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Reframing Climate Change and Ecosystem Restoration: Water Governance, Societal Resilience, and Institutional Dynamics

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ABSTRACT

The issues of climate change and ecosystem degradation are becoming well-known and interrelated phenomena that require more than concern for the environment; they require consideration of social, institutional, and governance aspects. The paper is a critical review of how water governance, societal resilience, and institutional dynamics influence ecosystem restoration to be climate-resilient. The paper is a critical narrative review that synthesizes interdisciplinary literature to examine the effects of governance structures, institutional arrangements, and social processes on the success of restoration outcomes under climate stress. According to the findings, ecosystem restoration is not a simple technical intervention but a socio-cultural and political process that depends on the quality of governance, institutional coordination, and power relations. Disunity in governance structures, poor institutionalization, and stakeholder involvement continue to be major obstacles to successful and fair restoration. Simultaneously, resilience within society is not evenly distributed, and vulnerable groups are more exposed to risks and less adaptive. The discussion emphasizes the role of adaptive and polycentric governance structures, which increase flexibility, learning, and cross-scale coordination. The finding suggests a socio-institutional model that integrates to bridge the impacts of climate change with the restoration of ecosystems, governance systems, and resilience outcomes. It highlights how inclusive, adaptive, and coordinated policy solutions should be incorporated into restoration strategies to build resilience and equity. In addition, the research identifies the main gaps in the study, including the need for interdisciplinary methods, data-driven governance, and the incorporation of digital technologies into environmental decision-making. On balance, the present paper can stimulate further development of critical thinking about ecosystem restoration, showing how governance and institutional forces influence sustainable and fair climate change adaptation opportunities.

Introduction

Climate change and ecosystem degradation have become closely linked world issues and events with expansive social, political, and institutional impacts. The effects of climate change in the present day are no longer limited to biophysical disruptions; they are increasingly influencing the ways societies access water, sustain livelihoods, and govern common resources (Mehta 2024). Additional disruptions to hydrologic processes, such as increased floods, extended droughts, and so forth, also contribute to ecosystem degradation and reflect deficiencies in governance at various levels (Barendrecht et al. 2024). Consequently, the restoration of ecosystems is no longer perceived as an environmental intervention but as a broader socio-political approach associated with resilience, sustainability, and governance reform (Schweizer, van Kuijk, and Ghazoul 2021). The global policy culture has increasingly recognised the importance of restoring ecosystems in combating climate change and addressing societal vulnerability. The United Nations Decade on Ecosystem Restoration is built around the idea of restoration as a means to increase biodiversity, promote water security, aid climate adaptation, and contribute to the Sustainable Development Goals (Nelson et al. 2024). The reconstruction of wetlands, rivers, and riparian systems, in particular, is important for controlling hydrological processes and reducing climate-related risks (Nile et al. 2025). Nevertheless, ecological effectiveness is not the only factor that defines the success of restoration efforts; it is also shaped by governance frameworks, institutional forms, and social endorsement (Baker, Eckerberg, and Zachrisson 2014).

These dynamics revolve around water governance. In contrast to conventional water management, which is rather technical and operational, governance includes the political, institutional, and social processes of allocating, regulating, and even contesting water resources (Pahl-Wostl 2017). Climate change exerts greater strain on water governance systems because it increases uncertainty, intensifies resource competition, and exposes institutional Fragmentation (Taylor and Sonnenfeld 2017). Better governance, therefore, needs to be adaptive, multi-level, and participatory, capable of addressing the complex and changing environmental challenges (Newig and Fritsch 2009). Meanwhile, resilience in society has emerged as a major analytical tool for understanding how communities and institutions adapt to environmental change. Resilience is not about shock absorption; it encompasses adaptation, reorganization, and transformation as responses to disturbances (Kais and Islam 2016). Social capital, the quality of governance, institutional flexibility, and access to resources are among the factors that determine societal resilience in the context of climate change (Carmen et al. 2022). Notably, the distribution of resilience across populations is uneven because vulnerable groups tend to be more exposed to risk and have fewer adaptive abilities. This indicates the necessity of scrutinizing resilience as a socially constructed and mediated entity, rather than an objective that is neutral and technical.

Institutional processes are critical in determining the outcomes of governance and resilience capabilities. Complex institutional arrangements embodied in environmental governance systems are marked by formal and informal rules and changing power relationships (Beunen and Patterson 2019). Effective responses to climate change and ecosystem degradation are usually hampered by institutional Fragmentation, lack of coordination, and path dependency (Zelli 2011). Conversely, polycentric systems of governance, which are constituted of several interacting centres of decision-making, have demonstrated resilience, adaptability, and learning in complex social-ecological systems (Berkes 2017). These findings indicate that institutional design and governance architecture play an important role in restoring climate-resilient ecosystems. Although there is an increasing body of literature in the fields of climate change, ecosystem restoration, and governance, gaps remain. Much of the extant literature treats restoration as an ecological or technical matter, mostly overlooking social, political, and institutional factors that inform

implementation and results (Baker, Eckerberg, and Zachrisson 2014). On the other hand, the ecological basis of restoration is often not incorporated into governance studies, and thus they cannot address the environmental challenges in their totality. This disjointedness highlights the necessity of a unified system that will help connect the environment and social-science world-views. It is on this basis that this paper aims to reinvent climate change and ecosystem restoration through the intertwined perspectives of water governance, societal resilience, and institutional dynamics. Precisely, the goals of this review include: (i) synthesizing important theoretical and conceptual frameworks that connect climate change, restoration and governance; (ii) critically examining how institutions and governance systems contribute to attaining climate-resilient restoration results; and (iii) providing a policy implication and future research agenda that would be more responsive and integrated in how restoration strategies are implemented. The work takes a critical social-science approach to the issue. It can contribute to current debates on how governance systems can be improved to respond to climate change more sustainably and equitably.

