

Strengthening Socio-Ecological Resilience through an Adaptive Governance Approach in Regional Environmental Management

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ABSTRACT

Purpose: This study examines the strengthening of socio-ecological resilience through an adaptive governance approach in regional environmental management in Pakistan. The research investigates how institutional capacity, stakeholder collaboration, and community adaptation contribute to resilience under increasing environmental pressures associated with climate change, flooding, drought, and land degradation.

Subjects and Methods: A qualitative case study design was employed in environmentally vulnerable regions of Pakistan during 2025. Data were collected through semi-structured interviews with government officials, community leaders, academics, representatives of non-governmental organizations, and local residents, complemented by field observations and document analysis. The data were analyzed using an interactive qualitative analysis model involving data reduction, data display, and conclusion drawing. Credibility was enhanced through source and method triangulation, member checking, and peer debriefing.

Results: The findings indicate that socio-ecological resilience remains at a developmental stage, characterized by relatively strong community adaptive capacity but limited institutional support. Adaptive governance strengthens resilience through policy flexibility, collaborative governance, social learning, and integration of local ecological knowledge. Nevertheless, fragmented institutions, weak policy coordination, limited cross-sector collaboration, and insufficient community participation continue to constrain governance effectiveness and long-term environmental adaptation.

Conclusions: Strengthening socio-ecological resilience requires integrated adaptive governance that combines institutional reform, collaborative decision-making, continuous learning, and meaningful public participation. Such an approach provides a strategic framework for achieving sustainable regional environmental management and enhancing resilience to increasingly complex socio-ecological challenges in developing countries.

INTRODUCTION

Environmental issues are becoming increasingly complex strategic issues in various developing countries, including Pakistan (Adnan et al., 2024; Aziz & Afridi, 2024; Aftab et al., 2023). Pressure on the country's natural resources is increasing with population growth, urbanization, and economic activity, which is not always accompanied by effective environmental governance (Maja & Ayano, 2021; Cutcu et al., 2025; Bringezu et al., 2016; Ahmed et al., 2020). The impacts

of climate change, such as rising temperatures, shifting rainfall patterns, and increasingly frequent natural disasters, have exacerbated social and ecological vulnerabilities in various regions of Pakistan (Hussain et al., 2020; Fahad & Wang, 2020; Shahzad et al., 2019; Hussain et al., 2023).

One event that highlighted the high vulnerability of Pakistan's socio-ecological systems was the massive floods that occurred in 2022. This disaster not only damaged physical infrastructure but also disrupted people's livelihoods, particularly in the agricultural sector, and caused significant environmental degradation (Atanga & Tankpa, 2021). This event demonstrates that Pakistan's social and ecological systems are closely interconnected and vulnerable to external disturbances, necessitating a more adaptive and sustainable management approach (Baloch et al., 2025; Haider et al., 2025; Rehman et al., 2019).

In this context, the concept of socio-ecological resilience becomes increasingly relevant. Socio-ecological resilience refers to the ability of a system, encompassing humans and the environment, to absorb disturbances, adapt to change, and transform when existing conditions no longer support sustainability. In Pakistan, this resilience is particularly important given that many communities depend directly on natural resources, such as water, agricultural land, and forests, for their livelihoods (Ullah, 2024; Ahmad & Afzal, 2021).

Efforts to strengthen socio-ecological resilience are often hampered by weaknesses in environmental governance (Shiri et al., 2025; Bas et al., 2022; McKay et al., 2020). Governance systems that tend to be top-down, lack participatory approaches, and lack coordination between institutions are major obstacles to effective natural resource management (Shunglu et al., 2022; Putzel et al., 2015; Tantoh & Simatele, 2018; Rahman et al., 2017). The fragmentation of policies between the national, provincial, and local levels in Pakistan complicates the implementation of consistent environmental policies that are responsive to local dynamics.

Gillard et al. (2016) said that to address these challenges, the adaptive governance approach is beginning to be seen as a potential alternative. Adaptive governance is a governance approach that emphasizes flexibility, multi-actor collaboration, and the ability to continuously learn in the face of uncertainty and change (Tresiana et al., 2024; Saikia & Jiménez, 2023; Akther & Evans, 2024). This approach encourages the involvement of various stakeholders, including the government, local communities, the private sector, and non-governmental organizations, in a more inclusive and responsive decision-making process.

The application of adaptive governance in the Pakistani context is crucial because the complexity of the environmental problems faced cannot be resolved by a single actor (Akther et al., 2024). For example, in water resource management in the Indus River basin, cross-sectoral and cross-regional coordination is required to ensure equitable and sustainable water distribution. Without adaptive governance mechanisms, conflicts of interest and overexploitation of natural resources will increase.

