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Ecosystem restoration and social cohesion interlinkages: the case of Western Rwanda

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Abstract

Ecosystem restoration is widely recognized as a response to land degradation. Common approaches include agroforestry, watershed protection, and woodlots. However, ecosystem restoration is complex, with inconsistent outcomes from each approach. Although increasing attention is being given to social dimensions, the dynamics between ecosystem restoration and social cohesion vary from context to context. This study investigates the interrelations between ecosystem restoration and social cohesion for the case of Western Rwanda. Drawing on systems thinking, we explore how ecosystem restoration activities related to agroforestry, watershed protection, woodlot plantings, and homegardens interrelate with social cohesion dimensions. The results, depicted with causal loop diagrams, reveal that ecosystem restoration, depending on drivers, can produce both desired and undesired consequences. It can enhance select social cohesion dimensions – social relations, integration, shared norms and values, and collective wellbeing, as well as a sense of belonging. In turn, social cohesion can enhance ecosystem restoration ownership. However, not everything is positive. Sometimes, ecosystem restoration reinforces resource competition, marginalization, and conflicts. To avoid negative effects, policy and practice implications include co-designing ecosystem restoration with the community beyond tokenistic participation, empowering traditional institutions to resolve conflicts, aligning ecosystem restoration design with local livelihood needs, and promoting local resource sharing.

Introduction

Restoration is increasingly recognized as a critical response to global land degradation. Emerging in the 20th century, the conceptual framework for restoration has evolved over time (Martin 2017). Ecosystem Restoration is “the process of halting and reversing degradation, resulting in improved ecosystem services and recovered biodiversity” (Tedesco et al. 2023, p. 3). Adopted by the UN Decade on Ecosystem Restoration, this definition encompasses a broad range of practices tailored to local conditions and societal preferences (Dickson 2021; FAO 2025; Mansourian et al. 2025). Common restoration approaches include watershed protection, agroforestry, and woodlots (Pfeifer et al. 2023; Cho et al. 2024; Jahel and Lambin 2025).

Land degradation, understood as the decline of land quality and productivity, involves not only biophysical processes but also a complex interplay of social, economic, and political drivers (Clewell and Aronson 2012; Ceccon et al. 2015). Key drivers include poor farming practices (Taddese 2001), poverty, and inequality (Nachibi and Morgan 2025), all intensifying pressure on natural resources (Abdeta et al. 2024). These conditions heighten the risk of conflict and contribute to governance failures (Malisa et al. 2023; Tavella et al. 2025). The resulting dynamics disrupt both ecosystems and the communities that depend on them, weaken institutional capacities, fracturing social cohesion, while posing land use governance and management challenges. Thus, contemporary restoration practice has expanded to include social goals, from human well-being and livelihoods to empowering local communities (Martin 2017).

Restoration practitioners use many approaches; each associated with distinct ecological and social outcomes (Tedesco et al. 2023; da Silva et al. 2025). For example, agroforestry can enhance biodiversity (Jose 2012; Udawatta et al. 2021) and stabilize microclimates (Liu et al. 2019), while also delivering food to communities (Sari et al. 2023). One under-explored social dimension of the effects of ecosystem restoration is social cohesion (Ullah 2024). Inclusive restoration fosters social integration and positive social relations, ultimately promoting collective action and reducing conflicts (Sigman and Elias 2021; Slayi et al. 2024). Conversely, unilateral decision-making, unequal benefit distribution, and/or weak institutional support will generate social tensions, undermine local norms, and fragment community identity (Mansourian 2018; Stanturf et al. 2019; Osborne et al. 2021). Restoration outcomes are also shaped by governance arrangements, management practices, and the specific objectives guiding restoration efforts (Pfeifer et al. 2023; Cho et al. 2024; Jahel and Lambin 2025). Consequently, restoration processes often produce uncertain and context-dependent outcomes at both environmental and societal scales (Clewell and Aronson 2012; Ceccon et al. 2015).

Regardless, social dimensions are typically insufficiently addressed, even in efforts that seek to incorporate social goals (Martin and Lyons 2018; Löfqvist et al. 2022; Maniraho et al. 2023). This gap is pronounced in developing countries, where restoration governance is often top-down and narrowly focused on ecological outcomes (Djenontin et al. 2018; Swart et al. 2018). In Rwanda, for example, while restoration governance engages farmers, fragmented networks and misaligned priorities dominate (Buckingham et al. 2021). Despite decentralization policies that increase community participation (Sabbi and Ndikubwimana 2024), decision-making remains largely top-down (Umuziranenge, 2019; Ndagijimana et el. 2026). Thus, central oversight constrains local initiatives and perpetuates economic inequalities (Clay 2019; Sabbi and Ndikubwimana 2024).

This study aims to investigate the dynamics between restoration and social cohesion by examining selected restoration practices in Western Rwanda. We focus on watershed protection, agroforestry, and woodlots – the most common restoration approaches. Homegardens are included due to their higher species richness and their management by community members with minimal external inputs. We assess (1) to what extent ecosystem restoration and social cohesion mutually reinforce one another; and (2) which challenges must be overcome to strengthen further mutual reinforcement? Three questions guide our research: (1) How do restoration approaches affect social cohesion and vice versa? (2) Which restoration-related drivers hinder or promote social cohesion? and (3) How do you better design restoration interventions that enhance social cohesion? Our study advances scholarly debates on the interactions between restoration and social cohesion. It also provides empirical evidence supporting the development of policies that strengthen social cohesion and improve restoration effectiveness, while offering appropriate guidance to practitioners.

Contextual background

In 2011, Rwanda committed to restoring 80% of its land by 2030 through the Bonn Challenge (Frietsch et al. 2023; AFR100 2025), employing a range of restoration approaches with diverse outcomes. The country launched the Crop Intensification Program (CIP) to drive economic growth and transform the agriculture sector, albeit with mixed environmental and social effects (Frietsch et al. 2024). The CIP prioritized agroforestry, watershed management, and soil conservation (Kiyani et al. 2017; Rispoli et al. 2019; Buckingham et al. 2021). Although agroforestry was promoted to boost food security (Ngango et al. 2024), the expansion of monoculture woodlots and other low-diversity systems delivered only short-term gains alongside uncertain long-term ecological and

social impacts (Frietsch et al. 2024; Ndayambaje and Mohren 2011). For example, evidence suggests that crop specialization and other land-related policies have intensified conflicts over land, resulting in poverty among smallholder farmers and increased communal tensions (Leegwater, 2015). Land use and tenure reforms, alongside poor land management practices, have driven erosion and land degradation, keeping rural productivity at subsistence levels and raising the risk of future large-scale conflict in Rwanda (Musahara and Huggins 2005). Thus, Rwanda offers a valuable setting for examining the interlinkages between restoration and social cohesion, particularly regarding how each approach distinctively intersects with social cohesion.

Linking restoration approaches to social outcomes

Building on the prominence of the ecosystem restoration approaches outlined earlier, we explore their distinct effects and interrelations with social cohesion. First, watershed protection is a common restoration approach encompassing soil, water, and biodiversity across a geographic area (Wani et al. 2011). As both a hydrological and socio-political entity, it integrates land and water resources (Wani and Garg 2009; Mayer et al. 2014; Wang et al. 2016). Watershed protection enhances livelihoods by boosting income, creating jobs, and improving farm productivity (Naji et al. 2024). However, poorly coordinated management can generate disputes among stakeholders (Zerga 2025; Hensel et al. 2006; Chanya et al. 2014), reducing trust and cooperation and weakening management outcomes (Kenney 2000; Rüttinger et al. 2014). Effective watershed protection requires integrated strategies, including land-use planning, soil conservation, and community engagement supported by inclusive governance and adaptive management (Plummer et al. 2011; Wagner et al. 2002; Zuniga-Teran et al. 2022). In Rwanda, bench and radical terracing implemented through government-led programs are increasingly prominent (Uwacu et al. 2021), alongside farmer-developed soil and water conservation practices (Rutebuka et al. 2021). Some initiatives adopt integrated participatory watershed management approaches (Kagabo 2013), reinforcing community participation, cooperation, and collective action (Kayijuka 2021), which are central to social cohesion.