Conceptual Underpinning

Reform: Climate Change and Ecosystem Restoration

Climate change has fundamentally altered the structure and functioning of ecosystems, accelerating the degradation of natural systems and diminishing their resilience. The increase in temperatures, changes in precipitation distribution, and the occurrence of extreme events, e.g., floods and droughts, have disrupted the ecological balance and water cycles (Woodward et al. 2016). The implications of these changes are far-reaching, not only for biodiversity but also for the human societies that rely on ecosystem services such as water regulation, food production, and climate mitigation (Pecl et al. 2017). One solution to such challenges has been ecosystem restoration. Restoration is the process of helping to restore degraded, damaged, or destroyed ecosystems, aimed at restoring ecological integrity and improving ecological services (Khan et al. 2024). Restoration is increasingly becoming a climate adaptation and mitigation measure, which can increase carbon sequestration, reduce disaster risks, and enhance water security. Nevertheless, the process of restoration is not only technical and ecological; it is also embedded in socio-political circumstances in which conflicting interests, governance forms, and institutional capabilities come into play (Elias, Joshi, and Meinzen-Dick 2021).

Water Governance: Water Concepts and Model

Water governance is a political, social, economic, and administrative system that affects water use, development, and management (Araral and Wang 2013). Governance is concerned with decision-making processes, stakeholder involvement, institutional setups, and policy frameworks, as compared to traditional water management systems, which are engineering-oriented (Seppälä 2002). Water governance is increasingly gaining prominence as a key measure for addressing unforeseen and complex issues arising from climate change. Integrated water resources management (IWRM) is one of the influential ideas in this field, and it advocates the harmonization of water, land, and other related resources development and management (Ibisch, Bogardi, and Borchardt 2016). Nevertheless, IWRM has been denounced because of problems in its implementation, such as institutional fragmentation and an inadaptable nature (Acheampong, Swilling, and Urama 2016). Recently, researchers have placed greater focus on the concept of polycentric governance, which entails several overlapping decision-making centres operating at various levels (Carlisle and Gruby 2019). Polycentric systems are more adaptive and resilient because they can be tested, learn, and be flexible in the face of fluctuating conditions (Lofthouse and Herzberg 2023).



Figure 1: Theoretical model of explaining the relations between climate change effects, ecosystem recovery objectives, water management, social resilience, and institutional processes in determining climate-resilient sustainability remedies

Resilience and Adaptive Capacity of Society

Resilience has now become a key concept in the practices of environmental change in societies. In ecological research, resilience was later applied to social systems, leading to the concept of social-ecological resilience (Folke 2006). Here, resilience means the ability of a system to absorb disturbances, adjust to change, and change where needed (Walker et al. 2004). The factors that influence societal resilience are diverse and include the quality of governance, social capital, institutional flexibility, and resource access (Goulden et al. 2013). A community with strong social bonds, a participatory governance system, and adaptive institutions would be better positioned to respond to the risks posed by climate change (Robinson and Berkes 2011). Nevertheless, resilience is not evenly distributed. The adaptive capacity of the vulnerable population may also be constrained by social inequalities, power dynamics, and marginalisation, leading to disproportionate resilience (Maru et al. 2014). It is important to note that resilience must be studied critically in the context of broader socio-political factors.

Institutional Dynamics: Formal and Informal Aspects

Institutions are very important for the development of environmental governance and resilience. Institutions may be perceived as the official rules, laws, and policies, together with the unofficial norms, practices, and social conventions that guide human behaviour (Ebbesson 2010). Institutions dictate resource allocation, decision-making, and conflict resolution in the context of water governance and ecosystem restoration. Institutional dynamics are seen as how institutions change

over time; this may take the form of adaptation, reform, and change (Young 2010). The problem of institutional Fragmentation is one of the issues in environmental governance in which various agencies and overlapping authorities act in the absence of coordination (Visseren-Hamakers 2015). This kind of Fragmentation can result in inefficiencies, policy conflicts, and reduced effectiveness of restoration work. Also, institutional change may be limited by path dependency, in which current policies and practices are likely to persist despite their ineffectiveness (Sorensen 2015). According to recent studies, the significance of adaptive governance, including flexible, learning-oriented institutional arrangements that can respond to uncertainty and change, is crucial (De Groot, Leendertse, and Arts 2020). Adaptive governance combines scientific knowledge, stakeholder involvement, and decision-making processes that are repeated as often as possible, making it more resilient and sustainable.

Interconnection of Governance, Resilience and Restoration

The relationships among water governance, societal resilience, and ecosystem restoration form the basis of this review. Restoration of the ecosystem requires ecological knowledge along with governance systems that facilitate coordination, participation, and accountability (Berkes 2017). Concurrently, governance systems shape the distribution of resilience within societies, thereby influencing adaptive capabilities and vulnerability (Gallopín 2006). Aligning with these relationships, institutional dynamics also mediate them by defining the flexibility and responsiveness of governance systems. For example, polycentric and adaptive governance systems have been demonstrated to increase resilience by facilitating learning, collaboration, and innovation (Berkes 2017). On the other hand, inflexible and disjointed institutions may impede the restoration process and exacerbate social inequity. There must then be an integrated conceptual framework to comprehend the interactions among climate change, ecosystem restoration, governance, and societal resilience. A framework of this nature must consider the multi-level and dynamic nature of governance systems, socio-political aspects of resiliency and the ecological underpinnings of restoration. The paper seeks to fill gaps in understanding climate-resilient ecosystem restoration within the social-science context.

Research Methodology

Research Design and Approach

The present study will use a critical narrative review to synthesize and evaluate the literature on climate change, ecosystem restoration, water governance, societal resilience, and institutional dynamics. Critical reviews, as opposed to systematic reviews, are geared toward the translation of interpretive, conceptual, and analytical information, as they seek to identify underlying assumptions, theoretical frameworks, and policy implications (Bullock et al. 2021). This method will be especially appropriate when one needs to analyse a topic that is interdisciplinary by nature and whose knowledge is scattered across various disciplines (Lach 2014). It has a social-science approach to the review, focusing on the processes of governance, institutional organisation, and societal reaction, rather than on technical or ecological aspects. Through a critical study of various literatures, the research aims to identify gaps, contradictions, and emerging themes used to restore climate-resilient ecosystems.

Thematic and Analytical Synthesis

The selected literature was analysed using a thematic synthesis methodology, which entails the identification, coding, and categorization of themes prevalent across the studies (Thomas and Harden 2008). The discussion was based around four fundamental dimensions: (i) climate change

and ecosystem restoration, (ii) water governance structures, (iii) societal resilience and adaptive capacity and (iv) institutional dynamics and governance structures. It was through the repetition of refinement of themes that interrelationships, tensions and overlaps between these dimensions were captured. Special consideration was paid to: the problems of governance and institutional obstacles; resilience outcomes across various social settings; and policy implications and applications. This method made it possible to create a comprehensive analytical framework for the interconnection of governance, resilience, and restoration from a social-science perspective.

