

Collaborative Forest Governance for Hydrological Resilience: Integrating Social Capital, Power, Adaptive Institutions, and Community Based Stewardship in Social Ecological Landscapes

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ABSTRACT

Collaborative forest governance is increasingly expected to deliver legitimate participation, livelihood benefits, and measurable ecological resilience under accelerating climate and hydrological risk. This integrative review synthesizes a closed corpus of 54 Scopus-indexed records published between 2016 and 2026 to examine how collaborative governance, social capital, community forestry, adaptive management, and hydrological evidence can be integrated. The literature shows that collaboration performs best when social networks, facilitative leadership, shared learning, equitable representation, and cross-scale coordination operate as interacting institutional capacities. Recent evidence also raises the outcome standard: deforestation has been associated with sharply higher flood occurrence in vulnerable mountain systems, while adaptive water governance emphasizes co-learning, traditional knowledge, participatory action research, and institutional flexibility. Yet governance studies often measure trust, participation, livelihoods, or institutional performance

without simultaneously assessing forest condition, watershed function, or disaster risk, whereas hydrological studies commonly omit power, benefit distribution, and implementation capacity. The review therefore proposes a Collaborative Hydrosocial Forest Governance Framework linking ecological-hydrological integrity, collaborative capacity, social capital architecture, political equity, livelihood security, and adaptive cross-scale coordination. The framework treats collaboration as a capacity whose value must be verified through socially equitable improvements in ecosystem function and risk reduction.

Keywords: collaborative forest governance; hydrological resilience; social capital; adaptive governance; community forestry; flood risk; social ecological systems

1. INTRODUCTION

Forests are governed through institutions, but the consequences of those institutions are expressed through landscapes. Rules governing access, harvesting, restoration, conservation, ecosystem-service payments, and community rights alter land

management and thereby influence livelihoods, water availability, erosion, flood exposure, and other dimensions of social-ecological resilience. Collaborative governance has emerged because these problems distribute knowledge, authority, resources, and consequences across public agencies, communities, civil society, private actors, and knowledge organizations (Wicaksono, 2023; Zhao et al., 2024; Ansell et al., 2025). Participation alone, however, is not an outcome. Collaboration can remain symbolic, asymmetric, or ecologically disconnected when procedural inclusion is not linked to measurable social and environmental change (Pearson & Dare, 2019; Ansell et al., 2021; Torfing et al., 2026).

The corpus identifies a mature set of social mechanisms. Networks, trust, norms, reciprocity, facilitative leadership, bridging organizations, and social learning can improve collective action, information exchange, institutional adjustment, and access to resources (Górriz-Mifsud et al., 2016; Lee & Baggio, 2021; Arai et al., 2021; Toda et al., 2023). Community forestry can strengthen livelihood assets, although rural diversification and agrarian transition alter dependence on forests and the incentives for stewardship (Mawa et al., 2021; Bardsley et al., 2024; Aryal, 2025). These findings position forest governance as a dynamic allocation of authority, knowledge, risks, and benefits rather than a simple form of decentralization.

Recent hydrological evidence raises the analytical stakes. In the India-Nepal Siwalik region, Gujree et al. (2026) report that a 1% decline in forest cover was associated with an 18.5-30.7% increase in flood occurrence using forest-change data, heavy-rainfall modelling, and historical flood records from 2001-2023. The authors also identify fragmented transboundary governance as a constraint. Adaptive water-governance studies similarly show that weak shared vision, leadership deficits, power asymmetries, and limited co-learning can restrict collective responses to water risk

(Galvez et al., 2020; Morante et al., 2025). Forest governance must therefore be judged not only by participation and legitimacy, but by whether institutions influence land-cover trajectories, watershed condition, and adaptive capacity.

This review asks how collaborative and adaptive mechanisms support effective governance; how social capital, power, conflict, and equity shape community-based forest institutions; how hydrological and disaster-risk evidence changes criteria of success; which methodological gaps prevent governance processes from being linked to biophysical outcomes; and what integrated framework can guide legitimate, adaptive, livelihood-sensitive, and ecologically effective collaboration. It contributes by distinguishing collaborative capacity from collaborative performance, placing power and conflict within the causal model, and integrating forest, watershed, and disaster-risk evidence through a Collaborative Hydrosocial Forest Governance Framework.

2. Review Design and Evidence Boundary

This integrative review is based exclusively on the two Scopus exports supplied for the study. The first contained 54 records published from 2016 to 2026; the second contained 53 records, all overlapping with the first. Ansell et al. (2021) appeared only in the first export, leaving 54 unique publications rather than 107 records. No references were added from web searches, external databases, model memory, or reference lists.

