion with the knowledge of scientists and policymakers through the embracement of diversity in ontological realities and values, self-critiques, and coalescing overlaps in theorizations. We selected a qualitative design as most appropriate using one of the cases—the Rwenzori region—where soil erosion is high. We conducted nine focus group discussions with participants selected purposefully from three stakeholder groups including scientists, policymakers, and farmers. Following the hylomorphic framework procedure, we carried out the content analysis. Drawing on insights from this study, we elaborate on how the hylomorphic framework supports deconstructing land degradation and soil erosion, and also further offers insights into a more nature-society-inclusive soil erosion management strategy.

KEYWORDS

land degradation, land use, natural hazards, soil management, sloping land

1. Introduction

Tackling "soil erosion" continues to be a challenge, especially among smallholder farms in tropical mountain regions where rainfall-induced erosion is high (El-Swaify and Dangler, 2015; Labrière et al., 2015). This is exacerbated by the steeply sloping land in these areas (Shanshan et al., 2018) and the traditional farming methods such as continuous hoeing and burning of plant residues which cause land degradation (Barungi et al., 2013; Eswaran et al., 2019). While this can be attributed to limited appropriate agricultural advisory services in these regions (Pender et al., 2004; Muhamud, 2015), it is also due to the mismatch between scientific as well as policy recommendations and the practices of the farming communities (Andersson et al., 2011; Poesen, 2018; Eswaran et al., 2019; Kelly et al., 2020).

In several related studies (Boardman, 2006; Andersson et al., 2011; Ramisch, 2014), this mismatch is largely attributed to the conceptualization of soil erosion control by scientists as well as policymakers; they largely follow the modern ontology which artificially separates humans from non-humans as well as the political from the technical (Latour, 2004; Collard et al., 2018). Meanwhile, most studies on soil erosion have focused on its aspects of computation, prediction, and measurement with policies that omit local perspectives (Boardman, 2006). Consequently, the epistemologies that derive from such a segregated ontology lead to the know-how of the biophysical or natural reality that is distanced from social or anthropogenic aspects of natural hazards (Bwambale et al., 2020; Mertens, 2021). More specifically, by focusing on the natural elements, scientists adhere to the hazard paradigm, depoliticizing soil erosion control, and thus ignoring the socio-economic aspects through which events like soil erosion occur (Zakour and Swager, 2018). They also, neglect local social learning as well as indigenous knowledge, infringing a systems approach and practices that would enhance tackling soil erosion (Tibasiima et al., 2022). This, according to various studies (Boardman, 2006; Akhtar-Schuster et al., 2011; Wilson et al., 2017; Bwambale et al., 2022b), also limits understanding of how anthropogenic and natural processes interact to cause soil erosion, and hampers the development of holistic strategies to best tackle it (Ashmore, 2015).

Toward solving such multifaceted constraints, various studies currently emphasize holistic approaches which go beyond taking into account the natural (looking into the triggers and controlling factors) and exploring the socioeconomic, cultural, and political contexts in which soil erosion occurs (Pender et al., 2004; Bewket, 2011; Teshome et al., 2014; Ekyaligonza et al., 2022). This aligns with the assemblage perspective which facilitates the re-conceptualizing of an issue to best develop means to tackle it from the hybrid of the social and natural, and the human and non-human aspects. This, itself, is possible when a hybrid epistemology is developed that enables understanding phenomena such as soil erosion as social natures in causing as well as tackling it (cf. Ashmore, 2015). For instance, the capture of the real-life experience through social and economic aspects and also the natural processes (such as triggers) and control their occurrence in which an issue such as soil erosion occurs. This implies that soil erosion control addressing the social and the natural aspects should be observed as "two faces of the same coin." Thus the social is integrated with the natural or non-anthropogenic, and the natural, vice versa, with the social, thereby pointing to a nature-society-inclusive context-specific soil erosion management strategy (Bewket, 2011; Tibasiima et al., 2022).

The management of soil erosion has not just continuously pointed to an understanding of land degradation as an assemblage or hybrid of the natural and anthropogenic aspects, but also, an epistemology that levels the grounds between scientists, policymakers, and farmers whose farm production, as well as livelihoods, are at-risk (Latour, 1993; Boardman, 2006; Ashmore, 2015; Poesen, 2018; Tibasiima et al., 2022; Mertens et al., 2023). The assemblage perspective welcomes different ontological groups, thereby enabling conceptualizing phenomena across multiple disciplines, including natural and social sciences, as well as among farmers, scientists, and policymakers. This would be the basis for a common epistemic understanding among actors, including scientists, policymakers, and farmers that enables the co-creation of knowledge as well as the co-development of context-specific soil erosion management practices that would be practically and sustainably implemented. To date, discrepancies between science, policies, and practice in soil erosion management hinder context-specific solutions. Moreover, soil erosion studies or frameworks toward assemblage thinking and a hybrid epistemology from which to draw context-specific soil erosion control measures are scarce.

As a step toward filling this gap, and based on the case of the Rwenzori region of western Uganda (a soil erosion-prone region), this study applied the recently developed *hylomorphic framework*. This framework was developed in natural hazard or disaster risk studies for bridging the real-life experiences of the communities at risk with the theoretical knowledge of scientists and policymakers (Bwambale et al., 2020; Bwambale and Kervyn, 2021). The motive was to not only enable the co-creation of knowledge but also propose a strategy for the co-development of options for solving natural land degradation-related disasters, particularly soil erosion. The framework presented an un-tested potential for eliminating the separation between elements that are social and natural as well as human and nonhuman. It thus enabled an assemblage in understanding soil erosion and a hybrid epistemology from which to design a context-specific strategy for tackling hazards like soil erosion.

2. Perspectives and theory: the hylomorphic framework in the context of soil erosion

The hylomorphic framework was proposed based on the philosophical theory of hylomorphism from Aristotle's philosophy of nature (Bwambale et al., 2020). It captured the hybrid nature of natural risks by emphasizing the substantial unity of both the real-life experiences of the communities-at-risk, i.e., the *hyle*, and the theoretical perspectives of scientists, i.e., the *morphe*. Thus, it favors a flattened ontology by understanding natural risk from context-specific elements, not only reorienting understanding of these risks as social natures but also facilitating a hybrid epistemology from which to develop strategies for tackling context-specific real-life environmental issues (Bwambale and Kervyn, 2021). By enabling the alignment of science with real-life experiences as well as culture and indigenous knowledge, the hylomorphic framework is a standpoint perspective. Standpoint theorists argue that indigenous knowledge exposes biases in scientific knowledge and integrating it with science enables strong objectivity. Thus, partial overlaps between science and real-life experiential know-how should be merged to enable hybrid know-how and action strategy: *real-life experiential know-how should be vivified to expose their explanatory powers.* Alternatively, related *scientific theorization should be inculturated to find a relevant "receptor" to weave into the local context to facilitate a concrete pragmatic epistemic stance* (Latour, 2004; Ludwig, 2016; Bwambale and Kervyn, 2021; Figure 1).

In the initial testing of the hylomorphic framework, three core processes were observed to facilitate both the flat ontology and hybrid epistemology as well as foster the development of innovative strategies (Bwambale and Kervyn, 2021): *(1) embracement of diversity in ontological realities and values attached to an environmental issue*, a process that levels the ground on what to consider as what constitutes the environmental issue at hand. *(2) self-critiques*, which is a core process since it opens space for equitation socio-political deliberation. Thus, an environmental issue is considered as a social nature as well as a matter of concern as opposed to a matter of fact that would preclude dialogue (Mertens et al., 2023). In other words, geopolitics is here apprehended as a space of free discussions that pave the way to a rational consensus (Mouffe, 2011). This then facilitates the third element, *(3) coalescing overlaps in theorizations of processes,* which enable the constitution of a context-specific knowledge system from which to develop context-specific appropriate measures for managing an environmental issue (Ludwig and El-Hani, 2020).