Second, agroforestry comprises land-use practices in which woody perennials are deliberately integrated with crops and/or livestock systems (Rodríguez et al. 2023). This long-standing restoration approach benefits both communities and the environment (Torralba et al. 2018). Socio-economic and ecological dynamics, including market forces, land access, family structures, and institutions, shape these systems (Soto-Pinto et al. 2022). Well-managed agroforestry can enhance livelihoods through food and income generation (Binam et al. 2017), reduce land degradation, provide ecosystem services (Nair 2007), and support biodiversity and climate adaptation (Rao et al. 2007). Inclusive agroforestry governance fosters community cohesion (Bezerra et al. 2019; Chavez-Miguel et al. 2022; Yusriadi 2025), whereas exclusionary governance and invasive species may trigger disputes and undermine social cohesion (Richardson et al. 2004; Sanginga et al. 2007; German et al. 2007; Llosa 2019). In Rwanda, agroforestry is promoted by government and NGOs through community-led tree planting (Mukundente et al. 2019). It improves agricultural productivity through soil conservation (Byiringiro et al. 2024; Cyamweshi et al. 2023), while supporting food security and livelihoods (Ndayambaje and Mohren 2011; Ngango et al. 2024). Farmer cooperatives also facilitate social interaction and knowledge exchange among members (Bucagu et al. 2013; Ngango et al. 2023; Ngango et al. 2024), potentially strengthening social relations within communities.

Third, woodlots are small, managed patches of trees used for timber, fuelwood, or ecological purposes, contributing to household income and livelihoods (Ndayambaje et al. 2013; Tadesse and Tafere 2017; Bailey et al. 2021). Woodlots also support ecosystem services and biodiversity (Vangansbeke et al. 2017; Nyiramvuyekure et al. 2026). Community-managed woodlots are linked to local group formation, trust, solidarity, social inclusion, empowerment, and improved information exchange (Zoysa and Inoue 2016). Similarly, community forest restoration fosters cooperation and conflict resolution through social cohesion (Ullah, 2024). However, poor woodlot management can lead to livelihood losses, poverty, inequality, and conflicts (Andersson et al. 2016; Bailey et al. 2021). In Rwanda, woodlots support livelihood diversification, fuelwood provision, and income generation (Ndayambaje et al. 2013; Mugunga et al. 2017). Yet benefits remain uneven, as access often favors households with larger landholdings (Clay and King 2019), potentially reinforcing socio-economic inequalities and trade-offs with food production.

Finally, homegardens are multifunctional, biodiversity-rich systems near homes that mimic natural ecosystems and support food security, nutrition, livelihoods, and ecosystem functions (Abdoellah et al. 2020; Sarkar et al. 2023). They also strengthen social interaction, knowledge exchange, seed sharing, cooperation, and mutual support within communities (Pulido Silva et al. 2008; Díaz-Reviriego et al. 2016). However, changes in governance and commercialization can weaken collective practices such as seed sharing (Prihatini et al. 2018). Homegardens are included in this study because they are widely practiced, horizontally organized community land use types across Rwanda (Issahaku et al. 2023), representing biodiversity-rich ecosystems (Nyiramvuyekure et al. 2026; Sun et al. 2026). While often overlooked, homegardens provide important entry points linking restoration policies with local livelihoods (Kuria et al. 2025; Nyiramvuyekure et al. 22026; van Oosten et al. 2018).

Social cohesion

We focus not just on the societal effects of restoration and social cohesion but also on how these interrelate. When looking at societal effects, we apply the concept of social cohesion: the ties or “glue” holding societies together (Burchi et al. 2025, p. 3) and a key condition for peace (building) (Brown and Zahar 2015; Löhr et al. 2021). In the early development of the concept, Émile Durkheim, Max Weber, and Georg Simmel were the first to conceptualize social cohesion (cited in Leininger et al. 2021). Scholars emphasize the key elements essential for maintaining a cohesive society. For instance, Chan et al. (2006, p. 290) define social cohesion as, “a state of affairs concerning both the vertical and horizontal interactions among members of society, characterized by a set of attitudes and norms including trust, a sense of belonging, and the willingness to participate and help, as well as their behavioral manifestations.” In this study, we use the social cohesion conceptual framework for the conflict-affected societies (Ndagijimana et al. 2026b). This multidimensional framework includes social integration (e.g., peaceful cohabitation, equality), social relations (e.g., cooperation, trust), shared norms and values (e.g., civic engagement), inclusive identity, and collective well-being (e.g., empowerment, food security). This conceptual framework is suitable for evaluating the relationships between restoration and social cohesion. The elements of social cohesion are inherently reinforcing interconnected components (Chan et al. 2006; Reeskens

and Wright 2013; Schiefer and van der Noll 2016; Leininger et al. 2021). Trust enhances participation in associations and voluntary organizations, while cooperative engagement within these spaces reciprocally strengthens trust (Chan et al. 2006; Leininger et al. 2021). Inclusive identity, trust, and cooperation likewise co-evolve, as social interactions develop and consolidate shared values, belonging, and interpersonal trust, all critical for collaboration (Leininger et al. 2021). Concurrently, active participation in public life reflects and reinforces solidarity and collective commitment to common goals (Schiefer and van der Noll 2016). Conversely, an ethnically exclusive identity diminishes trust toward outgroups, exerting a particularly strong negative effect on generalized trust (Leininger et al. 2021). For instance, an ethnically exclusive meaning to national identity is associated with roughly a halving of outgroup trust (Reeskens and Wright, 2013). These patterns underscore that social cohesion emerges from a dynamic and relational process in which multiple variables continuously interact and shape one another.

Rwanda is a post-conflict country that has undergone periods of ethnically based conflict, political instability, civil war, and genocide, during which weak natural resource governance contributed to the erosion of social cohesion (Mohamed 2003; Nat 2000). Several studies highlight the historical interplay between land policies, degradation, and conflict in Rwanda (Uvin 1996; Niaziº 2002; Moodley et al. 2010). Before the genocide, government policies restricting land sales contributed to popular discontent (Boudreaux 2009). These grievances were intensified by reliance on export-oriented crops over subsistence farming, combined with increasing land scarcity (McNab and Mohamed 2006). High population pressure caused land scarcity. This drove poverty, exacerbated by the lack of viable off-farm livelihood opportunities in rural Rwanda. Disputes over land, especially those concerning inheritance, were increasingly common (Musahara and Huggins 2005). Inequitable land distribution and tenure insecurity driven by displacement and state land redistribution, declining soil fertility, shrinking cultivable land, and family conflicts formed Rwanda's structural conflicts that, among other factors, contributed to the genocide (Uvin 1996; Niaziº 2002).

During the civil war and genocide, political elites mobilized youth by drawing on narratives of land scarcity and by exploiting pre-existing land disputes (Musahara and Huggins 2005; Boudreaux 2009; Moodley et al. 2010; Verpoorten 2012). Refugees fleeing the war and widespread internal displacement further intensified land degradation across Rwanda (Hintjens 2006). Simultaneously, social institutions responsible for managing resources and mediating conflicts collapsed following violent ethnic politics. Thus, beyond the massive loss of life and the breakdown of social cohesion, land degradation contributed to, and was intensified by, Rwanda's civil war and genocide (Moodley et al. 2010).

Case study description

Western Rwanda is particularly important in the national restoration agenda due to its complex socioecological context. The region's steep hilly topography (Karamage et al. 2016), the long-standing legacy of commercial tea cultivation since the 1960s, and intensive dairy farming have all driven land degradation (Clay 2019). The area not only hosted large refugee settlements but also experienced militia activity and insurgencies (Mills and Norton 2002; Jackson 2004; Clay 2019). These dynamics accelerated deforestation, biodiversity loss, and habitat fragmentation while further fracturing social cohesion (Bob and Bronkhorst 2010; Moodley et al. 2010; Ordway 2015). While still bearing the scars of these past shocks, the region now faces pressures from high population density, poverty, mining activities, and its landslide-prone terrain (Dawson et al. 22016; Hishamunda et al. 2024).

Rutsiro and Ngororero Districts, for example, rank among the most erosion-prone nationwide, amplifying degradation (Byizigiro et al. 2020; Macháček 2020). This has prompted both international NGOs and the government to invest in restoration. Thus, we selected six villages to study (Fig. 2): Shyembe, Karambo, and Rwamiyaga in Rutsiro; and Kabuga, Kagarama, and Bereshi in Ngororero. Across these sites, diverse restoration actors implement watershed protection, agroforestry, woodlot planting, and homegarden improvements. However, villages differ: for instance, terracing is implemented exclusively in Karambo, whereas homegardens are common across all villages. This context provides a valuable opportunity to examine the causal dynamics of distinct restoration interventions on social cohesion.

Methodology

System dynamics and causal loop diagrams

Our assessment uses a systems thinking approach for analyzing feedback within complex system interactions (Haraldsson 2004; Elsawah et al. 2017; Hanger-Kopp et al. 2024). Specifically, we employ causal loop diagrams (CLDs) to visualize system behavior and feedback relationships, illustrating how changes in one component influence others, shaping overall system outcomes (Haraldsson 2004). In restoration, CLDs illustrate interactions between ecological processes and social factors, thus not only supporting the design of effective restoration strategies (Maes et al. 2024) but also enabling a deeper understanding of leverage points for targeted interventions and policy implementation (Arnold and Wade 2015; Bravo et al. 2025).

