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A framework for drivers fostering social-ecological restoration within forest landscape based on people's participation. A systematic literature review

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Abstract
Degradation exacerbates food and water insecurity, economic hardship, biodiversity loss, and the devastating effects of climate change. Given that ecosystem restoration is a global challenge, the United Nations declared 2021 to 2030 as the Decade of Ecosystem Restoration.
Many ecological restoration projects overlook social perspectives, resulting in unsuccessful restoration outcomes within Forest Landscape Restoration (FLR). Against this background, we review social-ecological restoration frameworks and summarize seven key balanced drivers that could help enhance the adoption of ecosystem restoration in a dynamic social context. The drivers relate to including the most affected communities, privileging local knowledge and practices, empowering local representatives and opinion leaders, ensuring social and environmental justice and equity, targeting deep leverage points, aligning restoration practices with local needs and aspirations, and connecting neighboring communities.
We argue that ecosystem restoration will be most effective if approached from a social-ecological perspective. In developing countries, establishing social groups that share savings and credit structures within neighboring households can be a sustainable approach. With increasing global initiatives, taking a social-ecological perspective on ecosystem restoration as a social-ecological restoration approach offers new opportunities for both research and practice. Social-ecological restoration is a key strategy that can support the achievement of sustainable development goals (SDGs) and deliver net positive gains environmentally, socially, and economically. Further studies should focus on two new cross-cutting aspects: the ecological and social effects of restoration at small to large scales and social ecological restoration and peace building within a restorative landscape.

Keywords Social-ecological restoration · Adoption · Ecosystem restoration · Rwanda · Forest landscape restoration

1 Introduction

We are in the grip of a global crisis. More than 60% of the world's vegetation has been cleared or altered as a result of anthropogenic activities. Consequently, ecosystem degradation, climate change, and biodiversity loss are the result: Not only are 33% of the world's agricultural lands severely damaged, with far-reaching consequences for the people living in these systems, but 48% of forest cover is also depleted [1]. Land degradation is caused by multiple forces, including

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extreme weather conditions. It is caused by anthropogenic activities that pollute or degrade the quality of soils and land utility, with subsequent effects not just on food production but also the production and provision of other ecosystem goods and services [2–4].

The adoption of the sustainable development goals by the United Nations General Assembly on September 15, 2015 (cfr.Fig. 1), stimulated renewed interest in land restoration and rehabilitation, particularly as a strategy to help achieve SDG 15, "life on land" [5, 6]. Various initiatives have been designated to promote land restoration and rehabilitation, including the Bonn Challenge, the African Forest Landscape Restoration Initiative (AFR100), initiative 20 × 20 for Latin America and the Caribbean, the World Resource Institute's Global Restoration Initiative, and the UNCCDs Land Degradation Neutrality Fund (LDN Fund), an "impact investment fund for land degradation neutrality" [7].

Several other initiatives, focusing exclusively on achieving climate change mitigation (SDG 13) through soil carbon sequestration, have a strong focus on sustainable land management, including both restoration and rehabilitation. These include by no means limited to 4/1000, and NGOs such as "Justdiggit" explicitly touts their support for SDGs [8, 9].

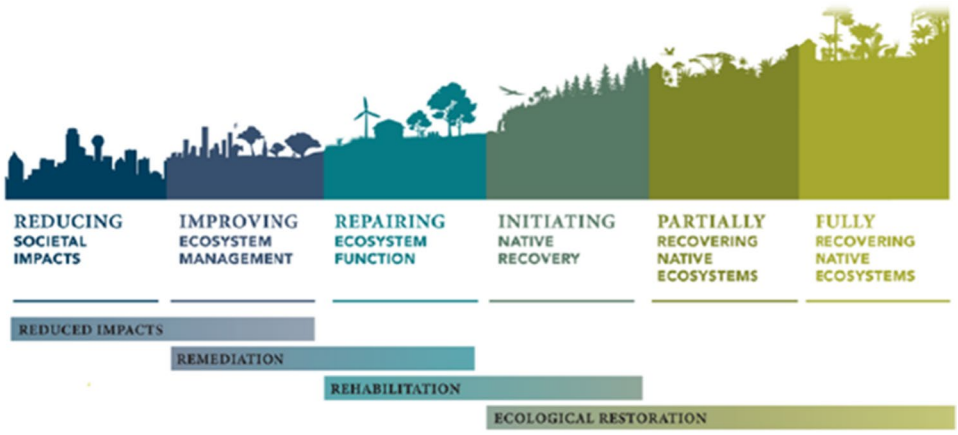
The UN Decade on Ecosystem Restoration, declared for 2021–2030, alongside the Aichi targets of the Convention on Biological Diversity, demonstrates universal recognition of the need for landscape restoration [10, 11].

Forest landscape restoration (FLR) is a planned process that aims to regain ecological integrity and enhance human wellbeing across deforested and degraded landscapes [12, 13]. FLR is more than just planting trees; it is restoring a whole landscape to not just meet present and future needs but also to provide multiple benefits and uses over the long term [14, 15]. FLR is about forests, boosting the number and health of trees in landscapes, interacting land uses, and restoration of biological productivity in order to accomplish various goals within a landscape.

Similarly, FLR is forward-thinking and dynamic, focusing on increasing landscape resilience, thus developing future options for adjusting and further optimizing ecosystem goods and services as societal needs change or new challenges emerge [16, 17]. The environmental, social, and economic benefits of restoring forests, farmlands, and pastures are tremendous. Although this is a wakeup call for all actors, especially entrepreneurs, who are changing the script by developing innovative ideas and sustainable practices that restore land, it is still difficult for restoration practitioners to access investment and scale their restoration practices [16, 18].

Restoration is defined as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" [19]. Indeed, FLR programs comprise a series of activities aligning with the "Restoration Continuum" (i.e., reduced impacts, remediation, rehabilitation, and ecological restoration) that illustrate how the implementation of restorative activities at all levels can optimize broad scale and social outcomes. Gann et al. [20] propose six procedural steps, as Fig. 1 illustrates. Additionally, restoration includes the preservation of existing protected areas and increasing sustainability in areas of major profitable production.

