

Contents lists available at ScienceDirect

Environmental Science and Policy



journal homepage: www.elsevier.com/locate/envsci

Factors influencing stakeholder interaction patterns in Forest Landscape Restoration: The role of institutional and organizational proximity

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ARTICLE INFO

Keywords: Social network analysis Stakeholder engagement Network structure Proximity Forest landscape restoration

ABSTRACT

Forest Landscape Restoration (FLR) relies on stakeholder engagement and participatory governance. However, understanding stakeholder dynamics remains limited. To address this, we applied social network analysis to assess how institutional and organizational proximity influence network formation within Forest Landscape Restoration (FLR) initiatives in Ethiopia and Madagascar. We used Net-Map to collect relational data from 202 interconnected stakeholders in Ethiopia and 85 in Madagascar. The igraph R package was used for network visualization and descriptive analysis, while the Exponential Random Graph Model (ERGM) was applied to identify factors influencing network formation. Our study shows imbalances in stakeholder participation between the two countries: Ethiopia's network is led by knowledge hubs, while Madagascar's is dominated by international NGOs with substantial funding, ERGM results reveal Ethiopia's network is more inclusive, whereas Madagascar's is concentrated among NGOs and government entities. Institutional proximity significantly influences network formation, while organizational proximity does not. Both countries have centralized networks, with stakeholders connecting to influential actors to build bridging trust. Additionally, high collaboration levels are observed, as stakeholders with shared partners often form connections, which fosters bonding trust. We conclude that forest landscape restoration relies on two key factors: academic knowledge and funding. Our findings highlight the need for more inclusive FLR networks, as current structures are dominated by research institutions and international NGOs, limiting local community participation. While institutional proximity shapes FLR efforts, balancing centralization with inclusivity is crucial for fostering collaboration, resilience, and longterm sustainability.

1. Introduction

Forest landscape restoration (FLR) emerged as a global strategy to rehabilitate and restore degraded forests and surrounding landscapes to their natural state, benefiting both the environment and communities that rely on these ecosystems (Boedhihartono and Sayer, 2012). The concept has gained increasing importance since the global push towards restoration through the Bonn Challenge and the New York Declaration (Bolte et al., 2023). Here multiple actors from global to local scale jointly implement various projects to reach national pledges to restore 350 million hectares globally (Pistorius and Freiberg, 2014; Wolff et al., 2018). In the case of Africa for example, 34 countries jointly committed themselves to restore 100 million hectares of degraded land by 2030 (AFR100). However, despite these global commitments, FLR implementation faces several persistent challenges, including governance complexities, competing land-use priorities, financial constraints, and

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https://doi.org/10.1016/j.envsci.2025.104112

Received 11 October 2024; Received in revised form 21 May 2025; Accepted 27 May 2025 Available online 4 June 2025 1462-9011/© 2025 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

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the difficulty of coordinating diverse stakeholders with varying interests. Stakeholder engagement is widely recognized as a fundamental principle for FLR success, as participatory governance enhances project legitimacy, ensures equitable decision-making, and fosters long-term sustainability (Mansourian, 2017; Van Oosten, 2013).

Many studies emphasize that involving multiple stakeholders is a key principle in implementing FLR (Chazdon et al., 2020; Kassa et al., 2017; Löhr et al., 2024; Sayer et al., 2013). However, the crosscutting and multidisciplinary nature of restoration involves diverse sectors and stakeholders, often bringing conflicting interests and priorities into the process (Sayer et al., 2013). These differences are often reflected in policies (Tesfaye et al., 2024), decision-making processes (Dudley, 2007), and the varied approaches to FLR implementation, creating both challenges and opportunities for collaborative restoration efforts. In this context, greater stakeholder collaboration results in more sustainable long-term restoration outcomes (Boedhihartono and Sayer, 2012). Yet, the mechanisms driving stakeholder interaction patterns within FLR initiatives remain insufficiently understood, limiting the effectiveness of collaborative governance structures.

One crucial aspect needing further exploration is the mechanisms that drive the embeddedness of stakeholders within networks associated with FLR initiatives. Understanding these mechanisms is essential for fostering complementarity among network actors, as they possess diverse skills that complement one another (Hermans et al., 2017). Social network studies offer theoretical frameworks that could explain such mechanisms that shape the dynamics of stakeholder connections (Cassi and Plunket, 2014; Mitincu et al., 2023). One proposed mechanism driving the establishment of these networks is known as the proximity effect, which suggests that stakeholders are more inclined to form connections with others who share close proximity to them (Delorme, 2023; Kabirigi et al., 2022; Lazzeretti and Capone, 2016).

The discussion on proximity has been pioneered by "the French school of proximity" since the 1990s (Bellet et al., 1993; Rallet and Torre, 1995). These researchers investigate the notion of proximity as a dialectical relationship in which territory and industry are simultaneously co-determined (Ferru and Rallet, 2016). Proximity literature, primarily explored within economic geography, defines proximity as the measure of closeness or distance between correlated entities. It acknowledges that proximity includes not only physical distance but also extends to various other dimensions (Boschma, 2005). While extensive research has examined proximity's role in fostering collaboration in industrial clusters and innovation networks, its relevance to stakeholder engagement in FLR remains inadequately explored. Existing studies have debated whether proximity consistently facilitates network formation or, conversely, whether excessive proximity can hinder innovation, a paradox that remains unresolved (Broekel and Boschma, 2011). Moreover, while scholars acknowledge that different forms of proximity interact, the precise mechanisms of these interactions and their implications for FLR governance remain unclear (Kabirigi et al., 2022).