Methodological steps

Four steps were taken to examine causal relationships between restoration and social cohesion (Fig. 2): (i) One-hundred semi-structured interviews (SSIs) were conducted between February 6 and March 7, 2025, capturing individual perspectives, experiences, and contextual nuances (Kallio et al. 2016; Longhurst and Johnston 2023). Purposive sampling selected participants involved in ER activities from six villages across the two case study districts, followed by stratified sampling to ensure representation by age, gender, education, and employment status. (ii) Next, a thematic analysis identified social cohesion characteristics and their interlinkages with restoration, drivers that influence change within each restoration approach, and actors' insights into restoration governance that foster social cohesion while enhancing restoration effectiveness (Froese 2023; Ullah 2024). (iii) These findings informed the development of CLDs, which (iv) on February 17, 2026, were reviewed and refined during a participatory workshop with 45 experts, who were recruited given their expertise in restoration and social cohesion (Reed et al. 2018). Their inputs strengthened the draft CLDs' accuracy and relevance before finalization (Hanger-Kopp et al.

2024). During validation, some linkages and variables were removed, added, or reframed, while other linkages were endorsed as accurately reflecting the local context.

Semi-structured interviews were conducted in the aforementioned six villages across the Rutsiro and Ngororero districts. Using purposive and stratified sampling to ensure diversity in age, gender, education, and employment, a total of 100 farmers aged at least 21 were interviewed between February 6 and March 7, 2025. Participants were drawn from Rwamiyaga, Karambo, and Shyembe in Rutsiro District (60% women and 40% men); from Kabuga, Bereshi, and Kagarama in Ngororero District (58% women and 42% men). Among all respondents, 79% completed primary education, 75% worked in agriculture, and 37% had been involved in restoration activities for 5–10 years. Interviews explored: (1) participants' understanding of social cohesion; (2) whether, in their experience, restoration is linked to social cohesion and how respective approaches may hinder or promote it; (3) restoration-related drivers that influence social cohesion and how good community relations influence restoration interventions; and (4) recommendations for designing restoration initiatives that strengthen community cohesion. The questionnaire was translated from English into Kinyarwanda, and each interview, conducted voluntarily in the local language upon informed consent, lasted approximately 90 minutes. Four trained local enumerators carried out the interviews, combining detailed notetaking with audio recording to ensure accurate documentation.

Following translation from Kinyarwanda to English, interviews were imported into MAXQDA for analysis (Kuckartz and Rädiker 2019). Thematic qualitative analysis (Terry et al. 2017) with inductive coding was applied, allowing codes to emerge from the data rather than using predefined categories (Oliveira et al. 2016; Rogers 2018). Analysis involved familiarization with transcripts, open coding, and grouping related codes into categories and themes, supported by memos for reflections. The unit of analysis was text segments, which were iteratively compared across interviews. This process generated 17 characteristic codes for watershed protection, 19 for agroforestry, 17 for woodlots, 12 for homegardens, and 33 for social cohesion, alongside 36 drivers that foster social cohesion. From these, variables were identified to construct the diagram for each subsystem. Variables were selected based on their relevance to the subsystem model, consistent with the model's purpose and the dynamics of the interactions of interest (Elsawah et al. 2017).

To construct the diagrams, we first analyze each restoration approach and social cohesion independently, documenting all causal relationships among the variables identified by participants. We then examined how each restoration approach interacts with social cohesion, specifying the variables through which these linkages occur. Additionally, we mapped the causal relationships embedded in the farmers' recommendations that promote social cohesion. After all possible loops were identified, we sketched the diagrams, including main interactions and built CLD models using Vensim® PLE software. Draft CLDs represented a larger view of the questions being addressed. Arrows represent relationships, originating from the causal variable, pointing toward the effect variable. Following Sterman (2000), we used a minus (–) sign to indicate variables moving in opposite directions; signs for variables moving in the same direction are omitted. The balancing loop (B) stabilizes the system by counteracting change, whereas the reinforcing loop (R) amplifies change (Haraldsson 2004; Meadows 2008). Red bold arrows denote balancing feedback loops and black bold arrows denote reinforcing feedback loops. Bolded variables indicate key system drivers. Italicized, boxed variables represent social cohesion dimensions and bold italicized variables within boxes denote the restoration approach.

Draft CLDs were presented during the February 17, 2026, validation workshop held in Kigali, Rwanda. Conducted in English, it lasted approximately 120 minutes. Recruited based on their expertise in restoration and social cohesion, 45 experts from NGOs, research institutions, and government institutions voluntarily participated (Reed et al. 2018). Following Del Río Duque et al. (2022), we presented the CLDs and facilitated discussion using the following guiding questions: (1) Are any key variables missing? (2) Please suggest additions or removals; (3) Are the feedback loops correctly identified? (4) Are all drivers identified? (5) Suggest driver additions or removals; and (6) Please recommend actions that could enhance not just effective restoration but also social cohesion. Each restoration approach and social cohesion CLD was printed on A0 paper. Participants were divided into four groups, with each group working on a specific draft CLD. A notetaker was assigned to each group to take notes, which were later used to refine the draft CLDs. This refinement process involved incorporating or removing suggested key variables, adjusting the relationships among variables, and revising the feedback loops. Following this validation workshop, we obtained the final CLDs for each restoration approach and social cohesion interlinkages, reflecting a shared understanding of the interlinkages between restoration and social cohesion.

Results

Agroforestry-social cohesion dynamics

We identified three reinforcing and two balancing feedback loops through which agroforestry and social cohesion dimensions interact (Fig. 3). Capacity building enhances agroforestry performance through a reinforcing feedback loop (R1). Interviewees described how agroforestry initiatives introduced by development partners have led to the establishment of farmers' extension beneficiary groups in their communities. These groups enable members to acquire skills and knowledge through various training sessions, peer-to-peer learning, and practical extension support from governmental and partner organizations' extension officers. The new skills and knowledge strengthen farmers' technical capacity with respect to agroforestry systems. Thus, improved capacity enhances the quality of agroforestry management practices, enabling farmers to address challenges that limiting agroforestry performance: inadequate pruning, inappropriate tree-crop and boundary spacing, and poor management of agroforestry trees.

Community conflicts, peaceful cohabitation, and the misappropriation of agroforestry produce are interlinked through a negative reinforcing feedback loop (R2). As some interviewees noted, occasional disputes arise between families due to limited access to resources such as seedlings, fruits, fodder and wood products (stakes, firewood and timber). Thus, some community members steal these from neighboring farms, undermining peaceful cohabitation. While improved management practices are reported to improve agroforestry performance, disputes are still reported. These disputes stem from crop damage associated with inadequate pruning or tree harvesting, livestock straying onto neighboring plots and damaging crops or young trees, as well as land

encroachment due to inadequate tree-crop spacing along farm boundaries. Conversely, interviewees observed that where peaceful cohabitation is strong, such conflicts occur less frequently.

Likewise, community conflicts interlink with civic engagement, cooperation, trust, social relations, as well as shared norms and values through a negative reinforcing feedback loop (R3). In this dynamic, rising community conflicts weaken civic engagement and cooperation, eroding trust and undermining social relations. Conflicts also undermine shared norms, like participation in collective work or community meetings. As these social cohesion dimensions deteriorate, the community's capacity to collectively resolve conflicts declines, thus reinforcing communal conflicts. For example, Interviewee (KGR8) revealed he cannot attend government meetings because of an unsettled disagreement with a neighbor. He insisted he must not attend any meeting until the issue is resolved, especially if he knows the neighbor will also be there.

Interviewees noted that some community members, particularly remote households, face barriers accessing agroforestry seedlings as nurseries are typically near tarmac roads, making it difficult for farmers living farther away to obtain planting materials. This reinforces feelings of spatial marginalization, limiting opportunities for socioeconomic improvement, collective wellbeing, and sense of belonging among these households. In this dynamic, socioeconomic improvement, collective wellbeing, and sense of belonging counteract spatial marginalization through a balancing feedback loop (B4). Overall, interviewees and workshop participants both concluded that embedding equity into an agroforestry system can reinforce community participation, potentially reducing competition over resources (B5).

The government should involve the community in discussions about suitable locations for tree planting. Additionally, it is important to establish tree nurseries close to the communities, so that people can easily access tree seedlings without difficulties and have the freedom to plant the species they choose. This will promote active participation in the restoration efforts (Interview SHY15).