In many cases, restoration seeks to recover degraded natural habitats based on historical baselines. However, since the 2010 s, the focus has increasingly shifted to new restoration trajectories oriented toward the future rather than the past [21]. In the same vein, there has been a shift from a purely ecological focus toward a social-ecological approach to restoration [22]. Restoration can take many forms, ranging from the reduction of pressures to facilitate natural regeneration,



The Restorative Continuum *illustrates how the implementation of restorative activities at all levels can optimize broadscale ecological and social outcomes. See Principle 8.*

Fig. 1 Different levels of restorative activities adapted from [20]

through remediation and rehabilitation, to the partial or full recovery of ecosystems [22]. Restoration is also halting pollution, reducing and treating waste, managing demand for water and fish, as well as reviving vegetation above and below the surface [11]. In practice, there is a tendency to focus on ecological dimensions of restoration, such as biophysical advantages [23] while ignoring the complex socioeconomic realities of restored systems [24, 25]. This results in a research divide between the ever-increasing technical knowledge derived by the ecological sciences and the complex socioeconomic realities of restoration practice [26, 27]. Furthermore, despite some examples of bottom-up and participatory restoration processes e.g., [28], the desire to implement restoration on a large scale has pushed top-down and standardized approaches.

The term social-ecological restoration was introduced by [29] in addressing the need for a comprehensive approach to reconstruct the areas devastated by the 2011 earthquake in northeastern Japan, including the ensuing tsunami and radioactive pollution. Further studies [1, 22, 30] review research and summarize major social-ecological themes and recommend the need for urgent use of social-ecological restoration and the assessment of related projects [1, 31, 32] attempt to show the relationship and difference between ecological restoration, ecosystem service, and social-ecological restoration concepts. Most notably, unlike purely ecological restoration, social-ecological restoration specifically integrates social dimensions within restoration practices [22]. States that restoration could benefit from stronger links with social-ecological systems theory.

We contend that approaching ecosystem restoration from a social-ecological perspective will be more effective. Restoration science and practice would greatly benefit from including socioeconomic dimensions into their design, implementation, and management: when gender, social-political inclusion, and local community views on nature and landscape are considered in restoration processes, they can guide the formulation of sensible, site-specific objectives, thus enhancing the success of restoration interventions [33, 34]. According to UN Water, in theory, social dimensions of restoration are internationally recognized [35]. However, in practice, social dimensions are typically neglected, making it difficult to address the contextual realities of the local communities that depend on lands to be restored [30, 36].

Restoration projects can unintentionally continue to propagate approaches that seem to be blind to local context, disqualify knowledge and priorities of the local population, and limit meaningful social inclusion [37]. This tendency grows more risky as global projects embrace social-ecological restoration, thus being required to recognize the importance of social inclusion in ecosystem restoration [38]. Therefore, meaningful stakeholder participation in social-ecological restoration projects is required in a transdisciplinary way [39]; without it, restoration can easily perpetuate, rather than fundamentally change, those systems that inextricably link environmental degradation to social exclusion. Despite the fact that research increasingly points to the need for greater social inclusion in restoration projects, the approaches that favor such inclusion remain opaque [40, 41]. Hence, there should be a focus on the successful adoption of restoration practices that benefit from a higher degree of participation [42, 43].

The adoption of restoration practices has the potential to achieve a wide range of social and community development aspirations in both developed and developing countries [20], thus contributing to the UN Decade on Ecosystem Restoration. For example, communities located within or near degraded ecosystems may gain health and other benefits from adopting restorative practices**.** Surprisingly, within this scope there are a range of hindering factors at the socioeconomic level that must be overcome. Examples include, among others, the interests of different stakeholders, low political priority given to restoration, insufficient funding, exclusion of local native community, ignoring local knowledge, as well as the lack of an integrated land use plan, legal rights, or property rights, [40, 44]. Therefore, some academics explicitly reject the use of frameworks to study practical change and innovation systems [45–47], while simultaneously acknowledging that adoption decisions are pragmatic measures of individuals or collectives.

On the other hand, although Rogers [48–52] develop theories for understanding individual adoption and collective diffusion, none consider social inclusion to be a significant factor. [48, 53] provides a comprehensive framework for understanding both individual adoption and collective diffusion. Rogers's theory is especially significant because it influences many other theories of adoption and diffusion [49–52]. The strength of Rogers's theory lies in the broad foundation it provides for understanding those factors that influence an individual's or group's decision to adopt an innovation-decision process. The theory proposes that there are five attributes of an innovation that affect and foster adoption: relative advantage, compatibility, complexity, trialability, and observability [53]. This is especially relevant with regard to understanding the drivers and hindering factors underlying the adoption of restoration practices at multiple levels, whether geographic scales or contexts [47, 54, 55]. The adoption theory investigates the decisions an individual makes to accept or reject a specific innovation [56]. In some frameworks, adoption not only includes the decision to accept restoration innovation, but also the extent to which that restoration is integrated into the context and the engagement of stakeholders within FLR, IUCN (International Union for the Conservation of Nature [57]. Here, adoption theory

is a micro perspective of change, revitalization, and resilience, focusing not on the whole but rather on the small scales that comprise the whole. It is well known that ecological restoration is a fundamental asset for agrarian societies, where maintaining land holds great transformative potential in combining ecological and socioeconomic outcome indicators as well as biodiversity resilience, and where forest landscape restoration has the potential to benefit people all over the world by revitalizing rural livelihoods, mitigating climate change, and meeting basic needs such as food, water, and energy. However, those drivers that boost or hinder local community participation or engagement are still unknown, necessitating an assessment of various frameworks, theories, principles, and standards [11, 30, 58–60].

The aim of this paper is to identify factors behind implementing restoration activities in order to develop a framework that fosters social-ecological restoration within forest landscape. We do so by reviewing and analyzing the existing literature, then presenting a meta-analysis of scientific articles relating to social-ecological restoration in the global context. To achieve adoption of landscape restoration at the local level, not only are context-specific strategies required but also combining factors or integrated frameworks alongside theories that foster the adoption of social-ecological restoration practices [61–65] or other new ecosystem-restorative services [43, 65]. The study assists individuals and institutions, both public and private, engaged in restoration around the world, build on an inclusive and balanced social-ecological restoration framework that is based on a systematic literature review.