This paper focuses on the role of institutional and organizational proximity in facilitating stakeholder interconnection within FLR initiatives for three primary reasons. Firstly, since FLR initiatives generally involve institutional actors rather than individual stakeholders, the importance of institutional and organizational proximity is especially important. Secondly, the strength and effectiveness of institutional and organizational structures are instrumental in shaping effective governance, which is crucial for the success of FLR initiatives (Mansourian and Sgard, 2021). Thirdly, while there exists extensive discourse on the correlation between effective governance and successful FLR (Mansourian, 2017), and considerable research on the influence of institutions on corporate governance (Arslan and Algatan, 2020), there remains a noticeable gap in the literature concerning how institutional and organizational structures shape stakeholder engagement in FLR initiatives. Prior research highlights the strong link between institutional and organizational proximity and network development. For

instance, Hermans et al. (2017) observed similar institutions forming connections in agricultural research, demonstrating institutional proximity's influence. Similarly, Lazzeretti and Capone (2016) noted organizational proximity significantly affects tie formation in evolving innovation networks. Drawing from proximity theory, we hypothesize that in FLR initiatives, institutions connect based on shared rules, procedures, and routines that facilitate collective actions. This suggests that both institutional and organizational proximities are influential factors in this process.

Despite the extensive literature on proximity, which offers insights into stakeholder engagement mechanisms for FLR initiatives, much of it originates from other contexts, such as industry (Heanue and Jacobson, 2001), technology clusters (Capone and Lazzeretti, 2018), and innovation systems (Lazzeretti and Capone, 2016), rather than being directly linked to FLR. Yet, FLR presents unique challenges that necessitate a closer examination of institutional and organizational proximity. Stakeholders in FLR initiatives often have diverse, and sometimes conflicting, objectives (e.g., economic vs. environmental goals), and governance challenges such as land tenure issues, decentralization, and corruption can further complicate stakeholder collaboration (McLain et al., 2021; Van Oosten, 2013). Furthermore, research has vet to adequately explore how institutional and agency mandates align with local stakeholders' needs, particularly in contexts where restoration efforts require long time horizons and must integrate multiple, sometimes competing, stakeholder perspectives (Chazdon et al., 2021). While the literature highlights the importance of institutional and organizational proximity in shaping stakeholder interactions, there remains a gap in understanding how these proximities can reform mandates for more inclusive and effective governance in FLR initiatives. Additionally, most proximity theories, particularly those related to institutional and organizational proximity, lack empirical validation, and the paradox of proximity remains unresolved and subject to ongoing debate (Broekel and Boschma, 2011; Cassi and Plunket, 2014).

To bridge this gap, we apply social network analysis on primary data about stakeholder interconnection to evaluate the impact of institutional and organizational proximity on network formation within FLR initiatives implemented in Ethiopia and Madagascar. Both countries were chosen as they are part of the AFR100 with high pledges towards FLR and multiple initiatives ongoing (Kassa et al., 2022; Slobodian et al., 2020). Additionally, research highlights stakeholder engagement as a crucial strategy for resolving governance challenges in FLR efforts in both countries (Mansourian et al., 2016; McConnell and Sweeney, 2005; Wiegant et al., 2023). Findings of this study shall support FLR activities, providing new knowledge on typical stakeholder network structures in the two countries of studies, identifying shortcomings in current network structures and discussing strategies to overcome imbalanced power structures toward more just and equal FLR. By examining the impact of institutional and organizational proximity on network formation, this study aims to provide new insights into stakeholder network structures, identify shortcomings in current collaboration patterns, and propose strategies to address power imbalances to achieve more equitable and effective FLR governance.

2. Theoretical background and hypotheses

2.1. Stakeholders in FLR networks

FLR interventions, aimed at enhancing the diversity, productivity, and resilience of landscapes, essentially should involve various stakeholders across sectors and scales. A stakeholder is someone who has the potential to influence or be influenced by an intervention (Buyucek et al., 2016). Therefore, the FLR framework operates within a dynamic and interconnected network of stakeholders, which includes governmental agencies, non-governmental organizations, local communities, indigenous groups, private sector entities, and civil society organizations, among others. Research indicates that networks inclusive of diverse stakeholders are generally more effective than those dominated by a single actor, as they benefit from the complementary skills and expertise of various participants (Hermans et al., 2017). Furthermore, an inclusive network, specifically that involving local actors, can better align with context-specific needs, as local actors provide legitimacy and a deep understanding of local contexts (Onumah et al., 2023). Given the complexity of stakeholder interaction in FLR due to its relevance and impacts from local to global scales, it is crucial for FLR efforts to include a diverse range of actors. This diversity is essential because the impact of FLR interventions extends far beyond local boundaries, influencing global challenges such as climate change mitigation and biodiversity conservation (Mansuy et al., 2020). Based on this background, we propose the following hypothesis to investigate the inclusivity of the stakeholder network in FLR initiatives:

H1a. In FLR initiatives, the stakeholder network will be inclusive, involving various categories of institutions.

Social network studies reveal that key stakeholders are assessed based on their centrality in the network (Ahmadi et al., 2019; Baek and Bae, 2019). Stakeholders who are most influential are likely to occupy central and influential positions (Zedan and Miller, 2017). The literature acknowledges that stakeholders' positions within a network, whether central or peripheral, significantly shape their impact and effectiveness (Ingold et al., 2021; Zedan and Miller, 2017). For instance, individuals providing knowledge might exert greater influence when centrally located within the network, while actors tasked with coordination may achieve optimal effectiveness by occupying brokerage positions (Baek and Bae, 2019; Iorio, 2022). Conversely, collaborators can still make significant contributions from peripheral positions. The literature also indicates an imbalance in FLR efforts, with government and international institutions often dominating the design and implementation processes (Aronson and Alexander, 2013; Van Oosten, 2013). This dominance results in top-down approaches that marginalize local communities and smaller stakeholders (Jacobs et al., 2018; Mansourian et al., 2020). Despite policies aimed at inclusivity, decision-making power frequently remains concentrated with larger institutions, sidelining local knowledge and priorities (Meli et al., 2019). Based on this background, we propose the following hypothesis to investigate who holds central positions, and who has influence:

H1b. Both government and international institutions hold central and influential positions in the network.