With these three processes, the hylomorphic framework aligns with the social epistemology tradition which advocates for a pluralistic production of knowledge to tackle issues that confront society. In the specific context of environmental studies, it meets the assemblage perspective, emphasizing nature-society-inclusiveness as well as enabling context-situated knowledge, practices, and innovations (Ashmore, 2015; Ludwig and Boogaard, 2021). We interrogate these processes in this study to understand soil erosion as a social nature, as assemblages of the natural and anthropogenic aspects, and explore if that can enable reaching a rational consensus on the conceptualization, understanding, and development of a context-specific soil erosion control management strategy.

3. Methodology: a case study approach

3.1. The case in the Rwenzori region

The study is based on a case from the Rwenzori region in western Uganda bordering the Democratic Republic of the Congo (Figure 2). The Rwenzori is a relevant case for various socio-ecological reasons. For instance, it is a steep sloping land with high population density, making it one of the areas highly prone to soil erosion in the African tropics (Muhamud, 2015; Karamage et al., 2017). Moreover, it is a region where multiple and frequent natural hazards co-occur (Jacobs et al., 2016, 2019a,b), capable of triggering cascades as well as intense disasters (Wisner and Gaillard, 2009; Shi et al., 2020). Yet, at the same time, there is a mismatch between science and practice in the Rwenzori that contravenes the effective management of hazards to prevent disasters (Maes et al., 2017, 2018; Tibasiima et al., 2022). Furthermore, the Rwenzori is also a region with an established cultural approach and indigenous practices to disaster, which generates resistance to measures imposed by top-down policymakers without consideration for the local context (Bwambale et al., 2018; Tibasiima et al., 2022).

Two additional factors make the Rwenzori relevant to this study. Firstly, it is a region where a recent study highlights the perceived importance of the acceptability of environmental disaster management measures by the local/indigenous people (Maes et al., 2019). Secondly, it is a region in a context of a least-developed economy that has limited resources to implement and sustain highly specialized technologies for soil erosion control (Muhamud, 2015). Hence, the conceptualization of the hylomorphic framework is relevant to identifying what determines the design and consensus-building about the context-specific soil erosion control options. Besides, like in other eroded sloping areas dominated by smallholder *Coffea arabica* farmers, the adoption of soil erosion control in the Rwenzori mountains is low (Muhamud, 2015). In this area, *C. arabica* is grown on soil erosion-prone land at high altitudes suitable for its growth. Thus, soil erosion is a challenge to the sustainability of *C. arabica* production in this area given that climate change is foreseen to push the *C. arabica* production zones to even higher altitudes where soil erosion is more rampant (Ovalle-Rivera et al., 2015). In addition, in this area, *C. arabica* was introduced without implementing erosion control measures thus, their integration into the existing coffee fields is complex and requires hybrid context-specific soil erosion control measures which are currently missing (Tibasiima et al., 2022).

3.2. Data collection

The data collection approaches used were adapted from Bwambale and Kervyn (2021), a study in which the scientific testing of the hylomorphic framework was first conducted. In our study, the point of departure was an in-depth investigation of the existing indigenous and scientific knowledge in the area or communities studied. This investigation followed the themes around which questions were structured to aid data collection, including the local perspectives on soil erosion, the local understanding of soil erosion challenges, and the co-creation of soil erosion control measures. Following these themes, data were collected from three stakeholder groups (Table 2). Participants representing these groups were gathered from the various soil erosion-prone areas of the Kasese district in the southwestern part of the Rwenzori region (Figure 2); but also, from the local university, Mountains of the Moon for some of the soil scientists. Since the study required participants from different stakeholder groups that have knowledge and experience in soil erosion control, purposive sampling was used to identify representatives of different categories (Creswell, 2014).

Focus Group Discussions (FGDs) were the main data collection method, supplemented with reviews of the local archives, related scholarly articles, and policy documents to begin with. We chose FGDs for their acknowledged contribution to policy analysis where stakeholders are enabled to participate in discussions, revealing the underlying power relations (Kahan, 2001). Moreover, they

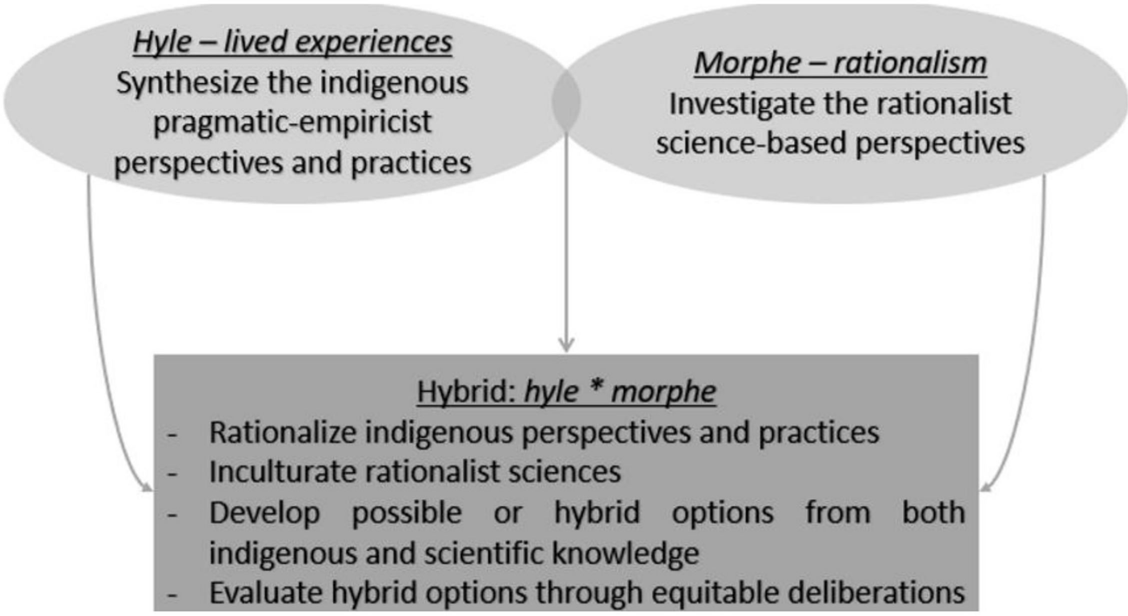

FIGURE 1
Graphical summary of the hylomorphic framework—Adapted from Bwambale and Kervyn (2021).

enhance gathering in-depth data in a participatory manner about disasters (Mercer et al., 2008; Reichel and Frömming, 2014) as well as related analysis in the study area (Maes et al., 2017, 2018). All participants involved in the FGDs were mature adults. The conduct of FGDs followed the procedure elaborated in Hopkins (2007) and Guest et al. (2017), with each FGD having 6 to 12 participants. Written informed consent was obtained from the individuals for the publication of any potentially identifiable images or data included in this study. All FGDs were held at the sub-county offices in each sub-county and were conducted in such a way that the themes of discussion were the same across different stakeholder groups (Table 1). The FGDs were conducted in the local language (Lhukonzo) which is majorly used in the studied area. Each FGD took an average of 3-4 hours in which various participatory methods such as problem tree analysis were used.