The corpus spans collaborative and adaptive governance, social capital, community forestry, protected areas, payments for ecosystem services, conflict, water governance, participatory action research, climate adaptation, disaster resilience, livelihoods, and social-network analysis. Evidence includes empirical cases, reviews, conceptual papers, bibliometric studies, and book chapters across multiple world regions. Because only metadata and abstracts were available, numerical results, methods, and causal interpretations were

retained only when explicitly reported. Associative evidence was not upgraded to causation, and social-governance studies were not assumed to demonstrate forest or hydrological improvement when such outcomes were unmeasured.

Studies were synthesized across six domains: collaborative and adaptive design; social capital and networks; power, conflict, equity, and legitimacy; community forestry, livelihoods, and incentives; hydrological resilience, water governance, and disaster risk; and integration of social and biophysical evidence. The review is neither a systematic review nor a meta-analysis because the source portfolio was supplied and outcomes were too heterogeneous for statistical pooling. Its contribution is a traceable cross-domain synthesis of a bounded evidence corpus.

3. Conceptual Foundations: From Collaboration as Procedure to Governance as Social Ecological Performance

Collaborative governance is most useful where environmental problems are genuinely interdependent: authority, knowledge, resources, and consequences are distributed among actors who cannot achieve durable outcomes independently. Across forestry, water, conservation, agri-environmental management, and climate adaptation, effective collaboration requires credible representation, facilitative leadership, information exchange, conflict management, monitoring, and the ability to revise decisions (Galvez et al., 2020; Rice & McCool, 2022; Westerink et al., 2017; Zhao et al., 2024). Social embeddedness means

that the same formal arrangement can perform differently across political and institutional settings (Ansell et al., 2021).

Adaptive governance extends this logic by treating uncertainty and feedback as normal conditions. Co-learning, traditional knowledge, monitoring, and participatory action research help institutions revise interpretations and rules as social or ecological conditions change (Apgar et al., 2017; Morante et al., 2025). Yet adaptation is political. Fundamental conflicts may reflect incompatible interests and worldviews rather than information deficits, and collaboration may manage minor disputes more readily than antagonistic conflict (Ansell et al., 2025; Torfing et al., 2026).

Social capital provides the relational infrastructure for these processes but is itself shaped by governance. Networks influence information, trust, power, sanctions, and innovation, while institutional experience can build or damage relationships over time (Górriz-Mifsud et al., 2016; Toda et al., 2023; Rojas et al., 2024). A social-ecological performance perspective therefore follows a causal chain from collaborative design to relational processes, collective decisions, land-management behavior, ecological and hydrological change, and feedback into livelihoods and future cooperation. Existing studies illuminate parts of this chain; few measure it end to end. Evidence beyond forestry also reports reciprocal associations between stakeholder salience and cooperation, while cautioning that such associations do not establish causality (Beck et al., 2025).

Table 1. Main evidence clusters linking collaborative governance, forests, and hydrological resilience

Evidence cluster	Focal problem	Dominant evidence or setting	Main synthesis insight	Evidence boundary	Ref.
Collaborative governance design	Coordination under interdependence	Water basins, environmental policy, agri-environment schemes	Starting conditions, leadership, institutional design, learning, and monitoring shape collaborative performance	Process quality does not by itself establish ecological effectiveness	Galvez et al. (2020); Rice and McCool (2022); Westerink et al. (2017)
Adaptive governance	Change, uncertainty, and climate risk	Global scientometric evidence and socio-ecological water review	Adaptive institutions require learning, flexibility, knowledge integration, and feedback	Broad reviews identify themes more readily than causal effect sizes	Zhao et al. (2024); Morante et al. (2025)
Social capital and forest governance	Trust, norms, networks, and collective action	Forestry, community-based management, policy networks	Social capital co-evolves with institutions and shapes information, legitimacy, rule enforcement, and innovation	Social-capital studies often omit direct forest-condition assessment	Górriz-Mifsud et al. (2016); Toda et al. (2023)
Power, conflict, and politics	Unequal influence and contested values	Environmental governance, forestry, collaborative-governance reviews	Collaboration must address asymmetry and antagonistic conflict rather than assume consensus	Deep worldview conflict may exceed deliberative problem solving	Ansell et al. (2025); Torfing et al. (2026); Arai et al. (2021)
Community forestry and livelihoods	Distribution of forest benefits and rural resilience	Nepal, Uganda, Indonesia and comparative forestry	Community forest institutions can support livelihood assets, but benefits depend on representation, changing livelihood strategies, and institutional design	Livelihood gains do not automatically demonstrate ecological or hydrological improvement	Mawa et al. (2021); Bardsley et al. (2024); Aryal (2025)
Forest–hydrology linkage	Deforestation, flood occurrence, watershed risk	India–Nepal Siwalik transboundary landscape	Forest-cover change can be strongly associated with flood occurrence, making watershed outcomes a governance concern	One regional study cannot define universal forest–flood response	Gujree et al. (2026)
Disaster and resilience governance	Flood, landslide, wildfire, climate adaptation	Rural tourism, fire-prone landscapes, disaster coordination	Local knowledge, networks, risk perception, communication, and multi-actor coordination shape resilience capacity	Institutional indicators require pairing with hazard and exposure outcomes	Darmi et al. (2025); Jacobs and Cramer (2017); Evangelista et al. (2025)
Ecosystem-service and incentive governance	Aligning conservation and welfare	PES, recreational landscapes, watershed villages	Incentives work through institutional legitimacy and social relations, not price signals alone	Acceptance and social stability do not establish long-term ecosystem-service additionality	Tikkanen et al. (2017); McGrath et al. (2018)