2.2. Governance, cooperation, and knowledge exchange in FLR networks

The literature highlights network structural properties that signify social processes fostering governance, cooperation, and knowledge exchange, such as preferential attachment (Popularity effect) and triadic closure (Cohesion effect) (Levy and Lubell, 2018). Preferential attachment, reflecting a popularity effect, indicates the tendency to form connections with influential individuals, leading to a "rich get richer" phenomenon (L. Liu et al., 2022). This phenomenon shapes network structures, with centralized networks featuring a few highly connected nodes exerting significant influence, while decentralized networks exhibit a more uniform distribution of connections (Levy and Lubell, 2018; L. Liu et al., 2022). Conversely, triadic closure, reflecting a cohesion effect, highlights the tendency for links between individuals who share mutual connections, expressing the notion that "a friend of my friend is my friend" (Bixler et al., 2020; Tan et al., 2015). Both preferential attachment and triadic closure mechanisms, commonly used in network theories, serve as potential predictors of collaboration, cooperation, and information exchange within a network (Levy and Lubell, 2018). Therefore, these mechanisms are expected to improve our understanding of effective governance driven by cooperation, collaboration, and knowledge exchange within FLR networks (Bixler et al., 2020).

FLR initiatives inherently require effective governance, a high level of cooperation, and efficient exchange of knowledge. Designed to address multifaceted socio-ecological issues and achieve long-term sustainable restoration goals, these initiatives involve a multitude of stakeholders with diverse objectives, raising questions about decision-making authority and restoration priorities (Chazdon et al., 2021). Additionally, they often operate within landscapes affected by complex land tenure arrangements and are subject to both local and global governance processes (McLain et al., 2021). As a result, within stakeholders' networks, preferential attachment and triadic closure are likely to be observed. Based on this literature background, we propose the following hypotheses:

H2a. Stakeholders demonstrate a tendency to establish connections with influential and popular actors (Preferential attachment effect).

H2b. Stakeholders with shared partners tend to have a higher probability of forming connections within the network indicating a high level of collaboration (Cohesion effect).

2.3. Tie formation as affected by institutional and organizational proximity

The proximity literature emphasizes the significant impact of both institutional and organizational proximity on tie formation within social networks (Kim, 2024; Usai et al., 2017). Organizational proximity refers to the rules and procedures that link organizations within a common framework, shaping their relationships and autonomy within these structures (Davids and Frenken, 2018). It can also involve the consolidation of knowledge and reference space, reinforced by hierarchical structures within the same organizational entity. In contrast, institutional proximity involves the convergence of institutional contexts, encompassing shared regulatory frameworks across different countries and industrial sectors (Lazzeretti and Capone, 2016). While organizational proximity governs inter-organizational relationships at the micro-level, institutional proximity facilitates the convergence of organizations through shared values and norms at the macro-level.

The operationalization of institutional and organizational proximity has posed challenges, as institutions may exhibit both forms of proximity concurrently. For instance, universities and research institutions often demonstrate both institutional and organizational proximity, given their shared institutional contexts and collaborative organizational relationships in knowledge generation endeavors. Typically, institutional proximity is quantified by shared norms, practices, and incentives, while organizational proximity is assessed through membership in the same organizational entity, such as subsidiaries or departments under the same parent company (Davids and Frenken, 2018). Given that FLR activities primarily involve institutional actors rather than individual stakeholders, it is expected that institutions and organizational frameworks play a substantial role in shaping FLR networks. Therefore, we test the following hypothesis.

H3. In FLR initiatives, stakeholders are anticipated to establish connections based on similarities in rules, procedures, and routines that facilitate collective actions.

3. Methodology

3.1. Study area

This study focuses on FLR networks in two African countries, Ethiopia and Madagascar, pledged to restore 15 and 4 million hectares accounting for 19 % of the AFR 100 pledge. The commitment by the Sab-Sharan African countries accounts for 28.6 % of the global restoration target. Fig. 1 shows geographical locations of study areas in both countries.

In Ethiopia, the study was conducted in the Lake Chamo catchment



Fig. 1. Geographical locations of study areas (source: authors).

area in southern Ethiopia. The Lake Chamo basin covers a total area of 1943 km², with the lake itself spanning 329 km² (Zebire et al., 2019). The dominant tributaries-Kulfo, Sile, and Elgo-permanently flow from the western escarpments of the lake catchment. Despite the catchment's immense ecosystem goods and services, land degradation and fragmentation have become serious challenges due to land use and cover conversions (Cholo et al., 2018; WoldeYohannes et al., 2018). Various stakeholders, including governmental and non-governmental organizations, international cooperation, community-based associations, and farmers, are currently implementing FLR interventions to restore degraded landscapes in the Lake Chamo catchment. These efforts also support Ethiopia's pledge to restore 15 million hectares. Stakeholders engaged in FLR are connected through multi-dimensional structures. For instance, Ethiopian government sectors and authorities operate within formal and decentralized structures with distinct jurisdictions and purposes, while the local community functions predominantly through informal vertical and horizontal structures. These structures often determine the success or failure of policies, projects, or natural resource management (Schiffer and Hauck, 2010). Hence, this research maps actors' structural networks to understand how stakeholders are connected for exchanging resources to implement tree-based restoration initiatives at the local, zonal, regional, and federal levels.

In Madagascar, the study was conducted in the DIANA region, specifically in the Irodo watershed, located in northern Madagascar within the Antsiranana province. The DIANA region is characterized by its rich biodiversity, housing vital ecosystems such as dry forests and mangroves (Lacroix et al., 2016; Waeber et al., 2015). These ecosystems play a crucial role in providing essential services to local communities and a diverse array of species, many of which are endemic to the area (Waeber et al., 2015). However, as the population grows, there are increasing challenges of unsustainable resource use and noticeable degradation of vegetation cover. In response, the region has initiated significant conservation efforts. For instance, DIANA has established four national parks, four reserves, and a protected area, demonstrating a strong commitment to biodiversity conservation. An assessment identified priority FLR zones in DIANA, particularly dedicated to preserving water resources, with a potential of 36,307 ha for FLR within the catchment, which spans a total area of 136,820 ha (Charpin et al., 2018).