2 Methodology

For the purpose of this study, a systematic literature review was conducted; following the preferred reporting items for systematic reviews and meta-analysis (PRISMA) protocol [66] (cf. Fig. 2). We searched for peer-reviewed articles and conference proceedings on SCOPUS and Google Scholar based on overall scholarly impact and multidisciplinary sources. Scopus was chosen because it covers journals across all disciplines. However, the database is slightly skewed toward natural science, engineering, and biomedical journals with a weaker focus on social science, arts, and humanities journals [32]. To compensate for these limitations, we searched Google Scholar and reference lists of retrieved articles for additional relevant journal articles (cf. Fig. 2). After article identification, duplicates were removed and the following three steps were then implemented to identify articles that were deemed irrelevant: (1) title screening; (2) abstract screening; and (3) full text screening (cf. Fig. 2). The documents we reviewed had to meet the criteria listed in Table 1. The number of studies that were screened, evaluated for eligibility, and included in the review, respectively, are depicted in a flow diagram (Fig. 2).

During the search, the combination of two or more keywords were applied such as ecosystem-restoration-ecology, social-ecological restoration, restoration-protection-social ecology, social-ecological-systems, restoration-ecology-agriculture, landscape ecology-restoration, ecology-evolution-environment.

Figure 2 shows that 117 studies were evaluated for eligibility out of a total of 1811. In addition, different adoption theories [48–52].were analyzed to better understand which factors influence an individual's or group's decision to adopt an innovative restoration approach. To that end, the reviewed papers were analyzed using qualitative comparative analysis toward a framework fostering social-ecological restoration within forest landscape. The literature search started in May 2022 and closed by July.

2.1 Data analysis and procedure

Much of the literature in this review explores and analyzes different frameworks [1, 20, 22, 67] and adoption theories [48–52]. However, there are also scientific papers reflecting on social-ecological restoration and community participation or adoption practices [29, 30].

We followed Qualitative Comparative Analysis and apply a crisp set, the score was 1 or 0, with 1 indicating the presence of the adoption theory and 0 its absence, as defined by Fischer & [68, 69]. Further, the factors of adoption of social-ecological restoration, features and strategies from 12 cases studies are analysed to understand underlying challenges and facilitating drivers of individuals or group to or not adopt the restoration approach within FL.

Limited research and difficulty in comparing studies among the studies identified in our literature review, there is a limited amount of academic literature on social-ecological restoration. Most studies on restoration focus on ecological restoration systems, which are already shown to be insufficiently inclusive of social dynamics in restoration activities. Moreover, for restoration efforts to restore land and livelihoods at scale, the restoration movement must create inclusive pathways for the people who work and manage the land, understanding their experiences and knowing who they interact with most often [70].

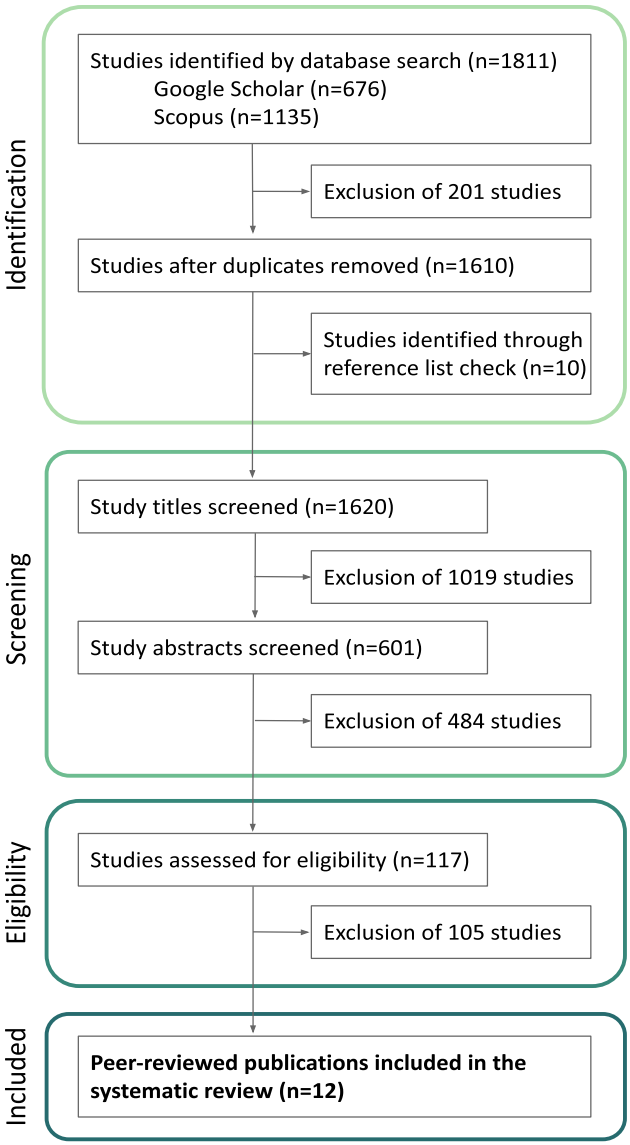


Fig. 2 Flow of information through the different phases

Box 1 provides a detailed summary of 12 case studies identified from ecological restoration systems in the review papers, indicating the diversity of methods, contexts, geographical areas, and stakeholders involved and under which the social-ecological systems/restoration framework is applied.