4. The Forest–Hydrology Nexus: Why Collaborative Forest Governance Must Become Hydrologically Accountable

The clearest hydrological extension of forest-governance research comes from Gujree et al. (2026). In the transboundary Siwalik ecological zone, a 1% decrease in forest area was associated with an 18.5–30.7% increase in flood occurrence over 2001–2023. The reported relationship reflects interactions among deforestation, fragile geomorphology, monsoon variability, and fragmented cross-border governance. The coefficient should not be transferred mechanically to other watersheds, but the study establishes an important evaluative principle: forest governance can have hydrological consequences that cross administrative boundaries.

This changes what counts as success. A community forest can have active committees, accepted rules, and high participation while landscape degradation persists because external clearing, road development, extraction, or other drivers remain uncontrolled. Similarly, livelihood gains do not demonstrate improved infiltration, erosion control, sediment retention, streamflow regulation, or flood attenuation. Toda et al. (2023) identify this disconnect in Asian community-based forest management, where social-capital studies rarely assessed forest condition. Hydrological accountability requires independent biophysical evidence rather than inference from institutional quality.

Scale is equally important. Watersheds connect upstream and downstream actors through flows that often exceed village or agency jurisdictions. Bridging organizations can reduce mismatches between local institutions and higher-level authorities, while landscape governance requires spatial coordination across landholders (Lee & Baggio, 2021; Westerink et al., 2017). Water-governance research adds that shared vision, leadership, political will, and balanced access to knowledge and resources

influence whether interdependence becomes coordinated action (Galvez et al., 2020).

A hydrologically accountable evaluation should therefore distinguish four levels: collaborative-process indicators such as participation and trust; institutional outputs such as rules, restoration, compliance, and cross-boundary coordination; ecological-hydrological outcomes such as forest condition, erosion, stream response, and flood exposure; and distributional outcomes such as livelihoods, avoided damage, and differentiated vulnerability. Success at one level should not be treated as evidence of success at another (Apgar et al., 2017; Morante et al., 2025; Darmi et al., 2025).

5. Social Capital as Governance Infrastructure: Enabling Cooperation without Romanticizing Cohesion

Social capital matters because formal rules operate through relationships. Networks shape information exchange, trust affects credibility, norms influence compliance, and reciprocity can support short-term sacrifice for collective benefits. Forestry research treats social capital and governance as co-evolving: network structure affects power, trust, information, and innovation, while institutional rules and sanctions reshape relationships (Górriz-Mifsud et al., 2016; Toda et al., 2023). Policy-network evidence from Catalonia similarly suggests that acceptance is related to whether affected users are connected to influential actors and whether their preferences enter policy design (Górriz-Mifsud et al., 2017).

The configuration of social capital is more informative than its aggregate amount. Bonding ties can support solidarity and local rule enforcement; bridging ties connect different communities or livelihood groups; linking ties connect local organizations to public authority, finance, and expertise (Ros-Tonen & Derkyi, 2018; Manlosa et al., 2023). These forms can trade off. Professionalization may strengthen vertical relationships with government while concentrating expertise and weakening internal representation (Westerink et al.,

2020). Dense cohesion can also reinforce exclusion, distrust of outsiders, or resistance to sustainability transitions (Gütte & Roggero, 2022; Alcorta et al., 2020). History further conditions trust. Broken commitments in protected-area governance can generate intergenerational distrust, so new collaborative initiatives may enter landscapes burdened by unresolved

grievances (Rojas et al., 2024). For forest-watershed resilience, social capital should therefore be assessed functionally: whether networks connect actors needed for collective action, permit dissent, bridge upstream and downstream interests, provide access to authority, and support ecological stewardship rather than simply measuring cohesion.