3.2. Data collection

For this study, we used the Net-Map tool, developed by Eva Schiffer and the International Food Policy Research Institute (IFPRI) in 2007, to collect relational information. This tool is an interview-based instrument that enhances stakeholder mapping by exploring actors' perceptions and motivations behind their actions and interactions (Hauck and Schiffer, 2012). Our approach comprised three main stages. First, we identified primary FLR actors. Next, we examined the types of links between these actors. Finally, we visually represented the connections between the selected actors. During the first stage, participants listed all FLR collaborators, which we documented on cards and placed on flip chart paper. In the second stage, participants rated each stakeholder's interest, importance, influence, and involvement in FLR policymaking on a scale from one to five. In the third stage, relationships between stakeholders regarding FLR were drawn on the cards, including links such as information flow, finance, contracts, authority or influence of the actor, and conflicts. These steps were followed by semi-structured interviews to gain a deeper understanding of the stakeholders' interests and relationships. While the stakeholder network analysis and the Net-Map approach were applied in both countries of study, some methodological variations existed.

In Ethiopia, we selected 11 stakeholders representing a mix of

regional and local FLR implementation partners, following a snowball sampling approach. The initial contact for this snowball method was the country's lead institute in FLR implementation, the Ethiopian Forest Development (EFD). The Net-Map process was conducted with one or two representatives from each institute, provided they had served in their respective institutes for at least five years. Semi-structured interviews were prepared to guide and moderate the mapping process, focusing on identifying stakeholders with whom they had collaborated over the past five years and the nature of these collaborations or exchanges. The key informant interviews, also conducted using a snowball approach, employed semi-structured interviews to collect data, primarily focusing on the bi-directional flow of information, finance, and resources between various stakeholders.

In Madagascar, we adopted a structured two-step process to identify stakeholders. First, we leveraged existing stakeholder lists from the ongoing global Forest and Landscape Restoration (FLR) initiative, the Forests4Future (F4F)/GIZ project. We began by conducting individual interviews with organizations and public institutions at both the national and regional levels, focusing on their work areas, involvement with FLR, and broader developments in FLR and land policies. During these interviews, we also identified additional key actors, particularly those frequently mentioned as central to FLR efforts in the region. In the second step, we organized focus group discussions with women's associations, traditional leaders, VOI (village forest management committees), and other land user groups. These discussions started with stakeholder mapping in a collective setting and then divided participants into sub-groups to explore specific land user experiences. Special attention was given to creating separate spaces for women to ensure their voices were heard. This method allowed some participants to be involved in multiple sessions, such as those participating in both VOI and women's association discussions. In total, we conducted 15 individual interviews and 24 group discussions.

3.3. Data analysis

3.3.1. Operationalization of institutional and organizational proximity

In our study, we recognize that institutional proximity, influenced by shared norms, practices, and incentives, guides our categorization of organizations involved in Forest Landscape Restoration (FLR) initiatives. We classify organizations into executives, funders, and knowledge generators based on this concept. For executives, institutions such as Enterprises (Either private or public), Government Entities, International NGOs, and Local Community/Community Based Organizations (CBOs) share responsibilities for executing FLR projects. Similarly, for funders, we categorize bilateral cooperation, multilateral cooperation, and international NGOs as sharing responsibilities for funding FLR efforts. Lastly, entities such as Research Institutions and Universities, focused on generating the knowledge necessary for FLR implementation, fall under the Knowledge category. Regarding organizational proximity, which consolidates knowledge and reference spaces within hierarchical structures, stakeholders operating at the same administrative levels are deemed organizationally proximate. We classify stakeholders into three categories: National, Regional, and Global. Organizations functioning within the national administrative framework, regardless of operating at the local or country level, are categorized as National. Those operating within regional administrative frameworks are labeled as Regional, while those within global administrative structures are categorized as Global.

3.3.2. ERGM set up

We used the Exponential Random Graph Model (ERGM) framework to analyse social network data using the statistical package R version 4.3.0. ERGM is a statistical method particularly useful for understanding the processes driving network formation and structure in complex network data (van der Pol, 2019). It offers flexibility in capturing various aspects of network topology such as triangles, degree

distributions, homophily, and reciprocity. ERGMs can account for dependencies between ties, making them valuable for analyzing real-world networks where one tie's formation may influence others. These models facilitate hypothesis testing regarding the underlying processes shaping network formation and allow prediction of new tie formation based on existing network structures (Kabirigi et al., 2022). Additionally, ERGMs enable model comparison to identify the most suitable representation for a given network dataset. By modeling the likelihood of tie formation between nodes based on various network features, ERGM allows us to understand the underlying mechanisms shaping network structures. In constructing our ERGM models for our specific case study, we systematically evaluated the relative importance of different factors in determining model fit. This involved incrementally introducing terms in successive stages. Initially, we started with a basic random graph model featuring only an 'edges' term, assuming uniform tie formation probabilities for all nodes. As we progressed, we incorporated additional complexity by including terms aligned with our hypotheses. These comprised 'nodematch' terms, aimed at capturing homophily effects such as institutional and organizational proximities, as well as affinity based on shared categorical attributes or operational levels. Furthermore, we integrated 'nodefactor' terms to reflect the likelihood of node involvement based on categorical distinctions and operational scopes. To account for structural characteristics of the network, we introduced 'gwodegree' terms to model anti-preferential attachment, where negative coefficients signify the occurrence of preferential attachment, and 'gwesp' terms to capture triadic closure tendencies, reflecting the inclination towards transitivity in network ties.