3 Results

3.1 General findings

Our analysis reveals that, since 2014, there is very limited research on factors affecting the adoption of social-ecological restoration (n = 12, cf. Fig. 3). Starting with 1,811 studies, only 601 abstracts were screened (33%), as the titles of the remaining articles reported information that did not meet the inclusion criteria (Table 1). Of these, 484 studies were eliminated from the review for not meeting the criteria (Table 1). Subsequently, of the 117 studies assessed for eligibility, 105 were excluded due to lack of methodological clarity. Hence, only 12 empirical studies are included in our review. These studies are built on a foundation of adoption theories that provide the adoption phases, which are:

Box 1 Details of 12 case studies

- Ten standard practices for planning and implementing ecological restoration projects,
- Six key concepts underpinning best restoration practice
- Six themes from social ecological endeavor
- Ten people-centered rules for socially sustainable ecosystem restoration
- Nine attributes of restored ecosystem
- Desk based on five social ecological restoration cycles
- Seven principles for building resilient in social ecological systems
- UN decade on ecosystem restoration
- Four official reports on ecological restoration within landscapes
- Five case studies used both primary and secondary data
- Ten case studies are national to regional levels
- Two cases are at international studies
- Main stakeholders involved are: researchers, policy makers, restoration practitioners, planners
- Ten studies used qualitative approaches

knowledge, persuasion, decision, implementation, and confirmation. The qualitative approach is seen as a dominant one used in social ecological restoration studies.

3.2 Seven drivers affecting the adoption of the social-ecological restoration approach

Based on the frameworks from the case studies and the adoption theories analyzed, we find 7 drivers that shape whether or not communities apply, and participate in, social-ecological restoration activities as a new approach for effective ecological restoration (Fig. 3). However, adoption is also based on the strategies used during the restoration process as well as the characteristics of the approaches identified based on the context, scale, and different types of knowledge.

Table 2 Indicates the details of drivers underlying adoption of social ecological restoration approaches as well as the features and strategies that local communities can adopt to facilitate successful restoration at their local scale within their local landscape.

Prioritizing the voices and needs of the local and native populations are found to be a positive action during the restoration planning and project implementation practice [1, 20, 22, 48, 67, 71, 72]. Of course, we assume an inverse relationship, i.e., if participation is low or when the adoption phases are not taken into appropriate consideration, we

Fig. 3 Overview of 7 key drivers that influence the adoption of social-ecological restoration approaches by communities at the local scale (own design)

Table 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• Social-ecological restoration characterized by the interconnections among ecological and social issues in the ecosystems; must be published between 2014 and 2022 to guarantee the source is up-to-date	• Does not reflect on social-ecological restoration as community inclusion approach
• Database indexed in English	• Paper that does not meet the keywords criteria, not database indexed, not peer-reviewed paper
• Peer-reviewed paper or conference proceeding	• Published prior to 2014
• Combination of keywords, such as social ecological restoration, ecosystem-restoration-ecology, restoration-protection-social ecology, social-ecological-systems, restoration-ecology-agriculture, landscape-ecology-restoration, ecology, evolution-environment, based on qualitative results	• Based on quantitative results
• Study focuses on local scales	• Study beyond local scale

argue for less successful implementation. Therefore, a critical issue is the neglect of the social dimension, principally that of the local communities that would otherwise make a significant difference. In addition, increasing financial resources for ecological restoration while eliminating environmentally harmful subsidies can also lead to the success.

These factors of social-ecological restoration adoption are designed to inspire and drive better restoration outcomes within landscapes while supporting those stakeholders and local communities, including indigenous people, addressing the challenges of ecological restoration while considering social perspectives.

4 Discussion

The literature analysis shows that whilst social-ecological restoration is considered a crucial concept for sustainable restoration, in practice focus remains on ecological and technical aspects. In particular, not only is the voice of local communities neglected, but structures are not yet established that can facilitate continuous interaction with stakeholders throughout restoration, i.e. capacities to join (time, money, information), complexity of tools and information, capacities to negotiate and raise discontent, etc. Within this scope, there are a range of hindering reasons at the socio-economic level that must be overcome to foster social-ecological restoration. Examples include, among others, the interests of different stakeholders, low political priority given to restoration, lack of an integrated land use plan, legal or property rights, insufficient funding exclusion of local native community, and ignoring local knowledge [40, 44]. Thus we propose 7 drivers that could facilitate a successful SER. A key challenge for restoration is to realize the interconnection of people and biosphere as well as the necessity for restoration that includes not only ecological tenets of success but also considers human benefits and social inclusion. Although interdisciplinary research approaches that engage more deeply in the social context of landscapes, with the potential to make a significant contribution to ecosystem restoration and studies of social ecological restoration, are still limited and novel [29, 30, 68, 73] the lessons from this work are valuable. A strong focus on ecological, social, and technical aspects of restoration is often neglected in restoration research. We align with this concept but also consider it critical to put this concept into action, as practice still shows an imbalance of social and ecological dimensions.

This study argues that it is time to find ways to integrate human lives into the rest of the environment. Social ecological-restoration can play a significant role in realizing this goal [31, 38, 75, 76]. The importance of social-ecological restoration and adoption factors in determining long-term restoration success is neglected [11, 30, 77]. While there appears to be agreement on the importance of making restoration a socio-ecological endeavor [22], not enough attention has been paid to analyzing those drivers that boost the adoption of the restoration practices. It is also important to consider ecological and social perspectives of different local stakeholders for the long term success of restoration projects [20, 22, 78].

However, it is known that communities located within or near degraded ecosystems may gain health and other benefits from the adoption of restorative practices [20]**.** It is confirmed that ecological restoration is a fundamental asset for agrarian societies, where maintaining land holds great transformative potential in socioeconomic outcomes as well as

Table 2 The 7 key drivers underlying the adoption of social-ecological restoration approaches by the community in landscape at local scale