Watershed protection-social cohesion dynamics

Our analysis identifies five reinforcing and one balancing feedback loops linking watershed protection with different dimensions of social cohesion (Fig. 4): a reinforcing feedback loop is evident with watershed protection initiatives interacting (Fig. 4, R1). Terracing activities create employment opportunities – particularly for financially marginalized families – thus reinforcing collective wellbeing. Government efforts to reduce poverty through other existing development programs, such as *Ubudehe* (social protection program) and the Vision Umurenge Program (poverty reduction program), are enhanced. These programs foster community trust in government, also encouraging community participation and ownership of government-led watershed initiatives.

Likewise, watershed protection, social integration and shared norms and values are each reinforced via a positive feedback loop (Fig. 4, R2). Interview respondents noted they earn income from terracing projects, then pay community health insurance and school fees, thus increasing their feeling of village life participation and community integration. Integrated community members are likely to engage in collective responsibility, fostering collective action. Thus, respondents stress that when they feel integrated in the village, they feel like engaging in collective activities like community work and watershed protection. Simultaneously, a positive feedback loop reinforces social integration and the sense of belonging (Fig. 4, R3). Some respondents explained that active community involvement enhances their feeling of belonging, encouraging them to contribute further.

A positive feedback loop interconnects trust in institutions, cooperations, and social relations (Fig. 4, R4). Respondents noted that regular meetings concerning terracing initiatives facilitate the ability to directly communicate concerns with leaders. When concerns are handled effectively, community members have increased confidence in governmental institutions. Ultimately, institutional trust enhances civic engagement. Civic engagement and community participation facilitate a positive feedback loop (Fig. 4, R5). As respondents express, they are more committed to government initiatives if their concerns are resolved:

As we work together on watershed protection projects, relations among community members and with the state become stronger. This continued cooperation builds trust between us and with institutions, making it easier to implement these projects effectively (Interview BRS05).

Despite reported benefits of watershed protection, a trade-off between terracing and land availability is revealed (Fig. 5, B6). While some respondents emphasize terracing projects' benefits, others observe that the expansion of these initiatives, which they refer to as "*government terraces*," further exacerbates the land scarcity problem by reducing available land for other agricultural purposes, such as animal fodder production. They also voice minimal involvement in decision-making over the selection of these terracing sites, which reinforces their perceptions that these projects are primarily government-owned initiatives.

Woodlot-social cohesion dynamics

Woodlot and social cohesion dimensions interact through two reinforcing and three balancing feedback loops (Fig. 5). For instance, Fig. 5 (R1) illustrates a reinforcing feedback loop between woodlots and social relations: respondents explained that woodlots provide essential wood products for cooking, construction, farming, and local infrastructure development. These products are often shared or sold among community members, particularly those without their own woodlots. These exchanges also include practices such as collecting firewood from neighbors, particularly by poorer families. Labor and knowledge are shared, ultimately enhancing social relations via increased social interactions and strengthened ties (e.g., friendships) between households. These social relations support woodlot development and management through traditional knowledge sharing between families alongside local labor provision.

Woodlots improve our social relations by providing construction materials that we share with those in need. As woodlots increase, sharing also increases, which strengthens solidarity and, over time, builds cooperation and trust among community members. As a result, our social relations continue to improve (Interview SHY29).

Woodlots and access to financial resources also show a reinforcing feedback loop (Fig. 5, R2). Some respondents noted wood products generate income via the sale of charcoal, timber, and stakes. Similarly, workshop participants noted woodlots are used as collateral for bank loans. Participants added that woodlot establishment and management is an investment requiring financial resources to cover costs related to labor, seedlings, plot preparation, timber harvesting, and charcoal production.

However, woodlot management is critical, whether balancing disputes around woodlot establishment or its effects on household agricultural land and cropping area (Fig. 5, B3). Respondents noted woodlots reduce household land size and are typically established by households with sufficient resources. Land size, including the area designated for crop production, significantly influences the quality of husbandry practices. Households with more land can implement better practices, such as establishing woodlots on marginal soils away from the cropping area, maintaining adequate distance from crop areas, and spacing trees appropriately. Well-maintained woodlots reduce crop damage during harvesting and prevent neighboring land encroachment, both common sources of disputes among community members. Disputes constrain cooperation, limiting woodlot development.

Establishing woodlots on non-designated land could lead to disputes (Interview KRB3).

Failing to leave the 15-meter buffer distance between the woodlot plantation and your neighbor's farmland can lead to conflicts between neighbors because when the trees are cut down, they may damage your neighbor's crops (Interview RWM19).

As Fig. 5 (B4) shows, land size, livelihoods, socioeconomic improvement, and poverty interact through a balancing feedback loop. As our analysis reveals, larger land size is associated with reduced family conflicts, as households with sufficient landholding can allocate land among members, particularly children, for inheritance. Conversely, an increased number of family conflicts also increases the conflicts at the community level. Community conflicts undermine community solidarity (Fig. 5, B5). Strong solidarity reinforces shared norms and values, such as civic responsibility and dialogue, which reduces incidences of conflicts in the community.

Homegardens-social cohesion dynamics

Our analysis reveals five reinforcing and one balancing feedback loops through which engagement in homegardens and social cohesion dimensions interact. Engagement in homegardens, resource pooling, and solidarity are linked through a positive feedback loop (Fig. 6, R1). Respondents explained that households share knowledge and skills, including quality seed selection, composting, and pest management, to maintain homegardens. Neighbors, friends, and relatives also exchange farming tools, materials, and labor, often sharing harvested produce. This resource pooling strengthens solidarity among community members, thus improving all homegardens.

Homegardens also interact with social relations through three positive reinforcing feedback loops (Fig. 6. R2, R3 and R4). First, homegardens enable nutritious food production, increase food security, and reduce incentives for individuals to steal crops from their neighbors. These dynamics reinforce not just social relations (trust and interactions) but also cooperation around homegardens establishment and maintenance.

Further, healthy food production combats malnutrition, diseases, and childhood stunting. Some respondents associated healthy children's development with school attendance, stressing that healthier children are better able to resist illness, attend school more regularly, and demonstrate positive behavior. This makes kids less likely to engage in antisocial behaviors, ultimately contributing to fewer communal conflicts. Community conflicts undermine social relations by reducing interactions, thus weakening trust and cooperation, all crucial for resource pooling and homegarden maintenance. Homegardens interact with a sense of belonging through a positive feedback loop (Fig. 6, R5). Respondents also explained that they sell part of their harvest, raising funds to pay for Rwanda’s mandatory mutual health insurance scheme. By contributing to this scheme, they feel more belonging to the Rwandan society, thus motivating further investment in homegardening.

Interviewees viewed the external support as driving community civic engagement and social relations, with respective actors collaborating to improve productivity through provision of extension services and subsidized inputs. While homegardens, social relations, and solidarity are linked through positive feedback loops, some respondents indicated that homegardens are associated with land fragmentation to meet family members' inheritance, family members’ subsistence, and livelihood needs (Fig. 6, B6). This fragmentation is often coupled with family disputes and land productivity reduction.

Discussion and implications for policy and practice

Overall, our findings indicate tremendous potential for mutual positive reinforcement between ecosystem restoration and social cohesion, albeit with the risk that the same feedback can be negative. In the following, we discuss (1) implications for policy and practice of co-designing ecosystem restoration with the community, beyond superficial participation; (2) the importance of harmonizing ecological goals with local livelihood needs; (3) integrating traditional institutions into restoration for conflicts resolutions; and (4) promoting local resource pooling for restoration resilience.

Participation beyond tokenism

Our findings suggest positive effects of community empowerment on agroforestry performance (Fig. 3, R1) and employment opportunities on social integration, sense of belonging, as well as shared norms and values supporting collective action in watershed protection (Fig. 4, R2–R3). However, minimal community participation in the decision-making process over restoration design and implementation led to some community members being marginalized, intensifying resource competition, conflicts, and social inequalities while constraining peaceful cohabitation and civic engagement (Fig. 3, R2, R3, B4–B5).

Implementing agroforestry through farmer extension groups strengthened farmers’ skills and improved agroforestry performance (Fig. 3. R1). This aligns with evidence from Uganda and Kenya, where integrating capacity building into restoration enhanced farmers’ skills and implementation capacity (Shames et al. 2016). However, community members reported limited involvement in decisions regarding tree nursery locations and species. Thus, remote households

experienced reduced access to seedlings, which increased social inequalities. Competition for seedlings often led to heightened conflicts, constraining peaceful cohabitation and diminishing community civic engagement (Fig. 3, R2, B4–B5). Consistent with earlier studies, poor supply systems for planting material and long travel distances further constrain access for remote households, thereby reinforcing existing social inequalities (Bertin et al. 2012; Larson et al. 22007; Lillesø et al. 2011).