Table 2. Social and institutional mechanisms shaping collaborative forest governance

Mechanism	Positive governance function	Potential failure or dark side	Implication for forest-watershed governance	Priority indicator	Ref.
Bonding social capital	Mutual assistance, local rule enforcement, collective action	Insularity, exclusion, resistance to new practices	Maintain cohesion while preventing closed decision networks	Internal trust, participation breadth, sanction legitimacy	Gütte and Roggero (2022); Ros-Tonen and Derkyi (2018)
Bridging social capital	Connects different communities, users, and sectors	Weak ties may not overcome entrenched conflict	Essential where upstream/downstream or livelihood groups differ	Cross-group ties, information exchange, joint activities	Westerink et al. (2020); Manlosa et al. (2023)
Linking social capital	Access to government, technical resources, finance, and policy	Dependency on elites or unequal vertical relations	Needed to connect local forest institutions with basin-level authority	Access to decision forums, responsiveness of agencies	Ros-Tonen and Derkyi (2018); Manlosa et al. (2023)
Facilitative leadership	Builds shared process, lowers coordination barriers	Leadership capture, dependence on individuals	Neutral or trusted convenors can connect agencies and communities	Perceived neutrality, agenda access, follow-through	Galvez et al. (2020); Alusiola et al. (2025)
Social learning	Revises assumptions and supports adaptation	Learning can remain discursive without behavioral change	Pair learning with monitoring and rule revision	Evidence of changed rules or practices after feedback	Schäpke et al. (2017); Zhao et al. (2024)
Participatory facilitation	Redistributes voice and supports local decision capacity	Participation may be tokenistic or project-dependent	Train local facilitators and create real decision space	Decision influence by less powerful actors	Arai et al. (2021); Apgar et al. (2017)
Policy-network legitimacy	Improves acceptance and compliance	Network centrality may privilege powerful actors	Include affected forest users in design and implementation	Network centrality, user representation, perceived legitimacy	Shen and Tai (2021); Gorriz-Mifsud et al. (2017)
Historical trust	Reduces transaction costs and supports cooperation	Broken commitments can create durable distrust	Governance reform may require explicit trust repair	Intergenerational perceptions, grievance resolution	Rojas et al. (2024)
Digital information networks	Transparency, mobilization, rapid coordination	Data inequality, surveillance, technocratic exclusion	Use community-accessible monitoring and transparent data rules	Data access, contributor diversity, feedback use	Xu and Zhang (2020)

6. Power, Equity, Conflict, and the Political Limits of Consensus

Conflict is not external to collaborative governance. Environmental actors may disagree over property, evidence, values, conservation priorities, livelihood rights, acceptable risk, and distribution of costs. Recent theory argues that collaboration must engage political pluralism and antagonism rather than assume that better dialogue will produce consensus (Ansell et al., 2025). Torfing et al. (2026) likewise find that collaborative arrangements are generally better suited to minor disagreements than to conflicts rooted in fundamentally different worldviews. Legitimate outcomes may therefore include negotiated trade-offs or transparent disagreement rather than full consensus.

Power asymmetry explains why formal participation can be misleading. In the Copiapo Basin, inequalities in knowledge, power, and resources constrained collaboration (Galvez et al., 2020). In West Kalimantan, joint village-government teams, shared facilitation training, local facilitators, equal knowledge exchange, and local decision space reduced some imbalances (Arai et al., 2021). Adaptive collaborative management similarly uses reflexivity, deliberation, and social learning to question not only ecological assumptions but also delegated authority and institutional categories (McDougall & Ojha, 2021).

Equity becomes substantive when representation changes material rules. In Nepal, greater representation of poor and disadvantaged households on community-forestry executive committees was associated with more favorable benefit-distribution provisions for those groups (Yadav et al., 2017). Gender research shows that women can remain disadvantaged in labor recognition, resource control, and decision influence even where household participation appears broad (Elias et al., 2024). Historical grievances can further weaken legitimacy, while the label of co-management may conceal arrangements that

remain hierarchical (Pearson & Dare, 2019; Rojas et al., 2024).

Effectiveness should therefore include political equity alongside ecological performance. A program that improves hydrological indicators by concentrating restrictions or labor on marginalized users may be biophysically effective but socially unstable; an inclusive forum that cannot alter degradation is procedurally strong but environmentally weak. Environmental peacebuilding adds mechanisms for dialogue, relationship repair, traditional norms, adaptive learning, and neutral convening where restoration depends on rebuilding cooperation (Alusiola et al., 2025). This integration is consistent with frameworks that distinguish antecedents, collaborative process, and equity outcomes (Tonelli et al., 2018).