	Driver of adoption of SoER	Features	Strategies	References
1	Include the most affected communities	For effective SoER, integrate all stakeholders who are indirectly and directly affected, (disadvantaged and invisible groups such as women, youth, and indigenous) Early, genuine, and active engagement with all stakeholders underpins long-term restoration success	Use a variety of tools to understand power dynamics, create a conflict resolution approach, maintain engagement with the state, and encourage social local governance arrangements necessary for addressing the complex land disputes under restoration Invest in local capacity-building programs that encourage participation and action, foster a shared vision, and promote effective restoration interventions that are relevant to the purpose and situation	[67, 71]
2	Privilege local knowledge and practices	Local practices are crucial for protecting ecosystems against extractive forms of development and, thus, restoration projects should invest in and support them. Restoration can be more effective if it engages with the relational values of diverse actors	Provide local groups greater voice and decision-making capacity, give long-term security for these lands and resources, as well as clarify and create local land tenure and access rights that recognize the integrity of local governance units	[1, 72]
3	Empower local representatives and opinion leaders	Engage and empower local leaders and communities most impacted by restoration to exert greater control over policies and decision that affect their land use and livelihoods	Empower local government agencies and opinion leaders to engage in ecosystem restoration within their own jurisdictions guided by local needs and aspirations Promote polycentric governance and downwardly accountable mechanisms that ensure policies are sustainable and equitable	[22, 73]
4	Ensure social and environmental equity and justice	Distribution, procedural and recognition equity, free from discrimination and bias, mutual respect and justice for all	Include local communities in project design and decision-making; revisit stakeholder analysis on a regular basis; develop a long-term restoration plan; and monitor the project for fairness, transparency, and social equity for a broad range of benefits (individuals must be free from physical threats and they must be offered complete and equal political rights)	[20, 22, 48, 53, 74]
5	Target deep leverage points	When seeking to change a social ecological system, not all interventions are equally powerful. Social ecological systems have produced insights on different types of leverage points to bring about change	Taking a leverage points perspective could help to make restoration more effective	[22, 29, 30, 48]
6	Align restoration practices with local needs and aspirations	Consider a variety of restoration practices driven by traditional ecological knowledge and local needs and aspirations rather than political and economic agendas	Assess and build relevant capacity for collaboration between environmental agencies (analysis of social ecological systems) and local communities to understand how restoration can best support the types of sustainable livelihoods community members desire, develop plans for sustainable community and well being specific to the aspirations and eco-social possibilities in different places and contexts	[1, 20]

Table 2 (continued)

	Driver of adoption of SoER	Features	Strategies	References
7	Connect neighboring communities for socioeconomic empowerment	Consider the establishment of social groups of credit and savings, and restoration committees	Create groups of community members who are living in the same village/area/landscape, let the group members elect their leaders. Let the community set the minimum amount to save every day/week based on their incomes, let the community set out the rules and regulations about how to get loans from their fund, train the group members about agribusiness plans and models	[73]

biodiversity resilience. Forest landscape restoration has the potential to benefit people around the world by revitalizing rural livelihoods, mitigating climate change, and meeting basic needs such as food, water, and energy. However, the drivers that boost or hinder local community participation or engagement are still unknown, thus requiring the development of new approaches to address this gap [11, 30, 58, 59].

The seven adoption drivers developed herein come at a time of unparalleled global human impacts, where climate change, land degradation, and biodiversity loss threaten the social ecological fabric of the planet. Social ecological restoration is a solutions-based approach that engages communities and considers social inclusion [19]. It is defined as repairing ecological damage and rebuilding a healthier symbiosis between people and nature [20, 71, 72]. To successfully support the established drivers underlying adoption of social-ecological restoration practice within FLR, each adoption factor has detailed features as well as strategies that can be applied across landscapes, strengthening the existing frameworks and adoption theories while also considering the voices, needs, and wants of local and native populations, all alongside social inclusion [47, 54, 55].

Restoration can also be quite valuable when it fulfils certain functions, even if the restored system does not resemble the historical reference system at all [77, 78]. Following full recovery, ongoing monitoring strategies can be viewed as a form of ecosystem maintenance by the local community within the restoration landscape. Our literature review shows that it is crucial for the community to include stakeholder involvement, participatory processes, and collaboration in the planning, designing, and implementation of the restoration process. By fostering knowledge exchange platforms and effective communication mechanisms, implementing best practices, and exchanging ideas, efforts can facilitate effective working relationships, promote ecological restoration across all areas, and highlight the contributions of ecosystem services to the benefit of the community. Further, transdisciplinary social ecological restoration projects can be implemented by incorporating political decision makers and all relevant stakeholders [11, 40, 44]. They also call for increasing financial resources for ecological restoration while eliminating environmentally harmful subsidies.

Not only is social-ecological restoration is still a new concept, compared to ecological restoration; it must also be integrated with conservation and sustainable production, especially at the landscape level. Therefore, we argue that the high involvement of local stakeholders is important throughout all FLR activities, especially in conflict affected scenarios. For now, however, low to no participation is still a key point of criticism. In the restoration context, there is point of curiosity for researchers: the establishment of a social group of savings and credit as a new approach for social-ecological restoration within the neighboring households/community under the restoration landscapes.

5 Concluding remarks

Ecosystem Restoration provides unique opportunities for simultaneously enhancing environmental outcomes and human well being. Yet, there are also serious risks. Ignoring the social dimensions of environmental initiatives has led not only to failure in achieving ecological objectives, but also to scarcity, land grabs, conflict, and further marginalization of vulnerable communities. In this review, many papers focus their analysis on ecological restoration systems while the nexus between social and ecological dimensions on restoration is rarely reported. Further, there is a shortage of research focusing on the social-ecological restoration approach. We argue that it is a time to find ways to reintegrated human lives into the rest of the environment. Social-ecological restoration can play a vital role in realizing this goal. Each of the seven social-ecological restoration drivers outlined herein translates into new priorities for the adoption and successful implementation of the ecosystem restoration projects. Thus, social-ecological restoration is a key strategy that can support the achievement of the sustainable development goals (SDGs) and can deliver net positive gains environmentally, socially, and economically, while providing opportunities for research. Based on these reflections, we suggest two cross-cutting research priorities focusing, in particular, on social ecological restoration: first, the ecological and social effects of restoration at small to large scales; and, secondly, social ecological restoration and peace building.

In the restoration context, one might note these drivers with curiosity. However, the proposed framework is best viewed as a preliminary draft that requires further validation through larger-scale studies and replication.

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Declarations

Competing interests The authors declare no competing interests.