4. Results

4.1. Descriptive information of observed network

Fig. 2 provides a visual representation of the stakeholders engaged in FLR. It shows that multiple diverse stakeholders are present, each with various and sometimes divergent interaction patterns between countries. Fig. 3 shows stakeholders' representation whereas Table 1 provides descriptive information of observed networks. Both networks, in Madagascar and Ethiopia, are largely dominated by Government Entities. In Madagascar, they constitute 35.3 % of the network, followed by Local Community/CBOs at 23.5 %. Meanwhile, in Ethiopia, Government Entities hold an even more significant share, representing 50 % of the network. The network analysis reveals distinct structural differences between Ethiopia and Madagascar. While Ethiopia has a larger network with 202 nodes and 333 ties, Madagascar's network is smaller, comprising 85 nodes and 222 ties. Despite its smaller size, Madagascar's network demonstrates higher density (0.06) and average degree (5.22), indicating a denser and more interconnected structure compared to Ethiopia's network, which has a density of 0.02 and an average degree of 3.30. Ethiopia's network has a smaller diameter (4) and a slightly longer average path length (3.36) compared to Madagascar's network (diameter: 5, average path length: 2.76). This implies that, on average, it may take fewer steps to traverse from one node to another in Madagascar's network compared to Ethiopia's, despite Ethiopia having a smaller diameter. Additionally, Madagascar's network exhibits a higher level of transitivity (0.31), suggesting stronger clustering or community structure, while Ethiopia's network shows lower transitivity (0.02).

4.2. Who is central, who is influential

In Madagascar's network, International NGOs command the highest degree centrality, scoring 8.25, while Government Entities and Research Institutions/Universities closely trail with a centrality of 5.67 each. Conversely, within Ethiopia's network, Research Institutions/Universities claim the top degree centrality spot at 6.16, followed by Bilateral cooperation organizations at 5.19. In terms of eigenvector centrality, International NGOs lead in Madagascar's network with a significant



Fig. 2. Visual representation of networks of stakeholders engaged in FLR in Ethiopia (left) and Madagascar (right). Node colors represent different types of organizations. Node shapes indicate institutional proximity (categorized by shared norms, practices, and incentives): executive institutions (circles), knowledge institutions (squares), and funding institutions (diamonds). Node size reflects organizational proximity (categorized by administrative at which they operate), where larger nodes operate at the global level, medium-sized nodes at the regional level, and smaller nodes at the national level.



Fig. 3. Stakeholders representation in the Ethiopia and Madagascar FLR networks.

Table 1

Descriptive information of observed networks.

Description	Ethiopia	Madagascar
Number of nodes	202	85
Number of ties	333	222
Network density	0.02	0.06
Average degree	3.30	5.22
Network diameter	4	5
Average path length	3.36	2.76
Network transitivity	0.02	0.31

0.427, followed by Local Community/CBOs at 0.236. Meanwhile, in Ethiopia's network, Research Institutions/Universities take the lead in centrality at 0.209, closely followed by Multilateral cooperation entities at 0.148. Results showing stakeholders' respective average degree centrality and average eigenvector are presented in Fig. 4.

4.3. ERGMs results

In both countries, institutional proximity plays a significant role in shaping connections within the network. Specifically, in Ethiopia, a strong positive effect (0.656) is observed, indicating that entities are more likely to connect if they share similar institutional characteristics. In Madagascar, this effect is slightly weaker but still significant (0.465), suggesting a similar propensity for institutions to cluster based on shared characteristics. However, our analysis did not provide evidence that organizational proximity plays a role in shaping networks in both countries. Regarding the likelihood of connecting based on typology, results show that Ethiopia's network is more inclusive, where different types of organizations have higher odds of being in the network. In contrast, in Madagascar, only government entities and international NGOs have higher odds of being embedded in the network. Furthermore, operating scale influences connectivity preferences in both countries. In Madagascar, entities operating at the local scale demonstrate a notably positive effect (0.721), indicating a preference for local collaborations. Conversely, in Ethiopia, there is a negative effect



Fig. 4. Stakeholders respective average degree centrality in Ethiopia (A) and in Madagascar (B) and respective average eigenvector in Ethiopia (C) and in Madagascar (D).

(-0.538) associated with national-scale operations, suggesting a preference for local or regional collaborations over national ones. Triadic closure (gwesp) has a strong positive effect in both countries, indicating a preference for the formation of closed triads within the network, fostering clustering and community formation. In both Ethiopia and Madagascar, this effect is significant and negative, with coefficients of -1.185 and -2.005 respectively. This suggests that there is a preference for new connections to be formed with less connected nodes rather than with highly connected ones. Table 2 summarizes ERGM results.

5. Discussion

Our research clearly shows that there are imbalances in stakeholder participation between Ethiopia and Madagascar, with notable differences in their stakeholder networks. One of key differences between the two countries is the inclusiveness of their FLR networks. In Ethiopia, the network is more inclusive, as evidenced by the higher odds of various categories of institutions being part of it. According to the literature, this inclusivity makes Ethiopia's FLR network more effective, stable, and likely more resilient compared to Madagascar's (Fernandez de Arroyabe et al., 2021; Villalba Morales et al., 2023). This difference may be linked to Ethiopia's larger commitment to restoration under the Bonn Challenge, where it pledged to restore a significantly larger area than Madagascar (Saint-Laurent et al., 2020). Although the area committed might initially correlate with the size of the country, Ethiopia's pledge to restore one of the largest areas in Africa could be the reason it attracts more attention and a greater diversity of actors. Additionally, the difference could also stem from Ethiopia's relatively higher development

Table 2

Parameter estimates and standard	l errors (in	brackets)	of ERGMs	for	FLR	net-
works in Ethiopia and Madagasca	r.					