Terracing initiatives generated employment opportunities for financially marginalized community members, allowing them to earn income and engage in community activities, while reinforcing not just their sense of belonging but also shared norms and values (Fig. 4, R1–R2). Our findings align with evidence that restoration initiatives like terracing not only create employment and income opportunities (Curtain 2008; Pretty and Shah 1997; Rafael 2023) but also foster social integration, shared values, and a sense of belonging (Zoumides et al. 2025; Zoumides et al. 2017). While the community participation in selecting sites for government-led terracing initiatives remained limited, official accounts portray citizens as central to policy and decision-making (Hasselskog and Schierenbeck 2015; Sabbi and Ndikubwimana 2024; Rwanda Governance Board [RGB] 2026). Simultaneously, this points to a gap between formal commitments and practice, underscoring the need for more inclusive governance mechanisms (Umuziranenge 2019). Lack of community involvement in the design and maintenance of terraces is not just generally associated with social disruption but also further intensifying land degradation (Pretty and Shah 1997; Tarolli et al. 2014).

Participatory planning and increased supply of planting materials were recommended as critical drivers for addressing seedlings access barriers, thereby reducing spatial marginalization, decreasing competition, and mitigating related conflicts (Fig. 3, B4–B5, R2). Furthermore, the inclusive selection of terracing sites can enhance community participation, reinforcing civic engagement (Fig. 4, R6). Studies show that participatory planning can effectively address competition among diverse stakeholders by facilitating joint intervention development and shared decision-making regarding resource allocation (Koutsovili et al. 2023, Zachrisson et al. 2021). This reinforces inclusion, reduces potential conflicts, and enhances restoration effectiveness (Löfqvist et al. 2023, Menzel et al. 2013). Equally, equitable access to planting materials and control over distribution by the community can reduce marginalization (Edwards et al. 2021, Fleischman et al. 2022, Löfqvistet al. 2023, Singh et al. 2021). Participatory land-use planning fosters local ownership, supports collective action, and improves the sustainability of restoration efforts (Mansourian 2016, Palmer et al. 2022).

Given that trust, cooperation and equity are often fragile in post-conflict contexts (Colletta and Cullen 2002, Fiedler 2023, Metcalf et al. 2015), meaningful participation requires deliberate efforts to strengthen community capacities. Thus, capacity building enables communities to effectively engage in, and influence, decision-making (Ndagijimana et al. 2026; Reed 2008). Ndagijimana et al. (2026) further highlight the need for specific quotas for community representation across all decision-making platforms to ensure full community representation.

Harmonizing restoration with local livelihood needs

Our findings indicate that livelihoods are situated at the intersection of ecosystem restoration and social cohesion, with the potential to either strengthen or weaken both. The four restoration approaches produced different types of livelihoods, each with implications for social cohesion. For example, interviewees recommended integrating livestock into terracing projects to enhance household livelihoods, ultimately strengthening their ownership of these initiatives (Fig. 4, B2). Institutional trust, cooperation, and social relations are consequentially fostered (Fig. 4, R5). Consistent with several studies, agro-environmental integration helps farmers manage trade-offs (Paul et al., 2022), strengthens economic resilience (Ali and Eunice, 2025), and improves income and food security. It also fosters trust, cooperation, and conflict resolution within communities (Alba-Patiño et al., 2021; Davids et al., 2021; Ullah, 2024). Such an alignment further reinforces restoration ownership and long-term sustainability (Erbaugh and Oldekop 2018, Ullah 2024). Furthermore, livelihoods are associated with socioeconomic status, poverty, and conflicts reduction (Fig. 5, B5), subsequently reinforcing shared norms and values (Fig. 5, B4) and sense of belonging (Fig. 6, R5). In post-conflict contexts, effective land use is associated with peacebuilding and social cohesion (Löhr et al. 2021).

However, unequal distribution of benefits undermines social cohesion and diminishes the effectiveness of restoration initiatives. For example, misappropriation of agroforestry produce, community conflicts, and peaceful cohabitation are interconnected through a negative feedback loop (Fig. 3, R2). Similarly, homegardening participation is limited by land availability, which is associated with family conflicts (Fig. 6, B6). Studies demonstrate that tensions arise when restoration benefits are not equitably distributed within communities (Asante-Antwi et al. 2025; Dyer 2023; Turner 2004). In Rwanda, land scarcity, rapid population growth, and slow growth of non-agricultural jobs have long caused tensions, even within families (André and Platteau 1998; Leegwater 2015; Rukema and Khan 2018).

Aligning ecological and livelihood objectives is critical when designing restoration initiatives. For example, Duguma et al. (2025) argue that prioritizing livelihoods is fundamental for effective ecological restoration. Codesigning restoration ensures all stakeholder needs are considered. Achieving this requires adopting a multifunctionality approach to restoration (Jay and Plieninger 2025, Pasgaard and Fold 2024). However, while land use planning policies exist, evidence shows that restoration is often emphasized at the expense of agriculture (Buckingham et al. 2021, Tuyizere et al. 2025, van Oosten et al. 2018). Therefore, revising and aligning these policies could enable restoration and agriculture to coexist, thus advancing together (Banerjee et al. 2020; van Oosten et al. 2018). Increased external support, such as extension services and subsidized inputs, can significantly enhance homegarden productivity. Evidence shows that access to extension services and inputs increases homegarden participation and output (Galhena et al. 2013, Issahaku et al. 2023). However, the economic sustainability of homegardens remains at risk due to market instability and the vulnerability of these agro-ecosystems (Pulido Silva et al. 2008).

Integrating traditional institutions for conflict resolution

Social relations improved through different restoration approaches. However, conflicts frequently arose at family and community levels during implementation, underscoring the necessity of enhancing conflict resolution mechanisms. The integration of livestock into terracing (Fig. 4, R4), sharing wood products (Fig. 5, R1), and food security (Fig. 6, R2) can not just enhance social relations but also improve watershed protection, engagement in woodlots, and homegardens. However, inadequate agroforestry management, product misappropriation (Fig. 3, R2), and boundary encroachment (Fig. 5, B3) disrupt peaceful cohabitation, potentially triggering disputes. Consistent with Takeuchi (2011), conflicts remain an inherent part of restoration processes.

This is especially true not just where resource access is unequal, but distribution systems and land governance are not equitable (Haase 2024, Ide 2015, Reuveny and Maxwell 2001, Schneider et al. 2020, Vesco et al. 2020).

Workshop participants recommended inclusive, traditional community mediators to enhance conflict resolution in agroforestry initiatives. Traditional institutions are common across many African traditions (Emborg 2007, Martha 2012). Locally embedded, culturally legitimate, and accessible to community members (Shyaka et al. 2016, Tangwe et al. 2023), they have the potential to handle conflicts originating from restoration implementation. Historically, in Rwanda, community mediators were trusted individuals, communally chosen to intervene in conflicts such as land-related family conflicts – thus promoting peace, unity, and reconciliation (Bognitz, 2018; Tangwe et al., 2023).

Although the government reintroduced community mediators, they have not just limited legal capacity (Martha 2012, Tiemessen 2003) and excessive workloads, but there are also insufficient mediators and resources (Landesa 2013). Their voluntary service (Tangwe et al. 2023) is also vulnerable to corruption and bias (Bognitz 2023). If empowered in legal matters, trained in mediation, and given more resources, Abunzi could address restoration-related conflicts, ensuring both effective restoration and social cohesion.

Resource pooling for resilient restoration

"Resource pooling" is our term for traditional practices involving social learning, skill sharing, tools, labor, and harvested produce, resources for which local community members both contribute to and draw upon. It enhances solidarity and engagement in homegardens (Fig. 6, R2). In contexts like Rwanda, where inter-generational transmission of traditional knowledge and skills was disrupted by genocide, these practices are essential for the resilience of restoration (Colletta and Cullen 2002; Masengesho et al. 2025; McDoom 2014). Transfer of traditional knowledge helps communities adapt to socio-ecological changes, improving the long-term sustainability of their livelihood strategies, and fostering social–ecological resilience (Haq et al. 2023). It also supports the conservation of indigenous tree species and their traditional use (Irakiza et al. 2016). Latin America studies show that such knowledge is unevenly distributed across gender and age groups (Pulido Silva et al. 2008). For instance, women demonstrate more knowledge not just in selecting useful food, medicinal, and ornamental species but also managing herbaceous plants and propagating commercial plant species (Howard 2006). By contrast, men manage agriculture parcels (Voeks 2007) and have greater knowledge of woody species and those destined for sale (Schneider 2004). Knowledge also increases with age (Voeks 2007). From a social perspective, resource pooling enhances socializing, and community solidarity (Pulido Silva et al. 2008; Esteves et al. 2021), while promoting collective action (Poteete and Ostrom 2004, Pretty and Ward 2001). Homegarden-based activities also strengthen social capital (Musavengane and Simatele 2016, Pretty and Ward 2001) and improve the community's ability to address challenges and conflicts that could hinder restoration activities (Agrawal 2001, Reed et al. 2018). Collectively, these are vital for the long-term sustainability of restoration initiatives.