References

1. McDonald T, Jonson J, Dixon KW. National standards for the practice of ecological restoration in Australia. Restor Ecol. 2016. https://doi.org/10.1111/rec.12359.
2. Eni I. Effects of land degradation on soil fertility: a case study of calabar south. Nigeria: INTECH Open Access Publisher; 2012.
3. Chotte J-L (2016) Chapter 5. land degradation and climate change. The Mediterranean Region under Climate Change, pp 605–609. https://doi.org/10.4000/books.irdeditions.23982.
4. FAO. The State of Food Security and Nutrition in the World. Rome: FAO; 2019.
5. UNCCD. A natural fix: A joined-up approach delivering the global goals for sustainable development. 2016.
6. IRP. Land restoration for achieving the sustainable development goals: an international resource panel think piece. Nairobi: United Nations Environment Programme; 2019.
7. Rakotonarivo OS, Rakotoarisoa M, Rajaonarivelo HM, Raharijaona S, Jones JP, Hockley N (2023) Resolving land tenure security is essential to deliver forest restoration. Commun Earth Environ. 4(1). https://doi.org/10.1038/s43247-023-00847-w.
8. Orr BJ, Cowie AL, Castillo Sanchez VM, Chasek P, Crossman ND, Erlewein A, Louwagie G, Maron M, Metternicht GI, Minelli S, Tengberg AE, Walter S, Welton S. Land in balance: the scientific conceptual framework for land degradation neutrality. Environ Sci Policy. 2018;79:25–35. https://doi.org/10.1016/j.envsci.2017.10.011.
9. Cowie AL, Orr BJ, Castillo Sanchez VM, Chasek P, Crossman ND, Erlewein A, Louwagie G, Maron M, Metternicht GI, Minelli S, Tengberg AE, Walter S, Welton S. Land in balance: the scientific conceptual framework for land degradation neutrality. Environ Sci Policy. 2018;79:25–35. https://doi.org/10.1016/j.envsci.2017.10.011.
10. Wortley L, Hero J-M, Howes M. Evaluating ecological restoration success: a review of the literature. Restor Ecol. 2013;21(5):537–43. https://doi.org/10.1111/rec.12028.
11. Elias M, Joshi D, Meinzen-Dick R. Restoration for whom, by whom? a feminist political ecology of restoration. Ecol Restor. 2021;39(1–2):3–15. https://doi.org/10.3368/er.39.1-2.3.
12. Mansourian S. From landscape ecology to forest landscape restoration. Landsc Ecol. 2021;36(8):2443–52. https://doi.org/10.1007/s10980-020-01175-6.
13. Besseau P, Graham S, Christophersen T, editors. 2018. Restoring forestsand landscapes: the key to a sustainable future. Vienna, Austria: Global Partnership on Forest and Restoration. https://www.forestlandscaperestoration.org/images/gpflr_final%2027aug.pdf.
14. Lamb D, Stanturf J, Madsen P. What is forest landscape restoration? For Landsc Restor. 2012. https://doi.org/10.1007/978-94-007-5326-6_1.
15 Stanturf JA, Kleine M, Mansourian S, Parrotta J, Madsen P, Kant P, Burns J, Bolte A. Implementing forest landscape restoration under the bonn challenge: a systematic approach. Ann For Sci. 2019. https://doi.org/10.1007/s13595-019-0833-z.
16. *Land Accelerator Africa 2022-Demo Day*. AFR100. (n.d.). https://afr100.org/content/land-accelerator-africa-2022-demo-day. Accessed 7 Nov 2022.
17. Lewis E, MacSharry B, Juffe-Bignoli D, Harris N, Burrows G, Kingston N, Burgess ND. Dynamics in the global protected-area estate since 2004. Conserv Biol. 2018;33(3):570–9. https://doi.org/10.1111/cobi.13056.
18. Palmer CG, Fry A, Libala N, Ralekhetla M, Mtati N, Weaver M, Mtintsilana Z, Scherman P. Engaging society and building participatory governance in a rural landscape restoration context. Anthropocene. 2022;37:100320. https://doi.org/10.1016/j.ancene.2022.100320.
19. *SER international primer O N ecological restoration*.(2004). (n.d.). https://www.ctahr.hawaii.edu/LittonC/PDFs/682_SERPrimer.pdf. Accessed 25 Oct 2022.
20. Gann GD, McDonald T, Walder B, Aronson J, Nelson CR, Jonson J, Hallett JG, Eisenberg C, Guariguata MR, Liu J, Hua F, Echeverría C, Gonzales E, Shaw N, Decleer K, Dixon KW. International principles and standards for the practice of ecological restoration. second edition. Restor Ecol. 2019. https://doi.org/10.1111/rec.13035.
21. Coleman MA, Wood G, Filbee-Dexter K, Minne AJ, Goold HD, Vergés A, Marzinelli EM, Steinberg PD, Wernberg T. Restore or redefine: future trajectories for restoration. Front Marine Sci. 2020. https://doi.org/10.3389/fmars.2020.00237.