The selection of participants aimed at knowledgeable members from each stakeholder group. Yet, still, where possible, the inclusion of both female and male participants was considered. The FGDs were conducted with participants from the same stakeholder group at first and then jointly with the three stakeholder groups. The separate FGDs with each of the stakeholder groups were aimed at gathering their views on all the stakeholder groups to develop a composite inventory of views that formed the basis for the joint FGD, as recommended in Bwambale and Kervyn (2021). A total of nine FGDs were held (Table 2). Other methods incorporated into the FGDs were sketch mapping, and problem and solution tree analysis.

The data collection process was conducted between August and December 2022. The farmers that participated were from the hills in Kasese, at an altitude of 1300-1800 m, and soil erosion-prone agrarian communities of the Rwenzori (Figure 2).

3.3. Data analysis

Data were analyzed following content analysis techniques (Fereday and Muir-Cochrane, 2006). The analysis followed the three hylomorphic processes: (1) embracement of diversity in ontological elements and values attached to soil erosion by the different actors. At this level, we explored whether the general perception was different from the context-specific perception. This aided in a common understanding of what constituted the soil erosion issue. (2) Self-critiques enabled a better understanding of the gaps in the current perceptions, the soil erosion control measures, and the co-creation of contextualized epistemologies around soil erosion and its control measures. (3) Coalescing overlaps in theorizations of processes enabled constituting a context-specific understanding of soil erosion from which to develop hybridized measures for managing soil erosion.

The results of this analysis are presented and discussed following the main themes that were coded from the stakeholder-specific FGDs (1-8) and used during the joint discussions (FGD 9). These include (1) Re-conceptualization of soil erosion where the local context perspectives on soil erosion by the different stakeholders were presented. At this level, the main question addressed was: What is soil erosion in the context of the Rwenzori area? (2) Understanding soil erosion contextual challenges. Here, we focused on soil erosion as a hazard that was increasingly causing agronomic losses, in particular, where it mostly occurred, its causes, and its consequences. (3) Contextualized soil erosion management, where soil erosion control measures that have been used were explored in addition to adjustments and new ways to better control soil erosion. The discussions under each of these themes were contrasted with the three processes of the hylomorphic framework

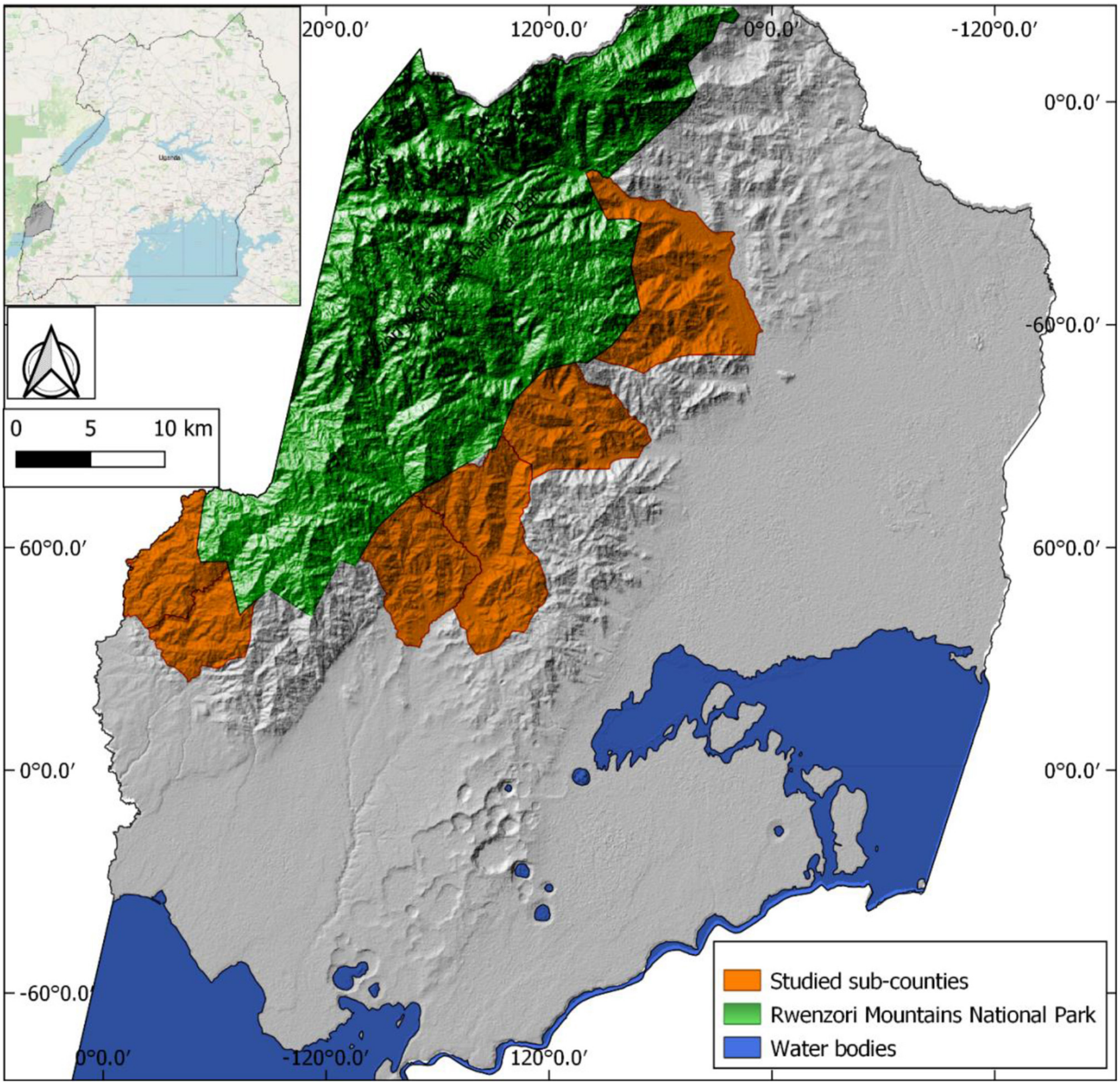

FIGURE 2
The geographical area under study.

as theorized in Section 2 and discussed. The final summing-up is captured in the Conclusions section.

4. Results and discussions

4.1. Re-conceptualization of soil erosion

The hylomorphic framework suggests re-conceptualizing reality from the perspective of social epistemology, enabling a co-production of context-specific knowledge (Bwambale et al., 2020; Bwambale and Kervyn, 2021). At the very outset, some contrasts in the re-conceptualizations of what soil erosion meant in the local context were noticed among the different stakeholders including farmers, scientists, and policymakers. Farmers understood (in consensus) soil erosion in terms of "washing away". This denoted a natural process, implying the ontological natural element of water in the form of rainfall, a key player in soil erosion. They were able to distinguish it from related hazards, e.g., landslides, through the process it takes. This was still in line with the natural sense as is the case in the study areas (Maes et al., 2018). For instance, views extracted from the several FGDs with farmers can be summarized as follows: "soil erosion is the natural wash away of soil, that occurs when it rains on sloping land. It happens over a long time as opposed to landslides which happen instantly" (FGD 1).