Limitations of the Research Methods

Although it is very thorough, this article is limited in several ways. To begin with, the use of publications in English can also create a language bias, thereby excluding relevant studies from non-English settings (Neimann Rasmussen and Montgomery 2018). Second, the analysis is a critical narrative review and contains an element of interpretative judgment, which could affect the selection and interpretation of themes (Mura and Sharif 2017). Third, the interdisciplinary nature of the topic implies that some aspects are addressed selectively, especially in technical hydrological or ecological research, to remain focused on governance and social aspects. However, the methodological approach followed in the research offers a sound mechanism for integrating the varied and sophisticated literature, providing a meaningful understanding of governance and the societal implications of climate-resilient ecosystem restoration.

Climate Change and Ecosystem Restoration from a Social Perspective

The climate threat poses risks to the ecosystem

Climate change has exacerbated challenges to ecosystems worldwide, altering their structure, functioning, and ability to provide vital services. The increase in temperature and alterations in precipitation levels, along with the increasing rates of extreme events like floods, droughts, and heatwaves, have intensified the degradation of ecosystems and decreased ecological resilience (Seneviratne et al. 2021). Water-based systems (such as rivers, wetlands, and floodplains) are particularly susceptible because they depend directly on hydrological regimes (Colloff et al. 2016). These environmental changes carry significant social implications. Poor ecosystems undermine water security, agricultural productivity, and disaster risk reduction, thereby impacting livelihoods and making communities more vulnerable (Adger and Brown 2009). In most places, ecosystem destruction due to climate change adversely affects marginalised communities that depend on natural resources for subsistence (Thomas and Twyman 2005). Climate threats to ecosystems cannot be understood without social and governance contexts.

Restoration of the ecosystem through adaptation and mitigation

Ecosystem restoration has become a key topic in climate adaptation and mitigation. Restoring ecosystems can increase carbon capture, stabilize water, minimize the risk of disasters, and maintain biodiversity (Simonson et al. 2021). Wetland restoration can serve as an example, as it reduces flood peaks and enhances water quality, whereas forest restoration can stabilise soils and control local climate (Erwin 2009). Restoration projects also help raise social resilience by improving people's livelihoods, offering job opportunities, and enhancing their general well-being (Erbaugh and Oldekop 2018). The success of restoration as a climate approach, however, is subject to governance structures, institutional capabilities, and stakeholder involvement. In the absence of inclusive, well-organised governance systems, restoration initiatives might not yield equitable, sustainable results (Adekunle et al. 2013).

Social Implications of Restoration during Climate Stress

The process of ecosystem restoration is social in nature and involves multiple stakeholders, conflicting interests, and diverse knowledge systems. Climate change further complicates the situation by increasing uncertainty and conflict over resource use (Bustamante et al. 2019). For example, restoration work can be more ecologically oriented and less sensitive to local livelihoods, which can cause social friction and opposition from affected populations (Ullah 2024). Additionally, power relations and governance systems influence the outcomes of the restoration. The choices on what to revert, where to revert, and how to revert are frequently determined by political interests, economic benefits, and institutional abilities (Elmelund-Præstekær and Klitgaard 2012). This raises important concerns about equity, participation, and justice in restoration practices. The scholars have discussed that methods of social inclusion and active participation are critical to the recovery initiative to ensure that the needs and priorities of the local communities are met (Ngulube, Tatano, and Samaddar 2024).

Contending Discourses in Restoration Policy and Practice

The ongoing discussion of ecosystem restoration has diverse priorities and opinions due to conflicting narratives that shape how the topic is represented. On the one hand, restoration can be seen as a technical solution that aims to restore ecosystems and mitigate climate change. Conversely, it is becoming more of a socio-political process that entails governing, institutions, and social change (Change 2006). These are diverse accounts that have an impact on policy and practice. Technocratic orientations would lean towards standardised interventions and top-down decision-making, whereas more inclusive approaches would be relevant to participatory governance, the integration of local knowledge, and adaptive management (Butler et al. 2015). These opposing views may pose implementation problems, especially in the absence of institutional capacity to direct or in fragmented governance systems. Moreover, the idea of nature-based solutions (NBS) has become popular as a model that combines ecological restoration with social and economic goals (Faivre et al. 2017). NBS points out the potential of ecosystems regarding climate change, water security, and disaster risk reduction in society. Nonetheless, NBS can succeed only when governance systems strike a balance among ecological objectives, social equity, and economic factors.

Governance and Institutional Dynamics of Water

Water Systems Governance versus Management

The difference between water governance and water management is key to understanding the modern challenges of climate-resilient ecosystem restoration. Traditionally, water management is associated with technical and operational dimensions, such as infrastructure development, allocation processes, and resource efficiency. Water governance, on the contrary, includes the broader political, institutional, and social processes within which water decisions are made, implemented, and debated (Pahl-Wostl 2017). Governance encompasses formal policies, informal conventions, stakeholder involvement, and power relations that influence outcomes at different levels. This difference is especially relevant in the face of climate change, where technical remedies do not provide a satisfactory approach to solving complex, unpredictable problems. The governance system should be effective and based on adaptive, inclusive, and transparent decision-making that incorporates ecological knowledge alongside social and institutional consideration. This has led to a growing reliance on ecosystem restoration activities on governance systems that can coordinate across sectors, scales, and actors.

Multi-level and Polycentric Water Governance

Water governance takes place at various levels, including the local community, the national government and international institutions. Multi-level governance models emphasize the importance of coordination among these levels to address cross-boundary issues, such as river basin management and adaptation to climate change. Nevertheless, there is low vertical and horizontal coordination, resulting in disjointed policy implementation and inefficiencies. Centralization has given way to polycentric forms of governance that seem to be promising. Polycentric systems are composed of several semi-autonomous decision-making centres that interact and cooperate in the management of common resources. These systems improve flexibility through experimentation, learning and solutions specific to the situation. However, polycentric governance is also associated with problems such as coordination costs, overlapping responsibilities, and potential conflicts among actors. This is why proper implementation requires collaboration mechanisms, information exchange, and conflict management (Stepanova, Polk, and Saldert 2020).