7. Bridging Organizations, Facilitation, Learning, and the Architecture of Collective Capacity

Complex forest-watershed problems require organizations that connect actors across institutional and spatial boundaries. Community-based organizations can bridge local communities and higher-level land managers when shared vision and flexible networks are present (Lee & Baggio, 2021). Facilitation is most useful when it redistributes capacity rather than merely manages meetings. Local facilitators, joint teams, and participatory action research can improve representation, make hidden governance barriers discussable, and create meaningful decision space (Arai et al., 2021; Apgar et al., 2017).

Social learning then provides the temporal mechanism for adaptation. Monitoring and repeated reflection allow actors to revise assumptions and rules under changing ecological or social conditions (Schäpke et al., 2017; Westerink et al., 2017; Zhao et al., 2024; Morante et al., 2025). For hydrological resilience, learning should be connected to observable feedback such as forest-cover trends, rainfall anomalies,

stream response, erosion, sediment, fire, or restoration survival. Collective capacity therefore depends on linked functions of convening, bridging, facilitation, learning, and monitoring; weakness in any one can disconnect participation from effective action.

8. Community Forestry, Livelihoods, and Changing Rural Economies

Community forestry is commonly expected to improve both forest management and livelihoods, but the relationship is conditional. In Uganda, community-forest membership was associated with improved access to natural, social, and financial capitals, while forest environmental income reduced poverty incidence among both members and nonmembers (Mawa et al., 2021). Aryal (2025) argues that community forestry should also support empowerment, entrepreneurship, and employment rather than focus only on natural-capital accumulation.

Rural transition complicates these expectations. In Nepal's mid-hills, increasing reliance on off-farm and off-forest activities has reduced some direct forest dependence, although community forests remain important for inputs such as fodder and mulch that support agroforestry (Bardsley et al., 2024). Distribution also depends on institutional design: representation of disadvantaged households can alter benefit rules, while gendered labor and control may remain unequal (Yadav et al., 2017; Elias et al., 2024). Resilient community forestry should therefore accommodate changing livelihood portfolios while retaining legitimate stewardship incentives and tracking who provides labor, who controls benefits, and who bears restrictions.

9. From Forest Condition to Hydrological Resilience and Disaster-Risk Reduction

Hydrological resilience emerges from coupled ecological and institutional

processes. Forest cover, land management, rainfall, geomorphology, infrastructure, settlement, and governance jointly shape hazard and vulnerability. Gujree et al. (2026) show this coupling in the Siwalik region, where forest loss was associated with higher flood occurrence and transboundary fragmentation constrained coordination. The implication is that restoration and protection should be evaluated at ecological scales, while social institutions remain accountable for distribution of upstream costs and downstream benefits.

Adaptive water-management research provides the institutional bridge. Co-learning, traditional knowledge, participatory action research, and flexible rules can help actors detect and respond to changing hydrological conditions (Morante et al., 2025; Zhao et al., 2024). Participatory monitoring can combine local observations of springs, turbidity, erosion, flood pathways, or slope instability with remote sensing and standardized hydrological measurements (Apgar et al., 2017). Local observations improve contextual interpretation, while independent measurements test whether perceived improvement corresponds to biophysical trends.

Disaster resilience also depends on networks. Local institutions and traditional knowledge can strengthen governance in flood- and landslide-prone settings, while communication, training, and spatial connectivity influence coordination among decision units (Darmi et al., 2025; Evangelista et al., 2025). Risk communication is filtered through trust and social information networks (Jacobs & Cramer, 2017). Resilience should therefore be measured as both capacity and outcome: institutional learning and networks are capacities, whereas changes in forest condition, flood exposure, water regulation, and losses are outcomes.

Table 3. Integrating hydrological and disaster-risk outcomes into collaborative forest governance