22. Fischer J, Riechers M, Loos J, Martin-Lopez B, Temperton VM. Making the UN decade on ecosystem restoration a social-ecological endeavour. Trends Ecol Evol. 2021;36(1):20–8. https://doi.org/10.1016/j.tree.2020.08.018.
23. Collard R-C, Dempsey J, Sundberg J. A manifesto for abundant futures. Ann Assoc Am Geogr. 2015;105(2):322–30. https://doi.org/10.1080/00045608.2014.973007.
24. *Un decade on Ecosystem Restoration 2021–2030*. UN. (2020, March 19). https://www.unwater.org/news/un-decade-ecosystem-restoration-2021-2030. Accessed 25 Oct 2022.
25. Erbaugh JT, Pradhan N, Adams J, Oldekop JA, Agrawal A, Brockington D, Pritchard R, Chhatre A. Global forest restoration and the importance of prioritizing local communities. Nat Ecol Evol. 2020;4(11):1472–6. https://doi.org/10.1038/s41559-020-01282-2.
26. Higgs E. The two-culture problem: ecological restoration and the integration of knowledge. Restor Ecol. 2005;13(1):159–64. https://doi.org/10.1111/j.1526-100x.2005.00020.x.
27. Martin DM. Ecological restoration should be redefined for the twenty-first century. Restor Ecol. 2017;25(5):668–73. https://doi.org/10.1111/rec.12554.
28. Lee DS, Fahey DW, Skowron A, Allen MR, Burkhardt U, Chen Q, Doherty SJ, Freeman S, Forster PM, Fuglestvedt J, Gettelman A, De León RR, Lim LL, Lund MT, Millar RJ, Owen B, Penner JE, Pitari G, Prather MJ, Wilcox LJ. The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. Atmos Environ. 2021;244:117834. https://doi.org/10.1016/j.atmosenv.2020.117834.
29. Takeuchi K, Elmqvist T, Hatakeyama M, Kauffman J, Turner N, Zhou D. Using sustainability science to analyse social–ecological restoration in NE Japan after the great earthquake and tsunami of 2011. Sustain Sci. 2014;9(4):513–26. https://doi.org/10.1007/s11625-014-0257-5.
30. Fernández-Manjarrés JF, Roturier S, Bilhaut A-G. The emergence of the social-ecological restoration concept. Restor Ecol. 2018;26(3):404–10. https://doi.org/10.1111/rec.12685.
31 Alexander S, Aronson J, Whaley O, Lamb D. The relationship between ecological restoration and the ecosystem services concept. Ecol Soc. 2016. https://doi.org/10.5751/es-08288-210134.
32. Mongeon P, Paul-Hus A. The journal coverage of web of science and scopus: a comparative analysis. Scientometrics. 2015;106(1):213–28. https://doi.org/10.1007/s11192-015-1765-5.
33. Lindig-Cisneros R. Ecological restoration in Mexico: The challenges of a multicultural megadiverse country. Ecol Restor. 2010;28(3):232–3. https://doi.org/10.3368/er.28.3.232.
34. Collard R-C, Dempsey J. Two icebergs: difference in feminist political economy. Environ Plan A Econ Sp. 2020;52(1):237–47. https://doi.org/10.1177/0308518x19877887.
35. WWAP(UNESCO World Water Assessment Programme). The United Nations World Water Development Report: 2019: Leaving No One Behind.Paris, UNESCO.
36. Temperton VM, Buchmann N, Buisson E, Durigan G, Kazmierczak L, Perring MP, SáDechoum M, Veldman JW, Overbeck GE. Step back from the forest and step up to the bonn challenge: how a broad ecological perspective can promote successful landscape restoration. Restor Ecol. 2019. https://doi.org/10.1111/rec.12989.
37. Fox H, Cundill G. Towards increased community-engaged ecological restoration: a review of current practice and future directions. Ecol Restor. 2018;36(3):208–18. https://doi.org/10.3368/er.36.3.208.
38. Krievins K, Plummer R, Baird J. Building resilience in ecological restoration processes: a social-ecological perspective. Ecol Restor. 2018;36(3):195–207. https://doi.org/10.3368/er.36.3.195.
39 Bergmann M, Schäpke N, Marg O, Stelzer F, Lang DJ, Bossert M, Sußmann N. Transdisciplinary sustainability research in real-world labs: success factors and methods for change. Sustaina Sci. 2021;16(2):541–64. https://doi.org/10.1007/s11625-020-00886-8.
40. Baker S, Eckerberg K, Zachrisson A. Political science and ecological restoration. Environ Polit. 2014;23(3):509–24. https://doi.org/10.1080/09644016.2013.835201.
41. Sigman E, Elias M. Three approaches to restoration and their implications for social inclusion. Ecol Restor. 2021;39(1–2):27–35. https://doi.org/10.3368/er.39.1-2.27.
42. Brown B, Nuberg I, Llewellyn R. Stepwise frameworks for understanding the utilisation of conservation agriculture in Africa. Agric Syst. 2017;153:11–22. https://doi.org/10.1016/j.agsy.2017.01.012.
43. Pannell DJ, Claassen R. The roles of adoption and behavior change in agricultural policy. Appl Econ Perspect Policy. 2020;42(1):31–41. https://doi.org/10.1002/aepp.13009.
44. Cortina-Segarra J, García-Sánchez I, Grace M, Andrés P, Baker S, Bullock C, Decleer K, Dicks LV, Fisher JL, Frouz J, Klimkowska A, Kyriazopoulos AP, Moreno-Mateos D, Rodríguez-González PM, Sarkki S, Ventocilla JL. Barriers to ecological restoration in Europe: expert perspectives. Restor Ecol. 2021. https://doi.org/10.1111/rec.13346.
45. Glover D, Sumberg J, Andersson JA. The adoption problem; or why we still understand so little about technological change in African agriculture. Outlook Agric. 2017;45(1):3–6. https://doi.org/10.5367/oa.2016.0235.
46. Glover D, Sumberg J, Ton G, Andersson J, Badstue L. Rethinking technological change in smallholder agriculture. Outlook Agric. 2019;48(3):169–80. https://doi.org/10.1177/0030727019864978.
47. Hermans, A., Bos, O. G., & Prusina, I. (2020, March 17). *Nature-inclusive design: A catalogue for Offshore Wind Infrastructure: Technical Report*. Research@WUR. https://research.wur.nl/en/publications/nature-inclusive-design-a-catalogue-for-offshore-wind-infrastruct. Accessed 5 Jan 2023.
48. Rogers E. Diffusion of innovations. 4th ed. NY: New York free Press; 1995.
49. Boyne GA, Gould-Williams JS, Law J, Walker RM. Explaining the adoption of innovation: An empirical analysis of public management reform. Eviron Plann C Gov Policy. 2005;23(3):419–35. https://doi.org/10.1068/c40m.
50. Deffuant G, Huet S, Amblard F. An individual-based model of innovation diffusion mixing social value and individual benefit. Am J Sociol. 2005;110(4):1041–69. https://doi.org/10.1086/430220.
51. Pennington MC. Cycles of innovation in the adoption of information technology: a view for language teaching. Comput Assist Lang Learn. 2004;17(1):7–33. https://doi.org/10.1076/call.17.1.7.29705.
52 Morris Venkatesh, Davis Davis. User acceptance of information technology: toward a unified view. MIS Quarterly. 2003;27(3):425. https://doi.org/10.2307/30036540.