Policy Incoherence and Institutional Fragmentation

One of the biggest obstacles to efficient water management and restoration of ecosystems is institutional Fragmentation. Fragmentation arises when there is insufficient coordination among institutions with overlapping or ambiguous mandates, resulting in inconsistent policies and inefficiencies. Water governance in most nations is fragmented, and within each sector, the industry has its own goals and objectives, regulatory bodies, and frameworks. The absence of integration between water management schemes and climate policies also aggravates such Fragmentation. Indicatively, the strategies associated with climate adaptation might not be consistent with current water management policies, leading to conflicting priorities and poor implementation. This lack of coherence will undermine the potential of ecosystem restoration as a climate-resilient solution, since coordinated efforts across sectors and institutions are key to success. To address fragmentation, institutional reform is needed to promote integration, coordination, and coherence among governance systems. This involves standardizing policies, defining roles and duties, and reinforcing inter-agency cooperation (Kamrul Ahsan 2023).

Power, Accountability and Decision-Making Processes

Water governance is also political in nature, defined by power relations, competing priorities, and institutional hierarchies. Water distribution, ecosystem restoration, and adaptation to climate change involve trade-offs among various actors, including governments, individual actors, and local communities. Power imbalances may dictate which interests are prioritized and who is not, influencing the decision-making process. Transparency and accountability are thus very important elements of good governance. Poor accountability systems may lead to corruption, mismanagement, and the inequitable allocation of resources. The idea of participatory forms of governance, where stakeholders are included in decision-making, has been advocated as a way to promote high levels of legitimacy, equity, and effectiveness. Nevertheless, involvement is not necessarily participatory or substantive, since marginalised groups might not have the resources or ability to participate. To establish a governance system that helps achieve equitable and sustainable ecosystem restoration, it is vital to understand the roles of power and accountability (Osborne et al. 2021).

Barriers to Governance in Supporting Climate-Resilient Ecosystem Restoration

Although there has been increasing awareness of the role of governance, several obstacles remain that are likely to impede efforts to restore ecosystems to climate resilience. They are: institutional

resistance to change and institutional rigidity; financial and technical capacity limitations; alignment among stakeholders; poor integration of scientific knowledge into policy; and poor understanding of the social and cultural context. However, in most instances, governance systems are reactive rather than proactive and focus on short-term responses rather than resilience. Moreover, the restoration process can be problematic due to land tenure, resource rights, and conflicting land uses, which complicate implementation and make it less efficient (Briassoulis 2019). The only solution to these obstacles is to adopt more adaptive, inclusive, and integrated forms of governance. These are strengthening institutional capacity, fostering cross-sectoral cooperation, and integrating resilience principles into policy and practice. By solving governance problems, one can make the process of restoring the ecosystem more effective as a measure to enhance climate adaptation and resilience in society.

Resilience of the Society and Community Adaptation

Community resilience theory and practice

The concept of resilience has been developing since its discovery in ecology and now also applies to social systems, leading to the emergence of social-ecological resilience. In that regard, the concept of resilience can be defined as the ability of communities and institutions to accommodate disturbances, adapt to changing environments, and reform in response to environmental stressors. In climate change discourse, communal resilience has emerged as one of the major frameworks for understanding how society responds to risks related to ecosystem degradation and water insecurity. As a matter of fact, resilience is not only a technical quality but also a social process influenced by governance, institutional structures, and socio-economic. The more developed the local institutions of communities, their access to resources, and decision-making processes based on participation, the more they are prepared to deal with the shock created by climate (Agarwal et al. 2012). Nevertheless, the issue of resilience should be scrutinized closely because, in certain instances, it may be used to hide latent inequalities and power dynamics that affect adaptive capacity.

Social Capital, Partaking and Local Knowledge

The aspect of social capital, which is networks, trust, and norms that enable group action, is very important in increasing the resilience of communities. Social networks are strong, allowing the sharing of information, the mobilisation of resources, and a coordinated response to the environment. Social capital in the ecosystem restoration context assists both collaborative governance and community participation in decision-making. Another important aspect of resilience is participation. Participatory and inclusive governance systems enable knowledge sharing, the airing of issues, and the impact on outcomes among stakeholders. However, local and indigenous knowledge systems offer precious insights into ecosystem dynamics and the sustainable management of resources. Incorporating this kind of knowledge into restoration programs will improve ecological performance and social legitimacy. However, it is not always fair to participate. Factors that may restrict the participation of marginalised groups in the process of governance include power imbalances, socioeconomic differences, and institutional constraints (De Freitas and Martin 2015). Thus, resilience improvement processes should consider issues of inclusion, equity, and representation.

Vulnerability, Inequality and Adaptive Capacity

The concept of resilience is closely related to vulnerability, since the ability to adjust to climate change differs across social groups and ecological regions. Income, resource access, education, and environmental exposure are issues that determine vulnerability. Climate change tends to

exacerbate existing inequalities, particularly among vulnerable populations with limited capacity to respond. One of the major determinants of resilience is adaptive capacity, or the ability to adapt to potential harm, capitalise on opportunities, and respond to outcomes. To build adaptive capacity, there is a need to invest in infrastructure, education, governance systems, and social protection. These initiatives, however, should be situation-specific, with the causes of vulnerability and resilience differing across socio-economic and cultural environments. Notably, resilience cannot be considered only as the capability to sustain the current systems. Transformational change may be required in certain instances to address structural inequalities and ensure long-term sustainability. This view emphasises the need for governance methods that facilitate not just transformation but also social transformation (Gillard et al. 2016).

Urban and Rural Dimensions of Resilience

There are major differences in the dynamics of resilience between urban and rural contexts. Cities are usually vulnerable to climate risks (floods, heat waves) due to population density, infrastructure strain, and socio-economic imbalance. Cities can also be better connected to resources, technology, and institutional capacity, allowing adaptation to be quicker. On the contrary, rural communities tend to be more directly reliant on the services provided by natural resources and ecosystems, and as such, they are highly sensitive to environmental changes. Inadequate access to infrastructure, financial resources and institutional support can also limit their adaptive capacity. Nevertheless, in rural populations, a robust social structure and traditional knowledge base can increase resilience. These differences are imperative for understanding how best to design context-specific policies and interventions that meet the challenges and opportunities of urban and rural contexts (Yu et al. 2024).