From a socioeconomic perspective, our findings show that community members supported each other through harvest and product sharing, helping members cope with the effects of erratic rainfall and crop failures. Households also engage in labor exchange, knowledge transfer, and skill sharing, all carrying significant economic value and critical for restoration resilience. Studies suggest that labor exchange, knowledge transfer, and skill sharing, foster interaction, socialization, and community solidarity (Pulido Silva et al. 2008; Esteves et al. 2021), while enabling collective action (Poteete and Ostrom 2004; Pretty and Ward 2001). These dynamics strengthen social capital (Musavengane and Simatele 2016; Pretty and Ward 2001) and enhance communal capacity to manage challenges and resolve conflicts that could otherwise hinder restoration efforts (Agrawal 2001; Reed et al. 2018). Shared local resource management enhances livelihood diversification and strengthens rural resilience against climate and market shocks (Pretty and Ward 2001; Razanatsoa et al. 2021). Homegardens activities and their related workforce generate economic benefits that are not typically captured by conventional productivity metrics yet remain essential for economic sustainability (Pulido Silva et al. 2008). Resource pooling within these systems reduces individual risks and transaction costs, enabling community members to access affordable services, inputs, and harvest products from within their community, thereby fostering participation in restoration initiatives (Adde 2018; Manlosa et al. 2020.pp103-104; Scoones 1998; Wilson et al. 2012).

From an environmental perspective, this study finds that permitting community members, especially children from financially marginalized families, to collect firewood from their woodlots enhanced collective monitoring of these resources. Existing research similarly demonstrates that community access to forest resources, including private woodlots, not just strengthens collective stewardship (Bailey et al. 2021; Djoudi et al. 2024) but also supports ecological performance and long-term recovery (Ros-Tonen et al. 2018). Facilitating resource pooling can improve livelihoods and restoration resilience by strengthening social cohesion, economic capacity, and stewardship. Policymakers and practitioners should integrate local resource-sharing mechanisms into restoration strategies to strengthen resilience capacity of restored ecosystems.

Conclusion

This study provides valuable insights regarding interrelations between ecosystem restoration and social cohesion, highlighting how both can produce desired and undesired consequences. Restoration activities can promote social integration, strengthen social relations, improve collective wellbeing, and reinforce shared norms, values, and a sense of belonging, thereby enhancing social cohesion. Conversely, social cohesion can increase the effectiveness of restoration efforts by fostering ownership, facilitating collective monitoring of initiatives, as well as encouraging civic engagement and community participation. Restoration and social cohesion often reinforce each other, provided that key challenges are carefully managed.

We draw four key recommendations. First, policymakers and practitioners should move from tokenistic participation to co-designing ecosystem restoration. Second, it is vital to harmonize ecological goals with local livelihood needs. Third, integrate traditional institutions to resolve conflicts around restoration implementation. Fourth, local resource pooling must be emphasized for the long-term sustainability of restoration initiatives and resilience. Future research should explore how policy can support local resource-pooling practices to strengthen restoration resilience and identify ways to align restoration with livelihood needs in densely populated, land-scarce contexts. Equal attention to ecological and social cohesion outcomes is essential for long-term sustainability.

Declarations

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Data availability

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Author contributions

Conceptualization and methodology: Valery Ndagijimana, Katharina Löhr, and Luis Schlindwein; investigation, formal analysis, and original manuscript drafting: Valery Ndagijimana; review and editing: Katharina Löhr, Luis Schlindwein, Joern Fischer, and Stefan Siber; supervision: Katharina Löhr, Joern Fischer, and Stefan Siber; funding acquisition and project administration: Katharina Löhr.

Declaration of conflicts of interests

No potential conflicts of interest are reported by the author(s).

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Figures

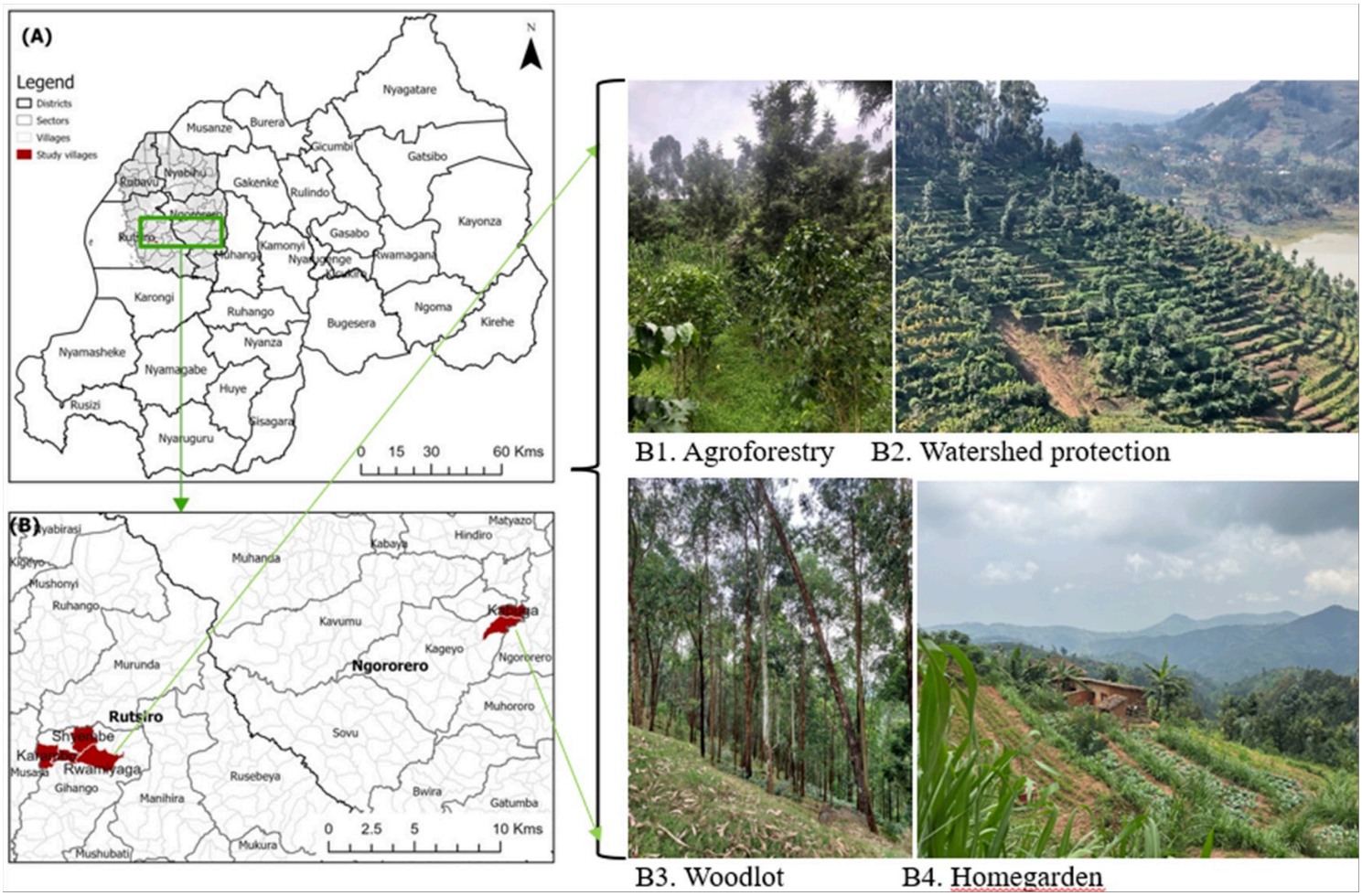


Figure 1

Map of study villages and images of key restoration practices implemented in the study area.