53. Rogers. Diffusion of innovations. 5th ed. NY: New York free Press; 2003.
54. Kuntosch A, König B, Bokelmann W, Doernberg A, Siebert R, Schwerdtner W, Busse M. Identifying system-related barriers for the development and implementation of eco-innovation in the German horticultural sector. Horticulturae. 2020;6(2):33. https://doi.org/10.3390/horticulturae6020033.
55. Prokopy LS, Floress K, Arbuckle JG, Church SP, Eanes FR, Gao Y, Gramig BM, Ranjan P, Singh AS. Adoption of agricultural conservation practices in the United States: evidence from 35 years of quantitative literature. J Soil Water Conserv. 2019;74(5):520–34. https://doi.org/10.2489/jswc.74.5.520.
56. Straub ET. Understanding technology adoption: theory and future directions for informal learning. Rev Educ Res. 2009;79(2):625–49. https://doi.org/10.3102/0034654308325896.
57. IUCN response to review of youth engagement and intergenerational ... (2018). https://www.iucncongress2020.org/sites/www.iucncongress2020.org/files/iucn_youth_review_-_response_grid_-_3_sep_2021_final_issued.pdf. Accessed 5 May 2023.
58. Maynard CM. How public participation in river management improvements is affected by scale. Area. 2013;45(2):230–8. https://doi.org/10.1111/area.12015.
59. Habtezion S, Adelekan I, Aiyede E, Biermann F, Fubara M, Gordon C, Gyekye K, Kasimbazi E, Kibugi R, Lawson E, Mensah A, Mubaya C, Olorunfemi F, Paterson A, Tadesse D, Usman R, Zondervan R. Earth system governance in Africa: knowledge and capacity needs. Curr Opin Environ Sustain. 2015;14:198–205. https://doi.org/10.1016/j.cosust.2015.06.009.
60. Smith LM, Reschke EM, Bousquin JJ, Harvey JE, Kevin Summers J. A conceptual approach to characterizing ecological suitability: Informing socio-ecological measures for restoration effectiveness. Ecol Indic. 2022;143:109385. https://doi.org/10.1016/j.ecolind.2022.109385.
61. Baumgart-Getz A, Prokopy LS, Floress K. Why farmers adopt best management practice in the United States: a meta-analysis of the adoption literature. J Environ Manage. 2012;96(1):17–25. https://doi.org/10.1016/j.jenvman.2011.10.006.
62. Tey YS, Brindal M. Factors influencing the adoption of precision agricultural technologies: a review for policy implications. Precision Agric. 2012;13(6):713–30. https://doi.org/10.1007/s11119-012-9273-6.
63. Wauters E, Mathijs E. The adoption of farm level soil conservation practices in developed countries: a meta-analytic review. Int J Agric Resour Gov Ecol. 2014;10(1):78. https://doi.org/10.1504/ijarge.2014.061058.
64. Liu T, Bruins R, Heberling M. Factors influencing farmers' adoption of best management practices: a review and synthesis. Sustainability. 2018;10(2):432. https://doi.org/10.3390/su10020432.
65. de Oca Montes, Munguia O, Pannell DJ, Llewellyn R, Stahlmann-Brown P. Adoption pathway analysis: representing the dynamics and diversity of adoption for agricultural practices. Agric Syst. 2021;191:103173. https://doi.org/10.1016/j.agsy.2021.103173.
66. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, Moher D. The Prisma 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021. https://doi.org/10.1136/bmj.n71.
67. Osborne T, Brock S, Chazdon R, Chomba S, Garen E, Gutierrez V, Lave R, Lefevre M, Sundberg J. The political ecology playbook for ecosystem restoration: principles for effective, equitable, and transformative landscapes. Glob Environ Change. 2021;70:102320. https://doi.org/10.1016/j.gloenvcha.2021.102320.
68. Fischer M, Maggetti M. Qualitative comparative analysis and the study of policy processes. J Comp Policy Anal Res Pract. 2016;19(4):345–61. https://doi.org/10.1080/13876988.2016.1149281.
69. Wolfert S, Ge L, Verdouw C, Bogaardt M-J. Big Data in smart farming—a review. Agric Syst. 2017;153:69–80. https://doi.org/10.1016/j.agsy.2017.01.023.
70. Buckingham, K., Ray, S., Morales, A. G., Singh, R., Martin, D., Wicaksono, S., Chrysolite, H., Minnick, A., Johnston, L., & Arakwiye, B. (2019, October 8). *Mapping social landscapes: A guide to identifying the networks, priorities, and values of restoration actors*. World Resources Institute. https://www.wri.org/research/mapping-social-landscapes-guide-identifying-networks-priorities-and-values-restoration. Accessed 1 Mar 2023.
71. Clewell AF, Aronson J. Ecological restoration: principles, values, and structure of an emerging profession. 2nd ed. Washington, DC: Island Press; 2013.
72. Wilson SJ, Cagalanan D. Governing restoration: Strategies, adaptations and Innovations for tomorrow's forest landscapes. World Dev Perspect. 2016;4:11–5. https://doi.org/10.1016/j.wdp.2016.11.015.
73. Albertine Rift Conservation Society (2022). Communication. Kigali. Rwanda
74. Schlosberg David. The justice of environmental justice:reconciling equity, recognition, and participation in political movement. In: Light Andrew, De-Shalit Avner, editors. Moral and Political Reasoning in Environmental Practice. London: MIT Press; 2003. p. 125–56.
75. Benayas JM, Newton AC, Diaz A, Bullock JM. Enhancement of biodiversity and Ecosystem Services by ecological restoration: a meta-analysis. Science. 2009;325(5944):1121–4. https://doi.org/10.1126/science.1172460.
76. Qiu S, Peng J, Zheng H, Xu Z, Meersmans J. How can massive ecological restoration programs interplay with social-ecological systems? a review of research in the South China Karst region. Sci Total Environ. 2022;807:150723. https://doi.org/10.1016/j.scitotenv.2021.150723.
77. Thomas E, Jalonen R, Loo J, Boshier D, Gallo L, Cavers S, Bordács S, Smith P, Bozzano M. Genetic considerations in ecosystem restoration using native tree species. For Ecol Manage. 2014;333:66–75. https://doi.org/10.1016/j.foreco.2014.07.015.
78. Weidlich EW, Flórido FG, Sorrini TB, Brancalion PH. Controlling invasive plant species in ecological restoration: A global review. J Appl Ecol. 2020;57(9):1806–17. https://doi.org/10.1111/1365-2664.13656.