ERGM Term	Ethiopia	Madagascar		
Proximity effect				
Institutional proximity	0.656 *** (0.149)	0.465 *(0.220)		
Organizational proximity	0.229 (0.168)	-0.001 (0.213)		
Likelihood to connect based on				
typology				
Enterprises (Either private or public)	0.790 **(0.244)	0.223 (0.154)		
Government Entity	0.290 (0.229)	0.355 **(0.126)		
International NGOs	0.913 ***(0.157)	1.921 ***(0.192)		
Local Community/CBOs	1.010 ***(0.242)	0.077 (0.129)		
Multilateral cooperation	-0.105 (0.210)	0.225 (0.328)		
Research Institutions/Universities	0.862 ***(0.205)	-0.025 (0.688)		
Likelihood to connect based on				
operating scale				
Local	0.352 (0.195)	0.721 **(0.259)		
National	-0.538 **(0.195)	0.440 *(0.220)		
Regional	-0.553 **(0.182)	0.685 **(0.234)		
Structural properties				
edges	-4.890 ***(0.275)	-4.597 ***(0.380)		
Anti-preferential attachment (gwodeg)	-1.185 ***(0.182)	-2.005 ***(0.328)		
Triadic closure (gwesp)	0.406 ***(0.093)	1.731 ***(0.108)		

index/GDP and greater institutional stability.

Our findings partially confirm the assumption that both government and international institutions hold significant influence within the network. In Ethiopia, research institutions/universities dominate, while in Madagascar, international NGOs take the lead. Building on Nita et al. (2016), who highlight the crucial role of central actors in shaping network dynamics and partnership structures, we argue that the degree and eigenvector centrality results reveal contrasting patterns in network dynamics and partnerships across the two case study contexts. In Madagascar, the dominance of International NGOs in both centrality measures aligns with a donor-driven approach to forestry interventions, as described in studies by Umar et al. (2020) and Ramcilovic-Suominen and Mustalahti (2022), suggesting a development-oriented agricultural system. In contrast, Ethiopia's agricultural innovation system is characterized by the prominence of Research Institutions and Universities, reflecting a knowledge-driven context focused on research-led policies and innovation, as noted by W. Liu et al. (2022). These structural differences likely stem from variations in development stages, funding mechanisms, and institutional capacities across the two countries. The hypothesis regarding stakeholder network inclusivity in FLR initiatives was supported in Ethiopia, where a diverse range of institutions participated. However, in Madagascar, only government bodies and international NGOs have higher odds of being embedded in the network. Both countries exhibited a pattern where stakeholders established connections with influential actors, resulting in centralized networks with significant popularity effects. Additionally, stakeholders in both countries showed a tendency to form connections with shared partners, indicating a notable cohesion effect. Notably, institutional proximity played a significant role in shaping networks in both contexts, whereas organizational proximity did not emerge as a significant factor.

Another key difference is the primary driving force of FLR efforts. Results suggest that knowledge is the primary driver of FLR efforts in Ethiopia, whereas finance is the main driver in Madagascar. This conclusion is based on the observation that in Ethiopia, research institutions and universities, which serve as primary knowledge hubs, lead the FLR network, followed by international institutions in both degree centrality and eigenvector centrality. In contrast, in Madagascar, international NGOs with greater financial resources lead the FLR network, with research institutions and universities coming next in terms of degree centrality. Overall, we argue that FLR efforts are shaped by a combination of knowledge and funding. This difference is likely due to Ethiopia's stronger presence of established research institutions and education systems. Our findings indicate that the leading actors in each country, International NGOs in Madagascar and research institutions in Ethiopia, shape governance structures differently, with implications for inclusivity and knowledge flow. In Madagascar, governance is financedriven, with international NGOs playing a dominant role, although government entities remain influential. This aligns with Oliveira and Hersperger (2018), who show that financial resources shape power dynamics and decision-making in governance structures. Conversely, Ethiopia exhibits a knowledge-driven governance model, where research institutions and universities hold central positions, fostering greater inclusivity and knowledge diffusion. While Manolache et al. (2018) found that NGO-led governance is centralized around public authorities, our results suggest a more nuanced interpretation: in Madagascar, international NGOs may dominate, but governance remains centralized with significant government involvement. In contrast, Ethiopia's network, led by research institutions, suggests a governance model driven by expertise and academic collaboration, which could enable more inclusive participation. This highlights that NGO-led governance may take different forms, either reinforcing public authority centralization (as in Manolache et al., 2018) or facilitating a finance-driven structure (as observed in Madagascar), while knowledge-driven governance (as in Ethiopia) could provide a pathway to more inclusive and collaborative engagement.

Organizations with greater financial resources lead FLR efforts in Madagascar due to several factors: the country's reliance on external funding for large-scale projects, limited capacity of local governmental entities to secure and manage resources independently, and the weaker presence of established governmental frameworks. International organizations often provide not only financial support but also technical expertise and strategic direction. In the context of FLR strategies in Madagascar, there is a notable lack of such expertise and planning within local institutions. This deficiency hinders the achievement of sustainability objectives, as local entities may struggle to design, execute, and maintain restoration projects without the necessary technical knowledge and strategic oversight. Consequently, while governance remains crucial, the availability of financial resources and external expertise plays a more significant role in shaping FLR efforts in Madagascar, highlighting the challenges in achieving long-term sustainability in the country's FLR initiatives.

It is important to note that even though some government entities might not show significant influence, the government's role is broader. It often involves close collaboration with international organizations and establishing framework conditions, such as setting up the rules of the game. For example, in Ethiopia, Government entities at the federal level influence FLR implementation through policies and directives, with regional entities executing what has been cascaded from the federal government. Moreover, all other institutions involved in FLR, whether supporting financially or conducting research, must go through the government to fulfil required clearances. Furthermore, research organizations and universities work closely with information exchange and support FLR through resource provision, but the government has an influential role in FLR implementation through policies and overall control of the network.