Forest–hydrology pathway	Governance challenge	Recommended evidence	Social–institutional requirement	Interpretation boundary	Ref.
Deforestation and flood occurrence	Forest change crosses administrative borders and redistributes risk	Forest-cover time series, heavy rainfall, flood records, spatial models	Cross-boundary coordination, community participation, equitable benefit sharing	Regional coefficients should not be generalized without local validation	Gujree et al. (2026)
Water scarcity and competing use	Asymmetries weaken collective allocation and planning	Stakeholder interviews, water-use data, institutional mapping	Shared vision, facilitative leadership, political will, recognition of interdependence	Stakeholder recognition of problems does not guarantee collaboration	Galvez et al. (2020)
Adaptive watershed management	Climate and land-use change create uncertainty	Repeated hydrological and social monitoring, scenario discussion	Co-learning, traditional knowledge, PAR, institutional flexibility	Conceptual integration requires prospective empirical testing	Morante et al. (2025)
Flood and landslide resilience	Local institutions may be disconnected from risk governance	Hazard maps, local knowledge, institutional analysis, FGD	Informal institutions, local leaders, diverse actor involvement	Governance models should be evaluated against actual risk outcomes	Darmi et al. (2025)
Wildfire and climate adaptation	Risk perception is mediated by social information networks	Network analysis, risk perceptions, hazard observations	Trusted information channels, local adaptation networks	Perceived risk is not equivalent to measured hazard	Jacobs and Cramer (2017)
Disaster coordination	Agencies vary in communication and willingness to cooperate	Coordination indices, communication frequency, network structure	Collaborative training, reciprocal coordination, hub connectivity	Perceived coordination should be compared with response performance	Evangelista et al. (2025)
Watershed PES	Benefits and participation may generate social tension	PES participation, social-capital data, ecological-service indicators	Transparent rules, participant/nonparticipant relations, reciprocity	Social stability does not prove hydrological additionality	McGrath et al. (2018)
Landscape-scale restoration	Ecological processes and governance tasks span holdings	Spatial ecological monitoring, task distribution, learning records	Professional coordination plus farmer/community involvement	Organizational coordination must be linked to landscape outcomes	Westerink et al. (2017)

10. Methodological State of the Art and the Missing Coupling between Governance and Biophysical Evidence

The corpus is methodologically diverse. Qualitative cases explain values, histories, power, and institutional mechanisms, while

participatory action research can combine knowledge production with governance change (Galvez et al., 2020; Arai et al., 2021; Apgar et al., 2017; Rojas et al., 2024). Participatory approaches in other environmental and development settings

likewise connect communities, NGOs, officials, and academics in shared problem framing and collaborative learning (Niyobuhungiro & Schenck, 2022; Francis et al., 2021). Reviews and bibliometric studies reveal broader trends: collaborative forestry is increasingly linked to sustainable development and environmental governance; social-capital research identifies a persistent lack of forest-condition assessment; adaptive-governance research emphasizes social learning and climate adaptation; and recent syntheses foreground conflict and socio-ecological water management (Wicaksono, 2023; Toda et al., 2023; Zhao et al., 2024; Morante et al., 2025; Torfing et al., 2026).

The main methodological gap is missing coupling. Gujree et al. (2026) link forest-area change to flood occurrence using spatial and statistical evidence, but hydrological analysis alone does not explain who has authority to change land use, how benefits are distributed, or whether institutions can implement interventions. Conversely, surveys of trust, participation, or networks cannot demonstrate watershed improvement without independent ecological measurement. State-of-the-art research therefore requires coupled designs. Such designs can combine social-network analysis, surveys of trust and legitimacy, qualitative analysis of conflict and history, institutional records, remote sensing of forest change, field ecology, and context-specific hydrological monitoring. Longitudinal measurement is particularly important because trust, livelihood dependence, land cover, and hydrological response evolve at different rates (Rojas et al., 2024; Bardsley et al., 2024; Westerink et al., 2017). Results should remain multidimensional rather than being collapsed prematurely into a single governance-success score, so ecological gains cannot hide inequity and livelihood gains cannot hide degradation.

11. A Collaborative Hydrosocial Forest Governance Framework

The synthesis supports a Collaborative Hydrosocial Forest Governance Framework with six interacting dimensions. Ecological-hydrological integrity asks whether management improves forest and watershed condition using context-specific measures such as forest cover, regeneration, erosion, sediment, streamflow variability, water quality, springs, flood frequency, or slope stability (Toda et al., 2023; Gujree et al., 2026). Collaborative capacity concerns the ability to convene relevant actors, exchange knowledge, negotiate decisions, commit resources, implement agreements, and manage disputes rather than participation rates alone (Galvez et al., 2020; Rice & McCool, 2022).

Social-capital architecture evaluates whether bonding, bridging, and linking ties fit the ecological and political scale of the problem while recognizing risks of exclusion or lock-in (Ros-Tonen & Derkyi, 2018; Westerink et al., 2020; Gütte & Roggero, 2022; Manlosa et al., 2023). Political equity assesses recognition, representation, decision influence, benefit distribution, gender inequality, and structural conflict (Yadav et al., 2017; Arai et al., 2021; Elias et al., 2024; Ansell et al., 2025; Torfing et al., 2026).