On the other hand, for scientists, soil erosion was an anthropogenic process resulting in the loosening of the soil and then such soil being carried away by several agents of soil erosion such as water, wind, and animals. More specifically, in controlling the process, they frequently cited the inability of farmers to implement soil erosion management practices: "soil erosion is the loss of top fertile soil on sloping land that has not been protected from the causes of erosion, and loosened by human activities such as frequent hoeing and overgrazing" (FGD 5). This attribution of soil erosion being a result of human behavior is also commonplace in literature (Nearing et al., 2017). This could be the reason behind scientists and policymakers disregarding the inclusion of natural (spiritual) forces in soil erosion control since they believe that soil erosion is caused by farmers. However, soil erosion is known not only to be human-caused but the causes are understood to be rather complex and geomorphological which result in a land degradation process that may cause environmental and property damage, loss of livelihoods and services, and social and economic disruption (Poesen, 2018). Although there has been no scientisation of the influence of natural forces (spiritual) on the soil erosion process, such broad descriptions of soil erosion could be the foundation for involving an unmeasurable/non-visible (spiritual) aspect in the causation of soil erosion which the farmers term as the "cleansing of the ridges" (Bwambale et al., 2023). It is these discrepancies in the ontological perspectives that prevent the adoption of some of the soil erosion control measures. For example, the fact that farmers call soil erosion a "wash away", implies that they perceive that soil erosion can never happen without rainfall on sloping land. Therefore, they would only adopt measures that control the soil erosion that is caused by rainfall, and whatever is displaced by other agents such as wind, animals, and hoeing are left unchecked. Whereas scientists perceive soil erosion as human-induced, farmers consider it a natural phenomenon that is beyond human control. This discrepancy in the understanding of causation has resulted in scientists perceiving the farmers as mindless keepers of the earth while the farmers consider soil erosion as the fate of their land which due to steep terrain will always be washed away regardless of measures adopted to address it. Farmers, therefore, undertake bare minimal measures to "save just some enough soil" to produce something to survive on. This concept of tolerable soil loss (Isabirye et al., 2007; Hancock et al., 2015; Nearing et al., 2017) explains why farmers let soil erosion continue since it is perceived as a natural process.

A related re-conceptualization was found among the policymakers, concurring that "soil erosion is the destruction of land due to loss of topsoil resulting into loss of livelihoods and famine accompanied by other disasters such as landslides and floods" (FGD 7). Whereas scientists and policymakers perceive soil erosion in terms of loss due to the inability of farmers to implement control measures, the farmers consider the long time it takes to happen and thus connect it to natural causes and less of a loss. Confirming the inference in Section 2 (Hermans et al., 2022), a co-learning attempt was observed among the three categories of stakeholders whenever they acknowledged a new ontological element from each other. For instance, the farmers learned from the scientists and policymakers that in the local context, soil erosion occurred even when there was no rain, implying that it was not just a natural occurrence that was understood as a "wash away"; but it also included any displacement of the soil through human activities such as tillage on a sloping piece of land. For instance, one farmer said,

> "...when we cultivate on sloping land, we displace the soil and thus create erosion in the absence of being washed away. We have also made the land easy to be carried away by constructing big iron-roofed houses. Therefore, soil erosion is not only caused by uncontrollable natural forces. It is not a wash-away but a displacement of soil" (FGD 9).

As theorized in Section 2, these overlaps enabled a hybrid understanding of soil erosion in the local context. Specifically, through the embracement of diversity in ontological realities as

TABLE 1 Details about the data collection.

FGD #	Data needed/extracted	Method
1. Farmers at risk	Indigenous, experiences, perspectives, and practices	3 FGDs, local archive reviews
2. Scientists	State-of-the-art scientific soil erosion control measures and any other Scientific recommendations	2 FGDs, scientific article reviews
3. Policymakers	Policy perspectives, recommendations, and implementation	3 FGDs, policy document reviews
4. Joint	Joint dialogue on soil erosion and soil erosion control	1 FGD

TABLE 2 Details of FGDs conducted.

FGDs	Stakeholder group	Selection criteria	Participants per FGD
FGDs 1-3	Farmers at risk	Smallholder (>2 acres) farmers cultivating on eroded sloping land	3 females, 3 males, 2 youths
FGDs 4-5	Scientists	Involvement in advising farmers on soil erosion	2 district councilors, 3 NGOs (KOFLEC, GLOFA, and BETT), 2 academia (MMU)
FGDs 6-8	Policymakers	Responsible for the formulation and implementation of regulatory guidelines on soil erosion	3 females from the district, 2 males from sub-county, 2 females and 2 males from local council 1
FGD 9	Farmers at risk, scientists, and policymakers	Participation in any of FGD 1, 2, or 3	3 farmers, 3 scientists, and 3 policymakers

well as the self-critiques, a hybrid comprehension of soil erosion emerged that soil erosion was both a natural and human-induced displacement of soil occurring on both sloping and flat lands which continued beyond the topsoil unless control measures were put in place. It posed no immediate threat to completely destroy livelihoods since alternative livelihood sources embedded in the social support structures such as food and seed sharing among farmers and emergency saving schemes existed. For a long time, therefore, soil erosion had stayed within tolerable soil loss amounts.

4.2. Contextual challenges of soil erosion

The re-conceptualization in the preceding section paved way for the participants to have a fresh dialogue on soil erosion, a hazard that increasingly caused agronomic losses. In the past, participants indicated, soil erosion was not explicitly identified as a challenge. Therefore, we aimed to find out how and when it gradually emerged as an issue. Towards this end, we explored key questions such as: what changes have occurred in the ontological setup of the triggers, susceptibility, driving factors, exposures, and vulnerabilities? What was the understanding of the stakeholders on how these changes have facilitated soil erosion as a challenge for farming communities?

According to the farmers, the sloping hills were previously (in the 1960s) reserved as "holy places" and designated for purposes other than farming and settlement:

> Such places were never to be tampered with. Now, these hills have been cultivated or built up and when the soil from these hills is being washed away, it takes along the soil from the gardens. But currently, even when there is no runoff from the holy hills, if you have constructed a big iron-roofed house, the land will be eroded. There are times when it is severe and the whole land mass is carried away at once. In such a situation, there is no production on our land, then it becomes hard to survive and alternative sources of food have to be sought (FGD 2).

The farmers believed that adopting modern techniques changed their lifestyles and the land was displeased with them:

> We had bushes on the hilltops as the source of grass for thatching houses, with the modernizing of houses by replacing rooftops with iron sheets, the hilltops were cleared. Then came the modern earth-moving machines that were brought to open the roads in the mountains. They caused vibrations and made steep road cliffs that have increased erosion. Also, when you see the gardens near the road, the erosion is more in such fields than in those fields that are not along the roads. Generally, soil erosion is a retaliation of nature against our modernization (FGD 1).

The farmers also felt that they lacked the capacity to control the erosion. They said, "this challenge is beyond our control, but we shall always survive on this mountain" (FGD 3). The farmers also considered the impact of soil erosion as a self-perpetuating curse. From the farmers' perspective:

> soil erosion starts by reducing the food and income of the household, once you are weakened by that, and you are not able to work further on the land. You leave the woman and children to cultivate the land as you (the man) go to find a job on which to derive daily survival. Consequently, conflicts begin in the home then the erosion digs deeper (FGD1).

According to scientists, soil erosion was pronounced in over-cultivated fields. They pointed out, "when you look in the old coffee fields, most of the roots of the coffee trees have been exposed by the erosion" (FGD4). In addition, scientists perceived that farmers had a choice to either control the erosion or let it happen on their farms. They believed that all the farms needed to adopt measures against erosion protecting the entire hill; otherwise, widespread erosion would still overpower the efforts undertaken to address erosion in a single farm. The scientists indicated that:

> soil erosion is not difficult to deal with. If the farmers on a particular hill would all choose to prevent erosion on their fields, then the entire landscape would be protected but because they are not educated, they (farmers) misinterpret the causes and just ignore the erosion (FGD 5).