Our results show that FLR networks exhibit significant cooperation and effective knowledge transmission, evidenced by the presence of preferential attachment and significant cohesion effects (Levy and Lubell, 2018). Closed network structures support cooperation, with individuals forming closed triangles more frequently than by chance, resulting in high clustering and positive-GWESP estimates in ERGMs. Effective communication is supported by high-degree centralization and negative-GWD estimates, reflecting a tendency for links to connect to popular actors. These processes are potential assets for effective governance as they are indicators of trust among actors, with preferential attachment linked to bridging trust and cohesion effects to bonding trust (Beugelsduk and Smolders, 2003; Lusher et al., 2014). Bridging trust facilitates connections across diverse groups, while bonding trust strengthens connections within homogeneous groups. Identifying these trust indicators within FLR initiatives reflects well-developed networks with a shared objective, signaling positive collaboration and effective communication.

Finally, results reveal that institutional proximity significantly influences network formation in both contexts, while organizational proximity did not exhibit the same significance. The absence of an organizational proximity effect can probably be explained by literature suggesting that certain forms of proximity play a more pronounced role in the early stages of network formation but gradually diminish over time (Lazzeretti and Capone, 2016). The strong institutional clustering observed suggests that networks are tightly knit within institutional boundaries, reinforcing cohesion among actors with shared regulatory frameworks. While this enhances coordination and knowledge exchange, it may also create echo chambers that limit engagement with diverse actors, such as smallholder cooperatives and emerging enterprises (Axelrod, 1997). The absence of an organizational proximity effect contrasts with studies emphasizing multi-actor alignment in collaboration, such as Wiegant et al. (2024), suggesting that ties in these agricultural innovation systems are shaped more by institutional affiliation than by organizational type. This could indicate openness to cross-sectoral interaction but may also reflect weak mechanisms for bridging different organizational actors. Emerging AIS research suggests that diverse networks, rather than those based solely on institutional homogeneity, better address complex, interdisciplinary challenges (Santos et al., 2024). Thus, while homophily strengthens coordination, it may also restrict the diversity of thought needed for transformative innovation. Overcoming these structural constraints is key to fostering

more inclusive and participatory agricultural networks. Proximity literature underscores the contextual dependency of various proximity dimensions and their effects on network dynamics at different stages of growth (Burigo and Coventry, 2010; Kabirigi et al., 2022). However, it's essential to acknowledge the challenges inherent in comparing results from institutional and organizational proximity analyses. Firstly, the definition of both forms of proximity lacks clarity, with instances where organizations may exhibit both types of proximity simultaneously. Secondly, the operationalization of institutional and organizational proximity varies widely across the literature. For example, D'Este et al. (2012) defined organizational proximity by considering prior collaboration experience, while Capaldo and Petruzzelli (2014) used membership in the same group as a criterion. In terms of institutional proximity, for example, Lazzeretti and Capone (2016) employed typology as an indicator, whereas Usai et al. (2017) utilized similar status for the same purpose.

These case studies provide critical insights into how different governance structures shape stakeholder engagement in FLR, offering lessons for global restoration efforts. By revealing how institutional proximity fosters inclusivity in Ethiopia while financial dominance centralizes power in Madagascar, the findings highlight key challenges in balancing knowledge-driven and finance-driven governance. At the international level, these results emphasize the need for more inclusive, locally engaged FLR networks that integrate both academic expertise and financial resources while ensuring equitable participation, particularly in regions where global restoration initiatives depend on multistakeholder collaboration.

5.1. Implications

These findings have profound implications for FLR initiatives. From a sustainability standpoint, the networks involved in FLR show a pronounced dominance of research and academic institutions, as well as international NGOs, over community-based organizations. This dominance highlights a top-down institutional setting, where local land use decisions are increasingly shaped by external entities rather than local communities. Andriamihaja et al. (2021) have discussed this situation as unsustainable. Furthermore, previous research, including Buckingham et al. (2021), highlighted the critical role of prioritizing local communities and empowering them for the effective implementation of FLR practices. The implications for engaging farmers in FLR practices are significant. However, given that FLR efforts are expensive and the primary benefits are indirect, long-term, and mainly environmental, farmers currently have few incentives to participate enthusiastically (Stanturf et al., 2019; Verdone and Seidl, 2017). Without direct and immediate benefits, their engagement is likely to remain low (Mills et al., 2018). This is particularly problematic because active and sustained involvement from local farmers is crucial for the success and sustainability of FLR initiatives. Therefore, we recommend the establishment of an incentive scheme designed to enhance farmers' willingness to participate in FLR initiatives. Furthermore, we recommend ongoing awareness campaigns within local communities, strengthening their capacity through training, and facilitating their access to finance, as our findings underscore the critical importance of finance and knowledge for successful FLR.

Our findings address the critical question posed by Van Oosten (2013) by showing that knowledge-based institutions and those with greater financial resources are driving FLR efforts. This study highlights the need to involve other institutions to create a more balanced and inclusive approach, ultimately strengthening the effectiveness and sustainability of FLR efforts. Based on the country's strengths, whether in its education system or financial stability, there should be a balanced approach to delivering training and awareness campaigns while securing funds. Additionally, the inclusiveness of the network in Ethiopia suggests that activities and progress towards meeting restoration pledges are likely to advance more rapidly compared to

Madagascar. It's crucial to recognize that the level of inclusivity within a network correlates with its strength, fostering mutual learning and support. Inclusive networks are likely more resilient and foster a greater sense of ownership over intervention outcomes. Strategies aimed at increasing the participation of local communities, diversifying stakeholder representation, and fostering collaborative partnerships can contribute to more inclusive and resilient FLR networks. Implementing Social-Ecological Systems Thinking is the optimal approach to achieve this (Fischer et al., 2021). In Madagascar, there is a pressing need for targeted efforts to enhance inclusivity in FLR initiatives, potentially by broadening stakeholder involvement. Conversely, in Ethiopia, strategies are needed to sustain inclusive stakeholder engagement. Regular monitoring and evaluation of networks can facilitate this.