Livelihood security examines whether governance expands or constrains economic options, forest access, labor conditions, income control, and protection from disaster losses as rural economies change (Mawa et al., 2021; Bardsley et al., 2024; Aryal, 2025). Adaptive cross-scale coordination asks whether institutions can revise decisions in response to monitoring and connect the village, landscape, watershed, and higher policy levels through bridging organizations and learning processes (Lee & Baggio, 2021; Westerink et al., 2017; Zhao et al., 2024; Morante et al., 2025).

The framework distinguishes capacity, output, outcome, and resilience. Capacity includes trust, networks, leadership, learning, and institutional fit. Outputs include plans, agreements, restoration actions, enforcement routines, and benefit-

sharing rules. Outcomes are observed changes in forest condition, hydrological function, risk, livelihoods, or equity. Resilience is the ability to maintain or adapt these gains under shocks and longer-term change. This distinction prevents frequent meetings, high trust, or participation from

being misinterpreted as proof of environmental success. The six dimensions should therefore be monitored as a transparent dashboard, with trade-offs visible rather than hidden by a single composite score.

Table 4. Research agenda for testing collaborative hydrosocial forest governance

Evidence gap	Priority research question	Recommended design	Core measures	Decision contribution	Ref.
Governance studies rarely measure hydrological outcomes	Do stronger collaborative institutions produce measurable watershed improvement?	Longitudinal mixed-method watershed study	Network structure, trust, forest cover, erosion, discharge, flood indicators	Tests the full governance-to-hydrology pathway	Toda et al. (2023); Gujree et al. (2026)
Social capital is often treated as uniformly positive	Which combinations of bonding, bridging, and linking capital support adaptation without exclusion?	Social-network analysis plus qualitative institutional study	Tie types, centrality, trust, exclusion, decision access	Identifies network configurations rather than generic cohesion	Gütte and Roggero (2022); Westerink et al. (2020)
Collaboration may mask structural power	When does participation redistribute influence and benefits?	Panel survey, decision-process tracing, representation analysis	Voice, agenda control, benefit rules, gender, disadvantaged-group representation	Distinguishes participation from political equity	Arai et al. (2021); Yadav et al. (2017); Elias et al. (2024)
Conflict management is stronger for minor than fundamental disagreements	How can forest governance operate when actors hold incompatible values?	Comparative conflict-process studies	Conflict type, negotiation strategy, outcomes, legitimacy	Clarifies where consensus is possible and where negotiated pluralism is needed	Ansell et al. (2025); Torfing et al. (2026)
Hydrological governance is often institutionally fragmented	Which bridging arrangements best connect upstream and downstream actors?	Multi-level network and watershed governance analysis	Cross-scale ties, coordination frequency, shared rules, hydrological interdependence	Improves institutional fit to watershed processes	Lee and Baggio (2021); Galvez et al. (2020)
Adaptive learning is frequently asserted rather than measured	Does monitoring lead to actual rule revision and behavioral change?	Repeated action-research cycles	Monitoring results, deliberation records, rule changes, implementation	Tests adaptive governance as a causal mechanism	Westerink et al. (2017); Morante et al. (2025)
Rural livelihood dependence is changing	How do migration and diversification alter incentives for forest stewardship?	Household panel plus institutional and forest-condition monitoring	Livelihood portfolio, labor, forest use, participation, forest condition	Enables adaptive social-forestry policy under agrarian transition	Bardsley et al. (2024); Aryal (2025)
Digital monitoring may create new power asymmetries	Who controls environmental data and how does that affect governance?	Participatory digital-governance experiment	Data access, contribution, interpretation rights, decision use	Supports transparent community-accessible monitoring	Xu and Zhang (2020)
Trust deficits can persist historically	How does institutional repair alter later collaboration?	Longitudinal trust and grievance study	Historical grievances, trust, participation, compliance	Guides collaboration in landscapes with contested conservation histories	Rojas et al. (2024)

12. State of the Art: Knowledge Frontiers, Contradictions, and Positioning of the Review

12.1 Evolution of the Knowledge Frontier

The knowledge frontier has shifted from asking whether collaboration is desirable to explaining when and through which mechanisms it generates durable outcomes. Forestry scholarship increasingly connects collaborative governance with sustainable development, while adaptive-governance research emphasizes social-ecological systems, climate adaptation, and social learning (Wicaksono, 2023; Zhao et al., 2024). Social capital has likewise moved from a generic asset to a configuration of bonding, bridging, and linking relations that can enable cooperation or reinforce exclusion (Górriz-Mifsud et al., 2016; Gütte & Roggero, 2022; Toda et al., 2023). Recent work also brings power and hydrological performance to the center. Representation can affect benefit rules, facilitation can reduce some power imbalances, and gender inequality remains embedded in resource governance (Yadav et al., 2017; Arai et al., 2021; Elias et al., 2024). Theoretical advances reject the assumption that all conflict can be resolved through consensus (Ansell et al., 2025; Torfing et al., 2026). At the same time, forest-cover change is now linked directly to flood occurrence in a transboundary mountain landscape, extending evaluation beyond institutional quality toward measurable risk outcomes (Gujree et al., 2026).