Comparative and Global Approaches to Community Adaptation

The comparative research shows substantial differences in resilience and adaptation between regions, and even greater differences between developed and developing countries. In most regions of the Global South, there is less institutional capacity, scarce resources, and governance issues that keep them poorly adapted to climate change. Concurrently, innovative, community-based adaptation strategies often manifest in areas that draw on local knowledge and social network. On the contrary, developed nations can be better equipped with institutional capacity and means of climate adaptation. Yet, they are also subject to issues of governance complexity, policy coordination, and inequality. All in all, the resilience of society and the adaptation of communities are complex processes influenced by social, institutional, and environmental factors. These dynamics are vital to be understood critically to develop governance systems that can restore ecosystems in ways that are just and sustainable amid climate change (Pandey and Ghosh 2023).

Crossings of Governance, Resilience and Restoration

Water governance, societal resilience and ecosystem restoration

Water governance is interconnected with the interpretation of climate adaptation in complex social-ecological systems. There is no independent functioning of these dimensions; instead, they create a dynamic, interdependent nexus in which governance structures determine resilience outcomes, and institutional dynamics influence the success of restoration initiatives. The following outcome is associated with governance systems and resilience. Governance regimes are decisive in defining the processes through which resilience is generated, shared, and maintained across societies. The level of resilience can be enhanced through adaptive and inclusive governance frameworks to facilitate coordination, learning, and adapting to environmental change. Conversely,

the system of rigid, centralized governance is often incapable of responding to uncertainty, thereby making it more vulnerable. Polycentric governance has been largely regarded as an important process of enhancing resilience. Polycentric systems enhance experimentation, knowledge exchange, and institutional learning because they allow the use of many decision-making centres at various levels. The empirical evidence indicates that these systems are better prepared to handle complex environmental issues such as climate change and ecosystem degradation (Rounsevell, Dawson, and Harrison 2010).

Institutional Change and Adaptive Ability

Adaptive capacity is significantly affected by institutional dynamics, which determine how governance systems respond to environmental change. Facilities that are flexible, learning-oriented, and responsive to stakeholder contributions have a higher chance of promoting resilience and sustainable restoration outcomes. Institutional rigidity, path dependency, and lack of coordination, on the other hand, may limit adaptation as well as the effectiveness of policy interventions. The adaptive governance structures are based on the need for iterative decision-making, stakeholder involvement, and the incorporation of scientific and local knowledge. These strategies make institutions more adaptive to uncertainty and complexity, thereby increasing ecological and social resilience (Welsh 2014).

Interactions among Ecosystems and the Society Feedback

The interaction between society and the ecosystem is described as a feedback loop: any alteration in the environment affects social systems, and the social reaction to environmental changes, in turn, affects ecological outcomes. For example, ecosystem degradation may reduce water availability and heighten vulnerability, thereby increasing the need for governance responses, e.g., restoration efforts. The effectiveness of such efforts, however, depends on institutional capability, the quality of governance, and social acceptance. Through these feedback loops, the need to think of ecosystem restoration as an evolutionary system of ecological and social systems becomes apparent. These interactions may have unintended consequences, including maladaptation or increased inequality when ignored (Magnan et al. 2016).

Towards an Integrated Socio-Institutional Framework

A coordinated structure that connects governance, resilience, and restoration is critical for addressing the realities of climate change. Such a framework must include: multi-level systems of governance, flexible and adaptive institutions, inclusive and participative decision-making and an appreciation of social and ecological interdependency. Recent literature highlights that climate-resilient restoration demands abandoning sectoral strategies in favour of holistic, system-based models of governance. This means crossing disciplinary boundaries and integrating ecological knowledge with social-science perspectives. It provides deeper insight into how societies can successfully respond to climate change by restoring ecosystems through the synthesis of knowledge from governance theory, resilience thinking, and institutional analysis (Berkes 2017).

Implications of Policy and Future Research

Enhancing Institutional Coordination and Governance Integration

The paper shows the need for more integrated, coordinated governance systems to facilitate climate-resilient ecosystem restoration. Divided institutional frameworks and sectoral islands are among the barriers to successful policy execution, especially with water-related ecosystems. Improving coordination among sectors, including water, agriculture, energy, and urban planning, is

necessary to promote consistency in climate adaptation and restoration measure. The policy frameworks ought to focus on integrating multi-level governance, which allows cross-country collaboration among local, regional, and national actors. This involves the creation of systems for exchanging information, making joint decisions, and resolving conflicts across institutional borders (Pardo, Gil-Garcia, and Luna-Reyes 2010). Moreover, it is possible to align climate policy with water governance to improve the effectiveness of restoration efforts and minimized policy conflict.

Building Promoting Communal and Participatory Governance

Inclusion in governance is important to ensure that ecosystem restoration activities are socially fair and context-specific. Adaptive capacity and resilience may also be improved by incorporating local and indigenous knowledge into restoration planning. Though the involvement should not be symbolic. The policies must address the inequality of power and the meaningful inclusion of vulnerable individuals in decision-making processes (Bell and Reed 2022). This involves institutional capacity development, access to information, and the creation of enabling environments to engage stakeholders.

Making Policies on Restoration Resilience

The restoration policies in the ecosystem should focus on resilience. This is achieved by developing interventions that increase adaptive capacity, decrease vulnerability, and promote sustainability over the long term. Policymakers should embrace adaptive governance strategies and focus on flexibility, learning, and multiple decision-making in situations of uncertainty. Social inequalities that affect vulnerability and adaptive capacity should also be incorporated into the integration of resilience into policy. This requires targeting marginalised populations, such as through resource accessibility, infrastructure, and social protection, to deliver equitable results. In this regard, ecosystem restoration must be perceived as a social development and resilience-building tool, rather than merely a goal in itself in the environmental sense (Adger and Hodbod 2014).