The scientists felt that the farmers neglected the erosion problem because the farmers believed that they will still survive on the depleted land: "you see the farmers survive on the minimum from the eroded land and that is why they have not taken it seriously" (FGD 4).

According to policymakers, soil erosion was widespread across the region affecting livelihoods and the entire social and economic system, and costing a lot to the government. They said, "The roads on these hills have always been eroded due to the low adoption of soil erosion control on the individual farms. From the bottom of the mountain to the top, the government must spend a lot of money every year to fix roads" (FGD 7). The policymakers also flagged mysterious forces that caused soil erosion in the local context:

> In our local situation, some of the things that are known to control erosion have not worked. We do not know why, but we realize that even where there are big trees near the roads for example such parts are badly damaged during the rain, so we fail to understand how to solve the problem (FGD 8).

With soil erosion continuing to destroy livelihoods despite various measures that have been tried, people have migrated from the mountains resulting in over-crowding of the lowlands below and increasing the pressure on resources in nearby urban areas. In the local context, the challenge of soil erosion was widespread and was understood to be a problem of the entire landscape that endangers the social, environmental, and economic aspects of society. As such it perpetuated itself cyclically and created situations that made its control complex e.g., it started from the hilltops, swept through the entire landscape, reduced crop yield, and caused food insecurity that led to domestic violence which in turn discouraged some family members from participating in soil erosion control measures. The uncontrolled runoff from the unmanaged fields accumulated and eventually destroyed the roads. This consequently hindered the transportation of produce to the market and farmers had to spend more to deliver their products to the market and as a result, received less in return. Farmers, therefore, had to resort to providing manual labor in nearby towns to sustain their day-to-day livelihoods as soil erosion further destroyed the land and rendered it fallow.

Farmers perceived soil erosion as a natural hazard where nature (the spirits of the land) punished human beings, and human beings cannot control such retaliation except by being obedient. On the contrary, scientists and policymakers believed that farmers were responsible for soil erosion because they were not educated and hence insisted that it is by penalizing (charging a huge sum of money) non-adopters that soil erosion can be controlled. However, education does not necessarily contribute to soil erosion control (Pender et al., 2004). Farmers, scientists, and policymakers critiqued their original perception of what caused erosion and where it happened most. For example, the scientists and policymakers highlighted that the Kilembe mines management had also preserved some hill slopes in the 1940s and that was not necessarily done to respect the spirits of the land but rather to protect the land from being weakened by human activity.

> The Kilembe mines management had left the entire area after the road barrier in its natural state thus it is logical that such civilized management could find sense in preserving hills and not for fear of the spirits but the cleansing of the ridges would not be a bad thing to them. After all, this (cleansing of the ridges) does not only entail appeasing the spirits of the land but instead is a cocktail of practices where the land is blessed alongside other activities such as planting cultural trees, planting cover crops, preserving natural covers (*omwepu*) that have been blessed, etc (Bwambale et al., 2022a,b) and hence make the soils strong from being displaced (FGD 9).

This scientisation of the holy hills made it possible for some of the traditional beliefs to be recast in science regarding the causes soil of erosion. Similarly, the farmers understood their contribution in weakening the land and thus, in real practice, through the cleansing of the ridges, could be at the forefront of implementing a combination of different soil-conservation practices to overcome the erosion hazard while contributing to the ecological, social, and economic resilience of the community against soil erosion. However, traditional practices of controlling soil erosion are also known to have their constraints (Ellis-Jones and Tengberg, 2000). The farmers also realized that believing in the spirits as the rebellious forces of nature could be the root cause for them doing nothing about the erosion and consequently accepting to survive on the minimum yields from the eroded land. This had been their logic: "soil erosion will always go on, but the land will never become completely unproductive. Therefore, it should not be treated as a crisis" FGD 1. This perspective of the farmers appeared to agree with the concept of tolerable soil loss that has commonly been referred to in several studies on soil loss and was therefore not unique to the farmers in this study (Isabirye et al., 2007; Hancock et al., 2015; Nearing et al., 2017). However, the concept of tolerable soil loss was challenged in the discussions: "we never neglect a neighbor who takes away an inch of our land, so how can we start agreeing with tolerable soil loss through erosion?" (FGD 9). The stakeholders jointly agreed that soil erosion was a slow hazard that destroyed the ecological, environmental, and social functioning of the entire community. This was opposed to the previous understanding of soil erosion as only an ecological challenge of sloping land. Thus, an appreciation evolved among all stakeholders that soil erosion control called for changes in field practices as well as attitudinal and social change that facilitate the adoption of holistic approaches that have been proposed by several scholars (Bewket, 2011; Teshome et al., 2014; Cordingley et al., 2015; Mwangi and Kariuki, 2015; Tibasiima et al., 2022).

4.3. Contextualized soil erosion management

According to the hylomorphic framework, different ontologies and self-critiques can prepare the ground for hybrid epistemologies. This results in the creation of new knowledge based on the scientization of real-life experiences and the inculturation of theoretical scientific perspectives (Section 2). Currently, there are several methods for controlling erosion but very limited implementation happens (Muhamud, 2015) because measures such as terraces are not contextualized in the local traditions (cf. Bwambale et al., 2022a). For instance, according to the farmers, "We have tried several methods to control soil erosion but still the fields are being eroded amidst even what the scientists have recommended to us such as water trenches. We cultivate our land and leave the fields rough. We believe such rough fields would resist erosion, but it does not". Farmers mainly blame the abandonment of good traditional practices and the introduction of destructive modern technologies for the continuing erosion: "The traditional practices to appease nature have been abandoned but these were ensuring that the spirits protect the land from being eroded. We now construct big homes and roads, and these undermine every effort toward managing erosion. The advice we receive is just we should do modern things in our fields, but they have not been tried by anyone and we know well the consequences that may result from that, so we do not follow blindly (FGD 2)". Findings from other research also suggest that neither farmers nor scientists are doing the correct thing (Ramisch, 2014). However, in the context of the hylomorphic framework, the current soil erosion control measures lack a fit with the local context, and relevant indigenous practices have not been integrated into practice.

The scientists believe that their existing knowledge of soil erosion control is adequate to stop erosion if the farmers do what they have been told. In FGD 4 it was mentioned that:

> Any single known soil erosion control measure particularly the structural measures if well implemented can stop the erosion. However, we have trained the farmers many times, but the adoption does not take place. We do not understand why farmers do not implement practices such as contour bands, cultivating across the slope, terracing, water-catching trenches, cover crops, stone bands, and others whose benefits are well known. It is thus not necessary to find new measures but rather tools to ensure the known measures are implemented (FGD 5).

The policymakers share the same perspective as the scientists. They agree that "the soil erosion control measures are there, and they are many and well known. We have been sensitizing the farmers about several methods, but they do not practice them. The solution will be to punish those farmers that do not do what we tell them otherwise soil erosion is being taken for granted yet it is a big and costly challenge" (FGD 7).