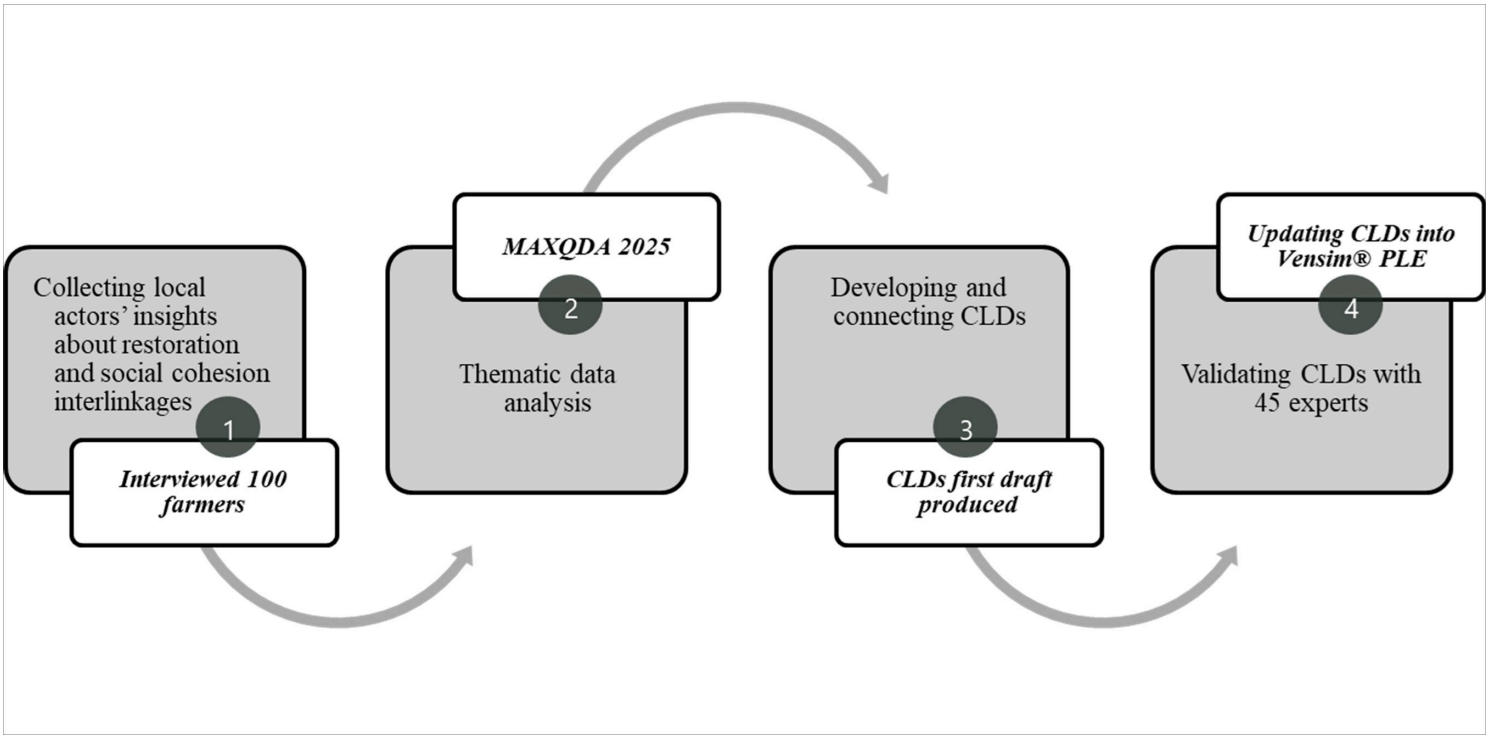


Figure 2

Steps to evaluate causal relationships between restoration and social cohesion.

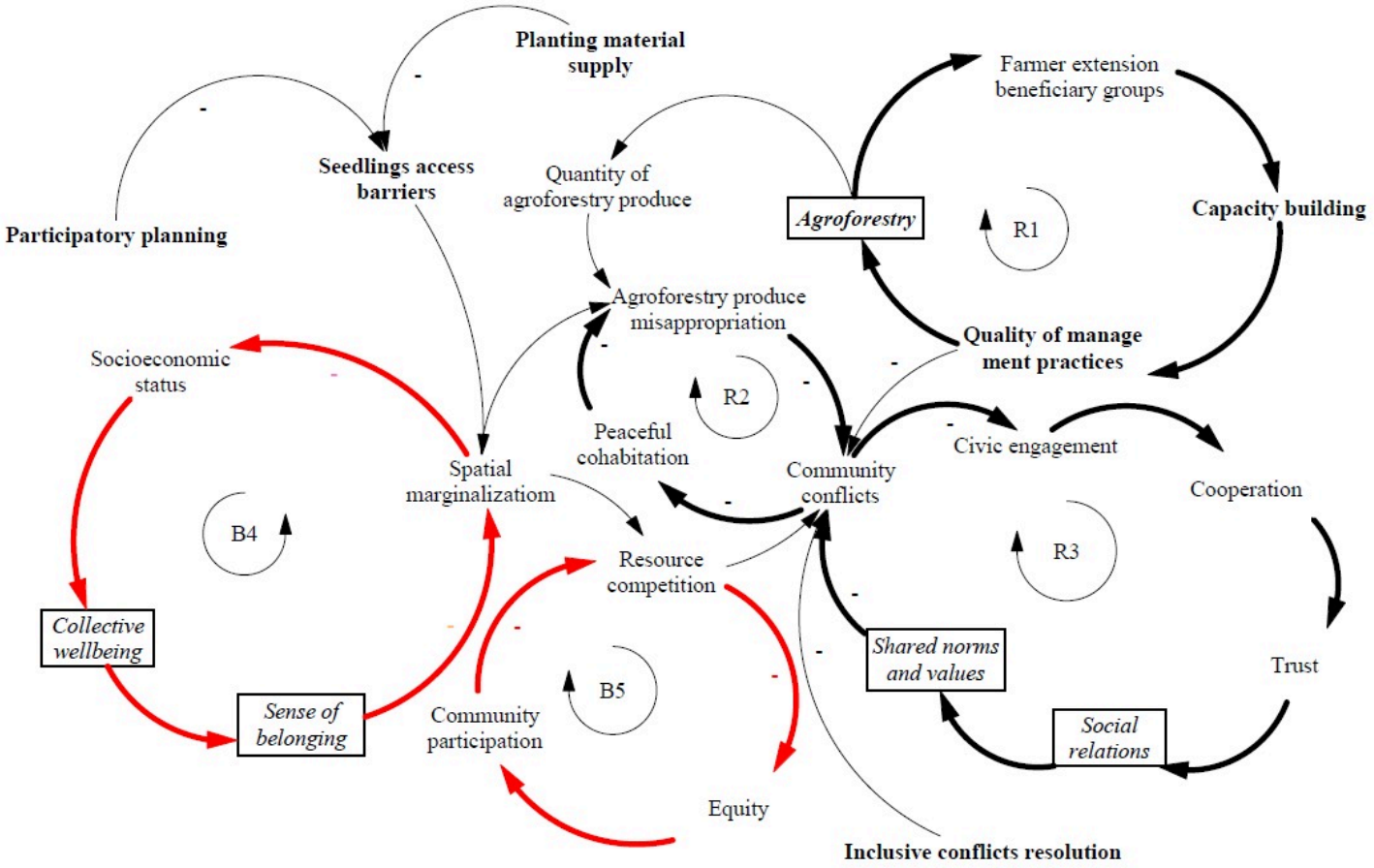


Figure 3

Feedback loops illustrating the interactions between agroforestry practices and dimensions of social cohesion.

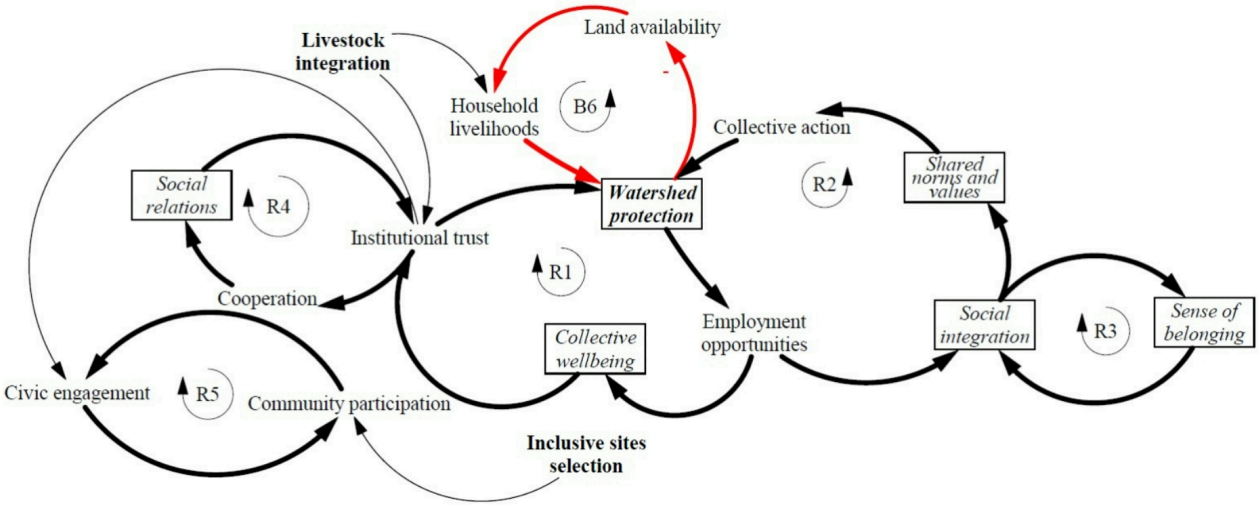


Figure 4

Feedback loops illustrating interactions between watershed protection and social cohesion dimensions.