Future Research Directions

Although there has been an increasing interest in climate-resilient ecosystem restoration, there are still some gaps in the research. First, interdisciplinary solutions that incorporate social, ecological, and institutional viewpoints are needed. Future research needs to transcend the boundaries of the discipline and develop holistic frameworks capable of capturing the complexity of social-ecological systems (Schlueter et al. 2012). Second, there is a need to understand better the impact of data-driven governance and digital technologies on resilience and restoration. The fields of remote sensing, big data, and artificial intelligence offer new opportunities to monitor ecosystems, assess risks, and make informed decisions. Nevertheless, ethical, social, and institutional considerations must be taken into account when such technologies are incorporated into the governance system. Third, a better study of context-sensitive adaptation measures, especially in the Global South, where climate change proneness is greatest. Comparative research can be a valuable source of knowledge on the role that various governance systems and institutional arrangements play in shaping resilience outcomes (Aligica and Tarko 2014). Lastly, the political economy of restoration, such as power, allocation of resources, policy priorities and prioritization, needs to be critically discussed in future studies. The dynamics will be central in determining how to create an effective and equitable governance system(Whitley and Svensson 2025).

Conclusion

The discussed how the three aspects of water governance, societal resilience, and institutional dynamics interact to form climate-resilient ecosystem restoration. The results emphasize that the restoration of the ecosystem cannot be viewed solely in technical or ecological terms but is inherent in the social, political, and institutional context. The analysis shows that to achieve effective restoration, governance systems must be adaptive, inclusive, and well-coordinated. The weaknesses of accountability, institutional Fragmentation, and low stakeholder involvement remain major obstacles to achieving sustainable results. Simultaneously, resilience to climate change is unevenly distributed across society, and vulnerable groups will have greater difficulty coping with the change. It can be used to gain a clearer picture of climate-resilient ecosystem restoration by incorporating perspectives from governance, institutional theory, and resilience. It stresses that the policies should not only focus on ecological goals but also on social equity, institutional capacity, and the effectiveness of governance. Finally, the idea of reframing climate change and ecosystem restoration through a social-science perspective can offer useful insights into how societies can better overcome the challenges of environmental change. The work to be undertaken in the future is to reinforce governance systems, increase society's resilience, and encourage equitable and sustainable restoration practices. It is only through these combined efforts that ecosystem restoration can help advance climate action and long-term sustainability.

Reference

1. Acheampong, Ernest Nti, Mark Swilling, and Kevin Urama. 2016. "Developing a framework for supporting the implementation of integrated water resource management (IWRM) with a decoupling strategy." *Water Policy* 18 (6):1317-1333.
2. Adekunle, AA, Jim Ellis-Jones, Igbekele Ajibefun, RA Nyikal, Solomon Bangali, AO Fatunbi, and Alain Angé. 2013. "Agricultural innovation in sub-Saharan Africa: Experiences from multiple stakeholder approaches."
3. Adger, W Neil, and Katrina Brown. 2009. "Vulnerability and resilience to environmental change: ecological and social perspectives." *A companion to environmental geography*:109-122.
4. Adger, W Neil, and Jennifer Hodbod. 2014. "Ecological and social resilience." In *Handbook of sustainable development*, 91-102. Edward Elgar Publishing.
5. Agarwal, Arun, Nicolas Perrin, Ashwini Chhatre, Catherine S Benson, and Minna Kononen. 2012. "Climate policy processes, local institutions, and adaptation actions: mechanisms of translation and influence." *Wiley Interdisciplinary Reviews: Climate Change* 3 (6):565-579.
6. Aligica, Paul Dragos, and Vlad Tarko. 2014. "Institutional resilience and economic systems: Lessons from Elinor Ostrom's work." *Comparative Economic Studies* 56 (1):52-76.
7. Araral, Eduardo, and Yahua Wang. 2013. "Water governance 2.0: A review and second generation research agenda." *Water Resources Management* 27 (11):3945-3957.
8. Baker, Susan, Katarina Eckerberg, and Anna Zachrisson. 2014. "Political science and ecological restoration." *Environmental Politics* 23 (3):509-524.
9. Barendrecht, Marlies H, Alessia Matanó, Heidi Mendoza, Ruben Weesie, Melanie Rohse, Johanna Koehler, Marleen de Ruiter, Margaret Garcia, Maurizio Mazzoleni, and Jeroen CJH Aerts. 2024. "Exploring drought-to-flood interactions and dynamics: A global case review." *Wiley Interdisciplinary Reviews: Water* 11 (4):e1726.
10. Bell, Karen, and Mark Reed. 2022. "The tree of participation: a new model for inclusive decision-making." *Community Development Journal* 57 (4):595-614.

11. Berkes, Fikret. 2017. "Environmental governance for the anthropocene? Social-ecological systems, resilience, and collaborative learning." *Sustainability* 9 (7):1232.
12. Beunen, Raoul, and James J Patterson. 2019. "Analysing institutional change in environmental governance: Exploring the concept of 'institutional work'." *Journal of environmental planning and management* 62 (1):12-29.
13. Briassoulis, Helen. 2019. "Combating land degradation and desertification: The land-use planning quandary." *Land* 8 (2):27.
14. Bullock, Heather L, John N Lavis, Michael G Wilson, Gillian Mulvale, and Ashleigh Miatello. 2021. "Understanding the implementation of evidence-informed policies and practices from a policy perspective: a critical interpretive synthesis." *Implementation Science* 16 (1):18.
15. Bustamante, Mercedes MC, José Salomão Silva, Aldicir Scariot, Alexandre Bonesso Sampaio, Daniel Luis Mascia, Edenise Garcia, Edson Sano, Geraldo Wilson Fernandes, Giselda Durigan, and Iris Roitman. 2019. "Ecological restoration as a strategy for mitigating and adapting to climate change: lessons and challenges from Brazil." *Mitigation and Adaptation Strategies for Global Change* 24 (7):1249-1270.
16. Butler, JRA, RM Wise, TD Skewes, EL Bohensky, N Peterson, W Suadnya, Y Yanuartati, T Handayani, P Habibi, and K Puspadi. 2015. "Integrating top-down and bottom-up adaptation planning to build adaptive capacity: a structured learning approach." *Coastal Management* 43 (4):346-364.
17. Carlisle, Keith, and Rebecca L Gruby. 2019. "Polycentric systems of governance: A theoretical model for the commons." *Policy studies journal* 47 (4):927-952.
18. Carmen, Esther, Ioan Fazey, Helen Ross, Melissa Bedinger, Fiona M Smith, Katrin Prager, Kerri McClymont, and David Morrison. 2022. "Building community resilience in a context of climate change: The role of social capital." *Ambio* 51 (6):1371-1387.
19. Change, Global Environmental. 2006. "Choose democracy: environmentalists' socio-political responsibility." *Global Environmental Change* 16:115-119.
20. Colloff, Matthew J, Sandra Lavorel, Russell M Wise, Michael Dunlop, Ian C Overton, and Kristen J Williams. 2016. "Adaptation services of floodplains and wetlands under transformational climate change." *Ecological Applications* 26 (4):1003-1017.
21. De Freitas, Cláudia, and Graham Martin. 2015. "Inclusive public participation in health: policy, practice and theoretical contributions to promote the involvement of marginalised groups in healthcare." *Social science & medicine* 135:31-39.
22. De Groot, Bert, Wim Leendertse, and Jos Arts. 2020. "Building adaptive capacity through learning in project-oriented organisations in infrastructure planning." *Urban Planning* 5 (1):33-45.
23. Ebbesson, Jonas. 2010. "The rule of law in governance of complex socio-ecological changes." *Global Environmental Change* 20 (3):414-422.
24. Elias, Marlène, Deepa Joshi, and Ruth Meinzen-Dick. 2021. "Restoration for whom, by whom? A feminist political ecology of restoration." *Ecological Restoration* 39 (1-2):3-15.
25. Elmelund-Præstekær, Christian, and Michael Baggesen Klitgaard. 2012. "Policy or institution? The political choice of retrenchment strategy." *Journal of European Public Policy* 19 (7):1089-1107.
26. Erbaugh, James T, and Johan A Oldekop. 2018. "Forest landscape restoration for livelihoods and well-being." *Current Opinion in Environmental Sustainability* 32:76-83.
27. Erwin, Kevin L. 2009. "Wetlands and global climate change: the role of wetland restoration in a changing world." *Wetlands Ecology and management* 17 (1):71-84.
28. Faivre, Nicolas, Marco Fritz, Tiago Freitas, Birgit De Boissezon, and Sofie Vandewoestijne. 2017. "Nature-Based Solutions in the EU: Innovating with nature to