The beliefs on soil erosion and its control held by the different stakeholders were challenged in several ways when different views were critiqued at the joint discussions which included all stakeholders. For example, the belief that a single soil erosion control measure could stop erosion was challenged noting that the slope of the land was too steep for one single method to be effective. The farmers and scientists knew well that water trenches had been tried and it never worked. Even the traditional cleansing of the ridges which was no longer being performed had never worked as a single soil erosion control measure. In reality, studies indicate that the Rwenzori region is still prone to soil erosion (Jacobs et al., 2017; Karamage et al., 2017). The stakeholders, therefore, jointly agreed that contextualized erosion control measures were relevant, but were currently missing. According to them:

> To manage soil erosion is surely not a matter of appeasing spirits and then waiting for them (spirits) to do the work. Neither is it to dig the trenches and the erosion stops, it requires serious innovation where different options that encourage adoption will be integrated into the control measures. It is not about science nor religion separated but reconstructing a strategy that can combine both without undermining the other. We should for example seriously ask ourselves, what and how the cleansing of ridges contributed to soil erosion control so that we adopt the good practice and merge that with the science otherwise no clear negative consequences, for example, justify the abandonment of the cleansing of ridges. It seems it was only misinterpreted to be against religion and science (FGD 9).

Equally, scientifically recommended measures were challenged: "We have seen situations where trenches without stabilizers were broken by runoff and caused more disaster than in the fields where they were never constructed as long as they are implemented near an iron-roofed house that collects a lot of runoffs" (FGD 5). Similarly, several control measures have been criticized and farmer preferences have been given priority (Teshome et al., 2014; Muhamud, 2015; Tibasiima et al., 2022). Policymakers were also equally criticized, although there was a strong belief that if policy regulations were implemented, then erosion would be controlled. It was found that the existing regulations were not clear to the policymakers to implement and create an environment that would enable/ensure the adoption of soil erosion control measures. A critique on policy (from FGD 9) was: "there is no way we can currently use policies to address the challenge of soil erosion. It is not clear and is very broad. We need something rather specific that is familiar and clear to the local situation. Something that is practical and can easily be implemented. But in the current state, no penalties are documented and non is in line with the culture of the local people, currently, no policy regulation fits the local situation." Indeed, the laws related to land use regulations in Uganda are scattered in several pieces of environmental legislation and non-specific (Karamage et al., 2017). This explains why despite several policies on control, soil erosion still exists (Akhtar-Schuster et al., 2011).

Although one local leader indicated that they had a by-law for soil erosion control, efforts to access this document were unsuccessful as the document could have been misplaced and was not known to any other members of the community. In addition, the lack of specific regulations on soil erosion control was also cited in the discussions (Karamage et al., 2017).

In the coalescing of perspectives, we noted that the common thread among all stakeholders about soil erosion management was: "When we speak about this problem of soil erosion, we need to consider that our hills are naturally prone to erosion. Such land should not be continuously tilled. The land use needs to be changed for example to perennial crops with perennial cover crops that have a self-sowing system." Such a cropping system has been recommended for soil fertility management in a study by Ekyaligonza et al. (2022) in the same geographical region. Apart from working on the methods, efforts are also needed on the social and regulatory elements. This will change the attitude of all stakeholders toward the ideologies of one another and soil erosion management will be achieved. The stakeholders reached a consensus that soil erosion cannot be controlled but only managed. For instance, while soil erosion control would imply putting in place structural measures that would interfere with the erosion during its occurrence, management entailed practices to prevent the erosion before it happens. This was the basis for proposing a new soil erosion management strategy. As proposed below, the hybridized soil erosion management strategy that resulted from a cocreated epistemology on the technical, natural, and social aspects addressed soil erosion management at different levels as indicated in Table 3.

5. Conclusion

The three processes of the hylomorphic framework i.e., conceptualization, self-critique, and coalescing overlaps proved insightful in bridging the mismatch between science, policy, and practice, toward co-creating a context-specific soil erosion management strategy. Moreover, the three processes through which the co-creating of knowledge happened leveled the ground and thus facilitated the exposition of blind spots in the re-conceptualization, understanding of challenges, and development of measures to control soil erosion in the current context.

In the re-conceptualization, for example, it was generally taken for granted that soil erosion is a "wash away" of topsoil; yet this study exposed the fact that soil erosion, or rather any form of displacement of soil particles, can be caused by human activity and natural agents. The hybrid understanding of soil erosion as a contextual challenge moved away from the limited understanding of soil erosion as a challenge to the sloping fields that are cultivated; rather, it came to be understood as a cyclic challenge that offsets the ecological, social, and economic functioning of the entire community by breaking the bonds that act against it. The modernist approach toward development was

TABLE 3 Assemblage of a hybrid soil erosion control strategy.

Aspect	Description
Technical/scientific	• Install gutters to harvest water on every iron roof house if not use grass to thatch houses • Cover all courtyards with vegetation cover to avoid the accumulation of runoff • Construct water trenches along the contour at an interval not more than 10 m apart • Stabilize water trenches with strongly rooted vetiver grass on both sides of the trench. Use slashing of weeds instead of hoeing • Replace annual crops with perennial crops and perennial cover crops
Natural	• Traditional cleansing of the ridges (including both the traditional and scientific relevance such as planting of holy plants that are believed to appease the spirits of the land)
Social regulation	• Farmers to work in groups (between 10 and 15 households) implement soil erosion management strategy as opposed to individual households
Bylaw	• Iron-roofed house construction is restricted to households headed by 30 years and above of age either live in their traditional house or on grass thatched roof
	• Any iron-roofed house should have an approved plan which includes rainwater harvesting and a runoff-catching courtyard (with vegetation cover)
	• Avoid hard surfaces that were not in the tradition such as hard surface graves. Instead, traditionally burry in the bark of the *Ficus natalensis* (*Omutoma*) trees
	• 10-15 households that work together should take the non-adopters to authorities
	• Traditional penalties (such as the seven goats) payable by non-adopters instead of cash penalties

also criticized in this context to be facilitating soil erosion through the construction of large iron-roofed houses as a serious example. What was learned in this case was that soil erosion should be dealt with from multiple fronts including social, economic, and field-based interventions.

The re-conceptualization as well as the hybrid understanding of factors that facilitated extremities in soil erosion inspired the co-creation of new soil erosion control strategies. For instance, as opposed to focusing on implementing structural measures and penalizing those who do not adopt soil erosion control, the hybrid contextualized strategy refocused on the *management* of soil erosion rather than *controlling* it. In the hybridized soil erosion control strategy, the management of soil erosion included off-field interventions such as regulating the construction of large iron roofed houses, re-considering the cleansing of the ridges as an integrated package of both traditional and scientific erosion management strategies alongside traditionally recognized regulations such as the payment of seven goats by any household that does not implement soil erosion management. This study found that such a soil erosion management strategy does not exist in any current soil erosion management-related strategies and provides new perspectives toward nature-society-inclusive soil erosion management strategy. The steps suggested in the hylomorphic framework as reflected in the preceding sections have highlighted their relevance in the contextualization of soil erosion management.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

TT: conceptualization, investigation, methodology, formal analysis, writing—original draft, and review and editing. BB: conceptualization, investigation, methodology, writing—visualization, review and editing, and mentorship. DE, PD, and FJ: conceptualization and writing—review and editing. JK: conceptualization, methodology, and writing—review and editing. BF: conceptualization, methodology, writing—review and editing, and supervision. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Akhtar-Schuster, M., Thomas, R. J., Stringer, L. C., Chasek, P., and Seely, M. (2011). Improving the enabling environment to combat land degradation: Institutional, financial, legal and science-policy challenges and solutions. *Land Degrad. Dev.* 22, 299–312. doi: 10.1002/ldr.1058