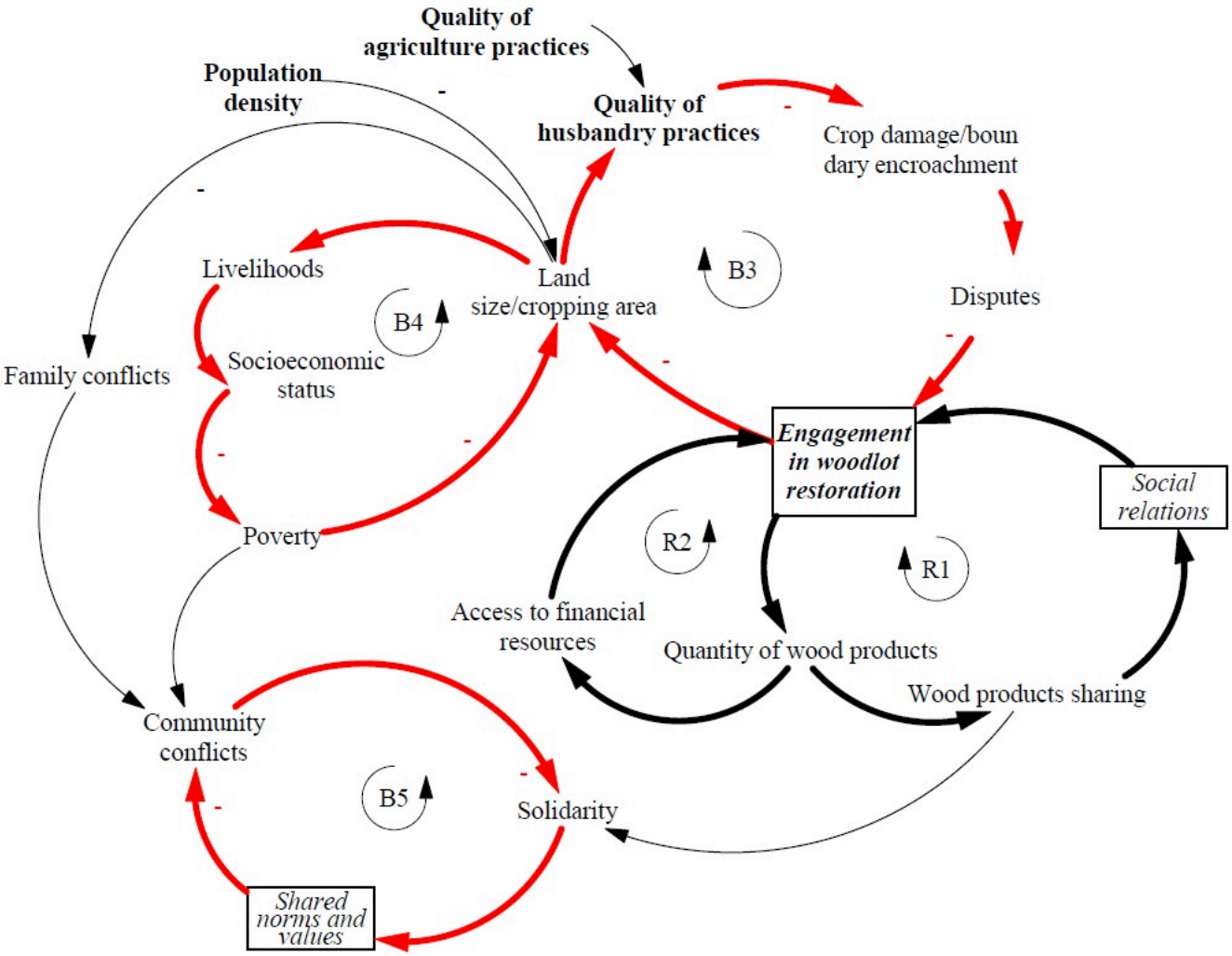


Figure 5

Feedback loops illustrating the interactions between the woodlot and the dimensions of social cohesion.

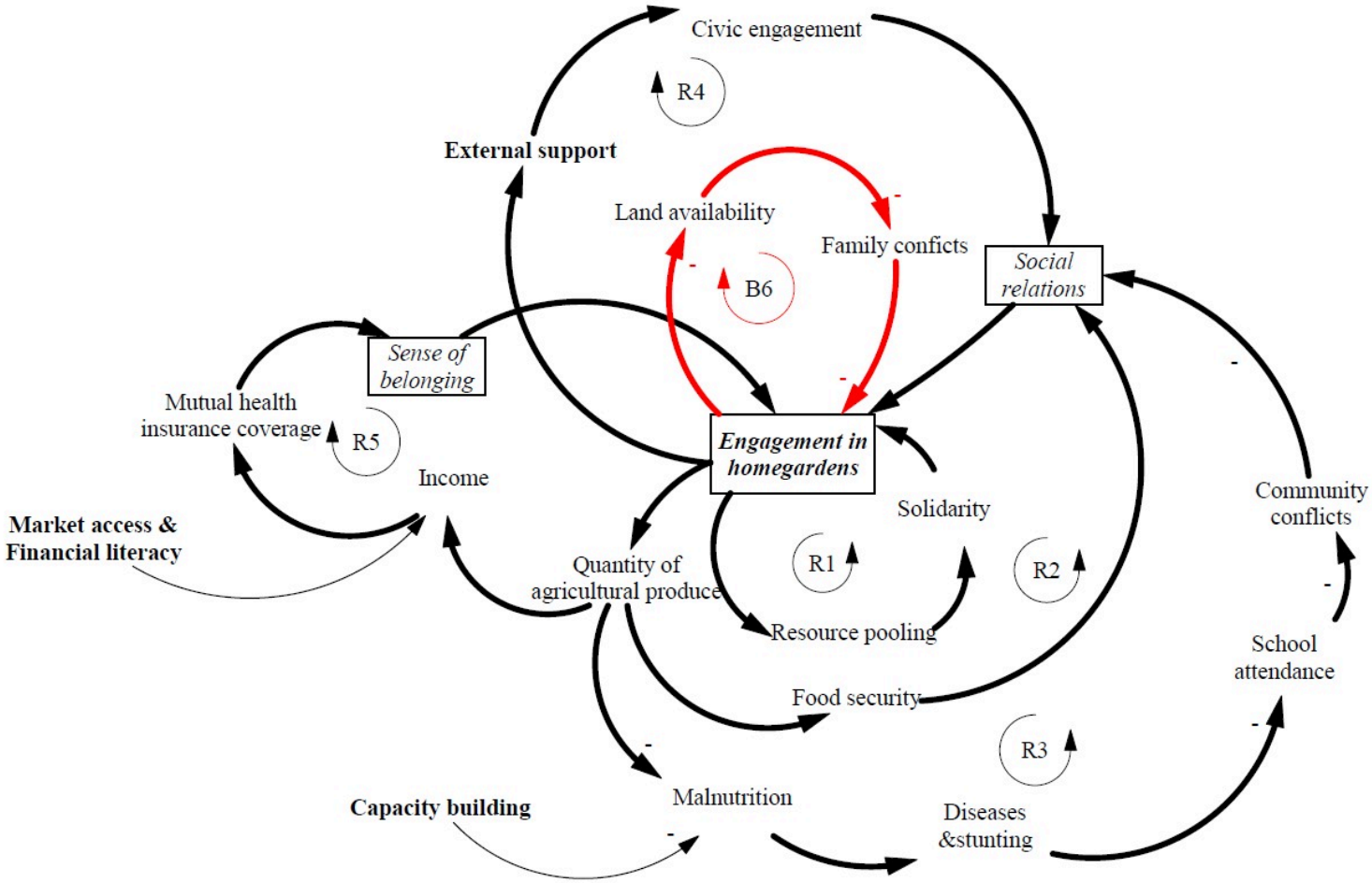


Figure 6

Feedback loops illustrating the interactions between homegardens and social cohesion dimensions.