address social, economic and environmental challenges." *Environmental research* 159:509-518.
29. Folke, Carl. 2006. "Resilience: The emergence of a perspective for social–ecological systems analyses." *Global environmental change* 16 (3):253-267.
30. Gallopín, Gilberto C. 2006. "Linkages between vulnerability, resilience, and adaptive capacity." *Global environmental change* 16 (3):293-303.
31. Gillard, Ross, Andrew Gouldson, Jouni Paavola, and James Van Alstine. 2016. "Transformational responses to climate change: beyond a systems perspective of social change in mitigation and adaptation." *Wiley Interdisciplinary Reviews: Climate Change* 7 (2):251-265.
32. Goulden, Marisa C, W Neil Adger, Edward H Allison, and Declan Conway. 2013. "Limits to resilience from livelihood diversification and social capital in lake social–ecological systems." *Annals of the Association of American Geographers* 103 (4):906-924.
33. Ibisch, Ralf B, Janos J Bogardi, and Dietrich Borchardt. 2016. "Integrated water resources management: concept, research and implementation." *Integrated water resources management: concept, research and implementation*:3-32.
34. Kais, Shaikh Mohammad, and Md Saidul Islam. 2016. "Community capitals as community resilience to climate change: Conceptual connections." *International journal of environmental research and public health* 13 (12):1211.
35. Kamrul Ahsan, AHM. 2023. "Inter-agency Coordination." In *Global Encyclopedia of Public Administration, Public Policy, and Governance*, 6887-6891. Springer.
36. Khan, Shaista, TH Masoodi, MA Islam, Tahera Arjumand, Azeem Raja, Aafaq Ahmad Parrey, Anushka Pallavi, and Javaid H Bhat. 2024. "Ecosystem degradation to restoration: a challenge." In *Climate Crisis: Adaptive Approaches and Sustainability*, 19-33. Springer.
37. Lach, Denise. 2014. "Challenges of interdisciplinary research: Reconciling qualitative and quantitative methods for understanding human–landscape systems." *Environmental management* 53 (1):88-93.
38. Lofthouse, Jordan K, and Roberta Q Herzberg. 2023. "The continuing case for a polycentric approach for coping with climate change." *Sustainability* 15 (4):3770.
39. Magnan, Alexandre K, E Lisa Freja Schipper, Maxine Burkett, Sukaina Bharwani, Ian Burton, Siri Eriksen, François Gemenne, Johan Schaar, and Gina Ziervogel. 2016. "Addressing the risk of maladaptation to climate change." *Wiley Interdisciplinary Reviews: Climate Change* 7 (5):646-665.
40. Maru, Yiheyis Taddele, Mark Stafford Smith, Ashley Sparrow, Patricia F Pinho, and Opha Pauline Dube. 2014. "A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities." *Global Environmental Change* 28:337-350.
41. Mehta, Prerna. 2024. "The impact of climate change on the environment, water resources, and agriculture: a comprehensive review." *Climate, Environment and Agricultural Development: A Sustainable Approach Towards Society*:189-201.
42. Mura, Paolo, and Saeed Pahlevan Sharif. 2017. "Narrative analysis in tourism: A critical review." *Scandinavian Journal of Hospitality and Tourism* 17 (2):194-207.
43. Neimann Rasmussen, Lauge, and Paul Montgomery. 2018. "The prevalence of and factors associated with inclusion of non-English language studies in Campbell systematic reviews: a survey and meta-epidemiological study." *Systematic reviews* 7 (1):129.
44. Nelson, CR, JG Hallett, AE Romero Montoya, A Andrade, C Besacier, V Boerger, K Bouazza, R Chazdon, E Cohen-Shacham, and D Danano. 2024. *Standards of practice to guide ecosystem restoration: A contribution to the United Nations Decade on Ecosystem Restoration 2021–2030*: Food & Agriculture Org.