Andersson, E., Brogaard, S., and Olsson, L. (2011). The Political Ecology of Land Degradation. *Annu. Rev. Environ. Resour.* 36, 295–319. doi: 10.1146/annurev-environ-033110-092827

Ashmore, P. (2015). (2015). Towards a sociogeomorphology of rivers. *Geomorphology* 251, 149–156. doi: 10.1016/j.geomorph.02020

Barungi, M. Ng'ong'ola, D. H., Edriss, A., Mugisha, J., Waithaka, M., and Tukahirwa, J. (2013). Factors influencing the adoption of soil erosion control technologies by farmers along the Slopes of Mt. *Elgon in Eastern Uganda. JSD* 6, 9. doi: 10.5539/jsd.v6n2p9

Bewket, W. (2011). Farmers' knowledge of soil erosion and control measures in the Northwestern highlands of Ethiopia. *Af. Geograph. Rev.* 30, 53–70. doi: 10.1080/19376812.2011.10539143

Boardman, J. (2006). (2006). Soil erosion science: eeflections on the limitations of current approaches. *CATENA* 68, 73–86. doi: 10.1016/j.catena.03007

Bwambale, B., and Kervyn, M. (2021). Testing Interscience in Understanding and Tackling Disaster Risk. *Front. Earth Sci.* 9, 783264. doi: 10.3389/feart.2021.783264

Bwambale, B., Mertens, K., Tibasiima, T. K., and Kervyn, M. (2022a). The socio-epistemic process of indigenous disaster risk reduction: evidence of adapting yet endangered indigenous strategies. *Int. J. Dis. Risk Red.* 75, 102953. doi: 10.1016/j.ijdrr.2022.102953

Bwambale, B., Muhumuza, M., Kahigwa, T. T., Baluku, S. M. B., Kasozi, H., Nyeko, M., et al. (2023). Foundations of indigenous knowledge on disasters due to natural hazards: lessons from the outlook on floods among the Bayira of the Rwenzori region. *Disasters* 47, 181–204. doi: 10.1111/disa.12529

Bwambale, B., Nyeko, M., Muhumuza, M., and Kervyn, M. (2018). Traditional Ecological Approaches to Flood Hazards: A preliminary case study of the Rwenzori. in *Climates and cultures: Perspectives for the Future* (Brussels: Royal Academy for Overseas Sciences). Available online at: http://www.kaowarsom.be/en/climates_cultures (accessed December 20, 2022).

Bwambale, B., Nyeko, M., Muhumuza, M., and Kervyn, M. (2020). Questioning knowledge foundation: What is the best way to integrate knowledge to achieve substantial disaster risk reduction? *Int. J. Dis. Risk Red.* 51, 101850. doi: 10.1016/j.ijdrr.2020.101850

Bwambale, B., Nyeko, M., Sekajugo, J., and Kervyn, M. (2022b). The essential contribution of indigenous knowledge to understanding natural hazards and disaster risk: historical evidence from the Rwenzori (Uganda). *Nat Hazards* 110, 1847–1867. doi: 10.1007/s11069-021-05015-x

Collard, R-. C., Harris, L. M., Heynen, N., and Mehta, L. (2018). The antinomies of nature and space. *Environ. Plann. E Nat. Space* 1, 3–24. doi: 10.1177/2514848618777162

Cordingley, J. E., Snyder, K. A., Rosendahl, J., Kizito, F., and Bossio, D. (2015). (2015). Thinking outside the plot: addressing low adoption of sustainable land management in sub-Saharan Africa. *Curr. Opin. Environ. Sustain.* 15, 35–40. doi: 10.1016/j.cosust.07010

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.* 4th ed. Los Angeles: Sage.

Ekyaligonza, D. M., Tibasiima, T. K., Dietrich, P., Kagorora, J. P., Friedel, J. K., Eder, M., et al. (2022). Short-term trade-offs of organic matter management strategies for smallholder farms. *Front. Sustain. Food Syst.* 6, 1035822. doi: 10.3389/fsufs.2022.1035822

Ellis-Jones, J., and Tengberg, A. (2000). The impact of indigenous soil and water conservation practices on soil productivity: examples from Kenya, Tanzania and Uganda. *Land Degrad. Dev.* 11, 19–36. doi: 10.1002/(SICI)1099-145X(200001/02)11:1<19::AID-LDR357>3.0.CO;2-2

El-Swaify, S. A., and Dangler, E. W. (2015). "Rainfall Erosion in the Tropics: A State-of-the-Art," in *ASA Special Publications*, eds. W. Kussow, S. A. El-Swaify, and J. Mannering (Madison, WI, USA: American Society of Agronomy and Soil Science Society of America), 1–25. doi: 10.2134/asaspecpub43.c1

Eswaran, H., Lal, R., and Reich, P. F. (2019). "Land degradation: An overview," in *Response to Land Degradation*, eds. E. M. Bridges, I. D. Hannam, L. R. Oldeman, F. W. T. P. de Vries, S. J. Scherr, and S. Sombatpanit (CRC Press) 20–35. doi: 10.1201/9780429187957-4

Fereday, J., and Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *Int. J. Qual. Methods* 5, 1–11.

Guest, G., Namey, E., and McKenna, K. (2017). How many focus groups are enough? Building an Evidence Base for Nonprobability Sample Sizes. *Field Methods* 29, 3–22. doi: 10.1177/1525822X16639015

Hancock, G. R., Wells, T., Martinez, C., and Dever, C. (2015). Soil erosion and tolerable soil loss: Insights into erosion rates for a well-managed grassland catchment. *Geoderma* 237–238, 256–265. doi: 10.1016/j.geoderma.08017

Hermans, T. D. G., Šakić Trogrlić, R., van den Homberg, M. J. C., Bailon, H., Sarku, R., Mosurska, A., et al. (2022). Exploring the integration of local and scientific knowledge in early warning systems for disaster risk reduction: a review. *Nat Hazards* 3, 8. doi: 10.1007/s11069-022-05468-8

Hopkins, P. E. (2007). Thinking critically and creatively about focus groups. *Area* 39, 528–535. doi: 10.1111/j.1475-4762.2007.00766.x

Isabirye, M., Ruysschaert, G., Vanlinden, L., Poesen, J., Magunda, M., Deckers, J., et al. (2007). Soil losses due to cassava and sweet potato harvesting: a case study from low input traditional agriculture. *Soil Till. Res.* 92, 96–103. doi: 10.1016/j.still.01013

Jacobs, L., Dewitte, O., Poesen, J., Delvaux, D., Thiery, W., Kervyn, M., et al. (2016). The Rwenzori Mountains, a landslide-prone region? *J. Int. Consort. Landslides* 13, 519–536. doi: 10.1007/s10346-015-0582-5

Jacobs, L., Dewitte, O., Poesen, J., Maes, J., Mertens, K., Sekajugo, J., et al. (2017). Landslide characteristics and spatial distribution in the Rwenzori Mountains, Uganda. *J. Af. Earth Sci.* 134, 917–930. doi: 10.1016/j.jafrearsci.05013

Jacobs, L., Kabaseke, C., Bwambale, B., Katutu, R., Dewitte, O., Mertens, K., et al. (2019b). The geo-observer network: a proof of concept on participatory sensing of disasters in a remote setting. *Sci. Total Environ.* 670, 245–261. doi: 10.1016/j.scitotenv.03177

Jacobs, L., Kabaseke, C., Bwambale, B., Katutu, R., Dewitte, O., Mertens, K., et al. (2019a). Geo-observers: participatory sensing of disasters in a remote setting. *Geophys. Res. Abstracts* 21, 54.