12.2 Unresolved Integration Gaps and Contradictions

Despite conceptual progress, governance and biophysical evidence remain compartmentalized. Governance studies commonly measure trust, participation, networks, leadership, learning, and benefit distribution, while hydrological studies measure land cover, rainfall, floods, or other environmental conditions. Toda et al. (2023) identify the absence of direct forest-condition assessment in social-capital

studies, whereas Gujree et al. (2026) quantify a forest-flood association without testing the collaborative mechanisms that might change land-use trajectories. The missing link is an empirical chain from institutions to behavior to ecological response.

Scale, time, and trade-offs deepen this gap. Watershed processes cross administrative boundaries, while trust, livelihood dependence, and hydrological responses change at different rates (Lee & Baggio, 2021; Westerink et al., 2017; Rojas et al., 2024; Bardsley et al., 2024). High cohesion may coexist with exclusion, livelihood gains with ecological pressure, and procedural inclusion with weak environmental performance. Governance success should therefore remain multidimensional rather than masking these contradictions in a single index.

12.3 Positioning and Conceptual Advance of This Review

The distinctive contribution of this review is integrative rather than a claim that any individual component is wholly new. The Collaborative Hydrosocial Forest Governance Framework places ecological-hydrological integrity, collaborative capacity, social-capital architecture, political equity, livelihood security, and adaptive cross-scale coordination within one evaluative architecture. It further separates enabling capacity from outputs, measured outcomes, and resilience, so participation or trust is not treated as evidence of improved watershed function.

The synthesis advances four testable propositions. Hydrological benefits should be more likely where governance networks fit watershed scale; social capital should support environmental performance when bridging and linking ties counter exclusionary bonding and unequal power; equity and livelihood security should influence compliance and durability rather than operate as secondary co-benefits; and adaptive learning should become environmentally meaningful only when

repeated biophysical monitoring can trigger rule revision. Testing these propositions requires longitudinal, multi-level designs that combine networks, institutional analysis, participatory methods, remote sensing, and field or hydrological monitoring.

13. Implications for Policy and Practice

Policy should move from program-centered participation toward landscape-centered governance. Social-forestry groups, watershed agencies, local governments, conservation and disaster institutions, private actors, and civil society need coordination that reflects ecological processes and upstream-downstream interdependence, especially where watersheds cross jurisdictions (Gujree et al., 2026; Lee & Baggio, 2021).

Collaborative design should address power from the outset through accessible information, local facilitation, shared training, genuine decision rights, representation of disadvantaged groups, and workable grievance mechanisms (Arai et al., 2021; Yadav et al., 2017; Elias et al., 2024; Torfing et al., 2026). Monitoring should integrate social indicators with forest cover, restoration, erosion, hydrological variables, and disaster outcomes, with data accessible to participating communities (Xu & Zhang, 2020).

Adaptive learning also requires budgets and authority for reflection and rule revision, not monitoring alone (Apgar et al., 2017; Westerink et al., 2017; Morante et al., 2025). Livelihood policy should recognize declining or diversified forest dependence and support broader livelihood assets while retaining incentives for stewardship and equitable benefit sharing (Bardsley et al., 2024; Aryal, 2025).

CONCLUSION

Collaborative forest governance now faces a stricter standard of evidence. Research has clarified the importance of trust, networks, facilitation, learning, power, conflict, and participation, but these mechanisms are still

too often measured separately from the ecological and hydrological outcomes that environmental governance is expected to produce. The association between forest loss and flood occurrence reported by Gujree et al. (2026), together with the measurement gap identified by Toda et al. (2023), makes that separation increasingly difficult to defend.

The Collaborative Hydrosocial Forest Governance Framework responds by linking ecological-hydrological integrity, collaborative capacity, social-capital architecture, political equity, livelihood security, and adaptive cross-scale coordination. Its central proposition is that collaboration is a capacity, not an environmental outcome. A defensible claim of success requires evidence that legitimate collective action changes land-management behavior, improves forest and watershed condition, supports livelihoods, distributes benefits and burdens fairly, and remains adaptable under changing risk. Future research should therefore couple longitudinal social and institutional analysis with forest, hydrological, and disaster-risk measurement.

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