45. Newig, Jens, and Oliver Fritsch. 2009. "Environmental governance: participatory, multi-level–and effective?" *Environmental policy and governance* 19 (3):197-214.
46. Ngulube, Nombulelo Kitsepile, Hirokazu Tatano, and Subhajyoti Samaddar. 2024. "Toward participatory participation: A community perspective on effective engagement in post-disaster recovery and reconstruction." *Community Development* 55 (6):895-915.
47. Nile, Basim K, Riyadh Jasim Mohammed Al-Saadi, Layth Abdulameer, Najah ML Al Maimuri, and Ahmed N Al-Dujaili. 2025. "Climate change impacts on river hydraulics: a global synthesis of hydrological shifts, ecological consequences, and adaptive strategies." *Water Conservation Science and Engineering* 10 (2):48.
48. Osborne, Tracey, Samara Brock, Robin Chazdon, Susan Chomba, Eva Garen, Victoria Gutierrez, Rebecca Lave, Manon Lefevre, and Juanita Sundberg. 2021. "The political ecology playbook for ecosystem restoration: Principles for effective, equitable, and transformative landscapes." *Global Environmental Change* 70:102320.
49. Pahl-Wostl, Claudia. 2017. "An evolutionary perspective on water governance: From understanding to transformation." *Water Resources Management* 31 (10):2917-2932.
50. Pandey, Bhanu, and Annesha Ghosh. 2023. "Urban ecosystem services and climate change: a dynamic interplay." *Frontiers in Sustainable Cities* 5:1281430.
51. Pardo, Theresa A, J Ramon Gil-Garcia, and Luis F Luna-Reyes. 2010. "Collaborative governance and cross-boundary information sharing: Envisioning a networked and IT-enabled public administration." *The future of public administration around the world: The Minnowbrook perspective*:129-39.
52. Pecl, Gretta T, Miguel B Araújo, Johann D Bell, Julia Blanchard, Timothy C Bonebrake, I-Ching Chen, Timothy D Clark, Robert K Colwell, Finn Danielsen, and Birgitta Evengård. 2017. "Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being." *Science* 355 (6332):eaai9214.
53. Robinson, Lance W, and Fikret Berkes. 2011. "Multi-level participation for building adaptive capacity: Formal agency-community interactions in northern Kenya." *Global environmental change* 21 (4):1185-1194.
54. Rounsevell, MDA, TP Dawson, and PA Harrison. 2010. "A conceptual framework to assess the effects of environmental change on ecosystem services." *Biodiversity and Conservation* 19 (10):2823-2842.
55. Schlueter, Maja, Ryan RJ Mcallister, Robert Arlinghaus, Nils Bunnefeld, Klaus Eisenack, Frank Hoelker, Eleanor J MILNER-GULLAND, Birgit Müller, Emily Nicholson, and Martin Quaas. 2012. "New horizons for managing the environment: A review of coupled social-ecological systems modeling." *Natural Resource Modeling* 25 (1):219-272.
56. Schweizer, Daniella, Marijke van Kuijk, and Jaboury Ghazoul. 2021. "Perceptions from non-governmental actors on forest and landscape restoration, challenges and strategies for successful implementation across Asia, Africa and Latin America." *Journal of Environmental Management* 286:112251.
57. Seneviratne, Sonia I, Xuebin Zhang, Muhammad Adnan, Wafae Badi, Claudine Dereczynski, A Di Luca, Subimal Ghosh, Iskhaq Iskandar, James Kossin, and Sophie Lewis. 2021. "Weather and climate extreme events in a changing climate." *Climate change 2021: The physical science basis: Working group I contribution to the sixth assessment report of the intergovernmental panel on climate change*:1513-1766.
58. Seppälä, Osmo T. 2002. "Effective water and sanitation policy reform implementation: need for systemic approach and stakeholder participation." *Water Policy* 4 (4):367-388.
59. Simonson, William D, Ellen Miller, Alastair Jones, Shaenandhoa García-Rangel, Hazel Thornton, and Chris McOwen. 2021. "Enhancing climate change resilience of ecological

restoration—A framework for action." *Perspectives in Ecology and Conservation* 19 (3):300-310.
60. Sorensen, Andre. 2015. "Taking path dependence seriously: An historical institutionalist research agenda in planning history." *Planning perspectives* 30 (1):17-38.
61. Stepanova, Olga, Merritt Polk, and Hannah Saldert. 2020. "Understanding mechanisms of conflict resolution beyond collaboration: An interdisciplinary typology of knowledge types and their integration in practice." *Sustainability Science* 15 (1):263-279.
62. Taylor, Peter Leigh, and David A Sonnenfeld. 2017. Water crises and institutions: Inventing and reinventing governance in an era of uncertainty. Taylor & Francis.
63. Thomas, David SG, and Chasca Twyman. 2005. "Equity and justice in climate change adaptation amongst natural-resource-dependent societies." *Global environmental change* 15 (2):115-124.
64. Thomas, James, and Angela Harden. 2008. "Methods for the thematic synthesis of qualitative research in systematic reviews." *BMC medical research methodology* 8 (1):45.
65. Ullah, Ayat. 2024. "Forest landscape restoration and its impact on social cohesion, ecosystems, and rural livelihoods: Lessons learned from Pakistan." *Regional Environmental Change* 24 (1):26.
66. Visseren-Hamakers, Ingrid J. 2015. "Integrative environmental governance: enhancing governance in the era of synergies." *Current Opinion in Environmental Sustainability* 14:136-143.
67. Walker, Brian, Crawford S Holling, Stephen R Carpenter, and Ann Kinzig. 2004. "Resilience, adaptability and transformability in social–ecological systems." *Ecology and society* 9 (2).
68. Welsh, Marc. 2014. "Resilience and responsibility: governing uncertainty in a complex world." *The geographical journal* 180 (1):15-26.
69. Whitley, Meredith A, and Per G Svensson. 2025. "Governance structures and processes in interorganizational collaboratives: The critical role of power and equity." *Human Service Organizations: Management, Leadership & Governance* 49 (1):26-43.
70. Woodward, Guy, Núria Bonada, Lee E Brown, Russell G Death, Isabelle Durance, Clare Gray, Sally Hladyz, Mark E Ledger, Alexander M Milner, and Steve J Ormerod. 2016. "The effects of climatic fluctuations and extreme events on running water ecosystems." *Philosophical Transactions of the Royal Society B: Biological Sciences* 371 (1694).
71. Young, Oran R. 2010. "Institutional dynamics: Resilience, vulnerability and adaptation in environmental and resource regimes." *Global Environmental Change* 20 (3):378-385.
72. Yu, Yang, Desmond Appiah, Bernard Zulu, and Kofi Asamoah Adu-Poku. 2024. "Integrating rural development, education, and management: Challenges and strategies." *Sustainability* 16 (15):6474.
73. Zelli, Fariborz. 2011. "The fragmentation of the global climate governance architecture." *Wiley Interdisciplinary Reviews: Climate Change* 2 (2):255-270.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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