Kahan, J. P. (2001). Focus groups as a tool for policy analysis. *Anal. Soc. Issues Public Policy* 1, 129–146. doi: 10.1111/1530-2415.00007

Karamage, F., Zhang, C., Liu, T., Maganda, A., and Isabwe, A. (2017). Soil erosion risk assessment in Uganda. *Forests* 8, 52. doi: 10.3390/f8020052

Kelly, C., Wynants, M., Munishi, L. K., Nasseri, M., Patrick, A., Mtei, K. M., et al. (2020). "Mind the gap": reconnecting local actions and multi-level policies to bridge the governance gap. An Example of Soil Erosion Action from East Africa. *Land* 9, 352. doi: 10.3390/land9100352

Labrière, N., Locatelli, B., Laumonier, Y., Freycon, V., and Bernoux, M. (2015). Soil erosion in the humid tropics: a systematic quantitative review. *Agric. Ecosyst. Environ.* 203, 127–139. doi: 10.1016/j.agee.01027

Latour, B. (1993). *We Have Never Been Modern*. Cambridge, Massachusetts: Harvard University Press.

Latour, B. (2004). Why has critique run out of steam? From matters of fact to matters of concern. *Crit. Inquiry* 30, 225–248. doi: 10.1086/421123

Ludwig, D. (2016). Overlapping ontologies and Indigenous knowledge. From integration to ontological self-determination. *Stud. History Philosophy Sci. Part A* 59, 36–45. doi: 10.1016/j.shpsa.06002

Ludwig, D., and Boogaard, B. K. (2021). "Making transdisciplinarity work: An epistemology of inclusive development and innovation," in *The Politics of Knowledge in Inclusive Development and Innovation* (London: Routledge) 19–33. doi: 10.4324/9781003112525-3

Ludwig, D., and El-Hani, C. N. (2020). Philosophy of ethnobiology: understanding knowledge integration and its limitations. *J. Ethnobiol.* 40, 3. doi: 10.2993/0278-0771-40.1.3

Maes, J., Mertens, K., Jacobs, L., Bwambale, B., Vranken, L., Dewitte, O., et al. (2019). Social multi-criteria evaluation to identify appropriate disaster risk reduction measures: application to landslides in the Rwenzori Mountains, Uganda. *Landslides* 3, 1030. doi: 10.1007/s10346-018-1030-0

Maes, J., Parra, C., Mertens, K., Bwambale, B., Jacobs, L., Poesen, J., et al. (2018). (2018). Questioning network governance for disaster risk management: Lessons from landslide risk management in Uganda. *Environ. Sci. Policy* 85, 2. doi: 10.1016/j.envsci.04002

Maes, J., Poesen, J., Parra, C., Kabaseke, C., Bwambale, B., Mertens, K., et al. (2017). "Landslide Risk Management in Uganda: A Multi-level Policy Approach," in *Advancing Culture of Living with Landslides*, eds. M. Mikoš, Ž. Arbanas, Y. Yin, and K. Sassa (Cham: Springer International Publishing) 395–403. doi: 10.1007./978-3-319-53487-9_46

Mercer, J., Kelman, I., Lloyd, K., and Suchet-Pearson, S. (2008). Reflections on use of participatory research for disaster risk reduction. *Area* 40, 172–183.

Mertens, K. (2021). Reassembling disaster risk: towards a more self-reflexive and enabling geography. *Belgeo* 4, 76. doi: 10.4000/belgeo.53076

Mertens, K., Bwambale, B., and Delima, G. (2023). Politicizing disaster governance: can a board game stimulate discussions around disasters as matters of concern? *Environ. Plann. E Nat. Space* 6, 514–536. doi: 10.1177/25148486211069000

Mouffe, C. (2011). *On the Political.* 1st ed. London: Routledge. doi: 10.4324/9780203870112

Muhamud, N. W. (2015). Socio-economic factors assessment affecting the adoption of soil conservation technologies on rwenzori mountain. *IJG* 47, 26. doi: 10.22146/ijg.6743

Mwangi, M., and Kariuki, S. (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *J. Econ. Sustain. Develop.* 6, 10.

Nearing, M. A., Xie, Y., Liu, B., and Ye, Y. (2017). (2017). Natural and anthropogenic rates of soil erosion. *Int. Soil Water Conserv. Res.* 5, 77–84. doi: 10.1016/j.iswcr.04001

Ovalle-Rivera, O., Läderach, P., Bunn, C., Obersteiner, M., and Schroth, G. (2015). Projected shifts in coffea arabica suitability among major global producing regions due to climate change. *PLoS ONE* 10, e0124155. doi: 10.1371/journal.pone.0124155

Pender, J., Nkonya, E., Jagger, P., Sserunkuuma, D., and Ssali, H. (2004). Strategies to increase agricultural productivity and reduce land degradation: evidence from Uganda. *Agricult. Econ.* 31, 181–195. doi: 10.1111/j.1574-0862.2004.tb00256.x

Poesen, J. (2018). Soil erosion in the anthropocene: research needs: soil erosion in the anthropocene. *Earth Surf. Process. Landforms* 43, 64–84. doi: 10.1002/esp.4250

Ramisch, J. J. (2014). (2014). "They don't know what they are talking about": learning from the dissonances in dialogue about soil fertility knowledge and experimental practice in western Kenya. *Geoforum* 55, 120–132. doi: 10.1016/j.geoforum.05009

Reichel, C., and Frömming, U. U. (2014). Participatory mapping of local disaster risk reduction knowledge: an example from Switzerland. *Int. J. Dis. Risk Sci.* 5, 41–54. doi: 10.1007/s13753-014-0013-6

Shanshan, W., Baoyang, S., Chaodong, L., Zhanbin, L., and Bo, M. (2018). (2018). Runoff and soil erosion on slope cropland: a review. *J. Res. Ecol.* 9, 461–470. doi: 10.5814/j.issn.1674-764x.05, 002.

Shi, P., Ye, T., Wang, Y., Zhou, T., and Xu, W. (2020). Disaster risk science: a geographical perspective and a research framework. *Int. J. Disaster Risk Sci.* 3, 5. doi: 10.1007/s13753-020-00296-5

Teshome, A., Graaff, d. e., and Stroosnijder, J. (2014). Evaluation of soil and water conservation practices in the north-western Ethiopian highlands using multi-criteria analysis. *Front. Environ. Sci.* 2. doi: 10.3389/fenvs.2014.00060

Tibasiima, T. K., Ekyaligonza, D. M., and Bwambale, B. (2022). Can agroecology provide a panacea for sustaining the adoption of soil erosion control measures? A Case of smallholder coffea arabica production in the Rwenzori Mountain Region, Uganda. *Sustainability* 14, 13461. doi: 10.3390/su142013461

Wilson, G. A., Kelly, C. L., Briassoulis, H., Ferrara, A., Quaranta, G., Salvia, R., et al. (2017). Social memory and the resilience of communities affected by land degradation. *Land Degrad. Develop.* 28, 383–400. doi: 10.1002/ldr.2669

Wisner, B., and Gaillard, J. (2009). An introduction to neglected disasters. *Jàmbá: J. Dis. Risk Stud.* 2, 23. doi: 10.4102/jamba.v2i3.23

Zakour, M. J., and Swager, C. M. (2018). "Vulnerability-plus theory," in *Creating Katrina, Rebuilding Resilience* (Elsevier) 45–78. doi: 10.1016/B978-0-12-809557-7.00003-X