The patterns of stakeholder connections observed, characterized by preferential attachment and cohesion effects, have important implications for cooperative governance. Firstly, effective information sharing, crucial to cooperative governance, is strengthened by these connection patterns. Secondly, cohesion effects and preferential attachment are crucial for building social capital because they foster bonding and bridging trust, respectively. According Borg et al. (2015), governance in networks intended for short-term operation, such as FLR initiatives, heavily relies on trust and social capital. However, it is crucial to recognize that preferential attachment within these networks indicates centralization. While this centralization is beneficial for leveraging influential actors in communication, it also presents challenges. Centralized networks can lead to information bottlenecks and increased vulnerability to disruptions. Therefore, while trust is a key component for the effective operation of short-term governance networks, addressing the issues associated with centralization is equally important. On the other hand, it is essential to establish platforms for exchange and learning among various stakeholders to foster trust, encourage collaboration, and strengthen cohesion across different stakeholder groups, from horizontal to vertical scales.

Finally, the significant role of institutional proximity underscores the importance of institutional structures in the planning and implementation of FLR. These structures help make FLR efforts more organized and systematic. Institutions provide the necessary framework for governing FLR activities and should be carefully considered during intervention planning. Institutionalization enables initiatives, such as establishing incentive schemes to enhance local community involvement, to be more effectively executed. Policymakers can leverage institutional proximity to enhance coordination in FLR networks while mitigating exclusion by fostering cross-institutional linkages, promoting broader knowledge exchange, and strengthening bridging mechanisms between diverse actors. Establishing multi-stakeholder platforms, funding collaborative projects, and implementing inclusive policy frameworks can reduce silos and encourage participation from smallholder cooperatives and emerging enterprises. However, further research is necessary to clearly differentiate between institutional and organizational proximity and to determine the most effective ways to operationalize them.

5.2. Limitations and future outlooks

While our study offers valuable insights into FLR initiatives, it is important to acknowledge its limitations. Firstly, data collection was not uniform across both countries, which may introduce biases or inconsistencies in our findings. Secondly, data was gathered from selected geographic areas of FLR intervention, which may not fully represent the variety of contexts within each country. Consequently, caution should be exercised when interpreting and extrapolating conclusions from our study to other contexts. Third, the information gathered do not provide more options to fully operationalize and define institutional and organizational proximity. As a result, our analysis may not fully capture the complexity of institutional and organizational relationships within FLR networks, highlighting the need for more comprehensive data collection methods in future research.

6. Conclusion

In this study, we applied social network analysis on primary data about stakeholder interconnection to evaluate the impact of institutional and organizational proximity on network formation within FLR initiatives implemented in Ethiopia and Madagascar. Our results reveal that institutional proximity has a significant influence on network formation in both contexts, while organizational proximity did not exhibit the same significance. The study highlights the leading roles played by research institutions/universities in Ethiopia and international NGOs in Madagascar. This leadership underscores the pivotal positions of knowledge hubs and organizations with access to financial resources in driving FLR efforts. Findings reveal differences in the primary drivers of FLR efforts between Ethiopia and Madagascar, with knowledge being the main driver in Ethiopia and finance being the main driver in Madagascar. The study underscores the importance of enhancing inclusiveness in FLR initiatives to strengthen network resilience and promote mutual learning and support. The observed patterns of stakeholder connections, characterized by preferential attachment and cohesion effects, highlight the presence of both bonding and bridging trust within FLR networks. This study provides valuable insights into the dynamics of stakeholder networks in FLR initiatives, emphasizing the significance of institutional proximity and the need for inclusive network structures to support successful restoration efforts. These findings underscore the global need for FLR networks that balance knowledge and funding while ensuring local inclusivity. Governance structures influence stakeholder engagement, highlighting the importance of integrating academic expertise with financial resources to foster equitable and sustainable restoration efforts.

CRediT authorship contribution statement

Michel Kabirigi: Writing – original draft, Visualization, Software, Methodology, Formal analysis, Conceptualization. Stefan Sieber: Writing – review & editing, Validation, Funding acquisition. Katharina Löhr: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. Hamy Raharinaivo: Writing – review & editing, Validation, Methodology, Investigation, Data curation, Conceptualization. Harifidy Rakoto Ratsimba: Writing – review & editing, Validation, Supervision. Naomi Weiß: Writing – review & editing, Validation, Supervision. Naomi Weiß: Writing – review & editing, Validation, Methodology, Investigation, Data curation, Conceptualization. Shibire Bekele Eshetu: Writing – review & editing, Validation, Methodology, Investigation, Data curation, Conceptualization. Shibire Bekele Eshetu: Writing – review & editing, Validation, Methodology, Investigation, Data curation, Conceptualization. Asmelash Tesfaye Gebremedhin: Validation, Methodology, Investigation, Data curation, Conceptualization.

Consent for Publication

All authors have reviewed and approved the final manuscript for submission and publication.

Funding

This work received financial support from the German Federal Ministry for Economic Cooperation and Development (BMZ) commissioned and administered through the global project on forest landscape restoration and good governance in the forest sector (Forests4Future) of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (ref no: 81277142/19.0125.5-101.00).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This research was conducted in the frame of TREES project Tropical Restoration Expansion for Ecosystem Services, accompanying research to the Project Forest Landscape Restoration and Governance in the Forest sector (F4F) coordinated by the German Leibniz Centre for Agricultural Landscape Research (ZALF). The content of this publication is the sole responsibility of the authors of this publication and can under no circumstances be regarded as reflecting the position of GIZ/F4F or the BMZ.

Data Availability

Data will be made available on request.

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