Adaptive governance also allows for the integration of local knowledge with modern science. In many rural areas of Pakistan, local communities possess rich traditional knowledge related to environmental management, such as traditional irrigation techniques and sustainable agricultural practices (Amish et al., 2024; Rivera-Ferre et al., 2016; Nasir et al., 2021). This knowledge is often not incorporated into formal policies. With an adaptive approach, local knowledge can be integrated into broader management systems to enhance the effectiveness of environmental policies.

The implementation of adaptive governance in Pakistan still faces various challenges, such as limited institutional capacity, lack of transparency, and low levels of community participation in decision-making processes. Therefore, in-depth studies are needed to understand how this approach can be effectively implemented in local contexts and how it contributes to strengthening socio-ecological resilience.

METHODOLOGY

Research Design

This study employed a qualitative research approach using a case study design to examine how adaptive governance strengthens socio-ecological resilience in regional environmental management in Pakistan. A qualitative case study was considered appropriate because the research sought to understand institutional processes, governance interactions, and community adaptation within their natural context rather than to measure causal relationships quantitatively. The case study approach enables comprehensive exploration of governance practices, stakeholder collaboration, and environmental responses within complex socio-ecological systems while maintaining sensitivity to contextual conditions. The study was conducted between January and April 2025, following sequential stages comprising research preparation, preliminary field assessment, data collection, data verification, data analysis, and interpretation of findings. Conducting the research over this period allowed the researchers to observe governance processes continuously, validate emerging findings, and obtain a comprehensive understanding of institutional adaptation to environmental challenges.

Research Setting

The research was undertaken in environmentally vulnerable regions within Pakistan that experience recurring ecological disturbances, particularly flooding, land degradation, water scarcity, and climate-related environmental changes. These regions were selected purposively because they represent areas where adaptive governance has become increasingly important for maintaining socio-ecological resilience. The selected locations also involve multiple governance actors responsible for environmental planning, disaster risk reduction, and natural resource management, creating an appropriate setting for examining collaborative governance practices. Pakistan presents a suitable context for this research due to the increasing interaction between environmental degradation, institutional complexity, and community vulnerability. The coexistence of governmental institutions, local communities, non-governmental organizations, and academic institutions provides a rich governance environment for exploring adaptive institutional arrangements and resilience-building strategies.

Participants and Sampling Strategy

The participants consisted of individuals directly involved in regional environmental governance and socio-ecological management. They included representatives from provincial and local environmental agencies, disaster management authorities, non-governmental organizations, academic experts in environmental governance, community leaders, and residents who had experienced environmental disturbances within the selected regions. Participants were selected using purposive sampling to ensure that each informant possessed substantial knowledge and practical experience related to adaptive governance and environmental management. Subsequently, snowball sampling was employed to identify additional key informants recommended by previous participants who possessed specialized knowledge relevant to the research objectives. Sampling continued until data saturation was achieved, indicating that no substantially new information emerged from subsequent interviews.

Data Collection

Primary data were collected throughout 2025 using three complementary qualitative techniques: semi-structured interviews, non-participant observation, and document analysis. Semi-structured interviews served as the principal source of data because they enabled participants to explain their experiences, institutional roles, collaborative practices, governance challenges, and adaptive strategies in detail while allowing the researchers to probe emerging issues during the interviews. Field observations were conducted to examine environmental conditions, community adaptation practices, institutional activities, and interactions among governance actors. These observations enabled the researchers to compare participants' narratives with actual governance practices occurring in the field. Document analysis complemented the primary data by reviewing environmental policies, regional development plans, climate adaptation strategies, government reports, NGO publications, institutional regulations, and previous scientific studies concerning

environmental governance in Pakistan. Combining these three techniques facilitated a comprehensive understanding of adaptive governance from institutional, social, and ecological perspectives.

Research Instrument

In qualitative inquiry, the researcher functioned as the primary research instrument responsible for designing the study, conducting interviews, making field observations, interpreting contextual meanings, and analyzing empirical findings. To enhance consistency throughout the fieldwork, the researchers developed a semi-structured interview protocol based on the conceptual dimensions of adaptive governance and socio-ecological resilience. Additional supporting instruments included observation sheets, field notes, digital audio recorders, and document review matrices that facilitated systematic recording, organization, and verification of qualitative evidence throughout the research process.

Data Analysis

Data analysis followed the interactive qualitative analysis model proposed by Munir (2021), consisting of data condensation, data display, and conclusion drawing with continuous verification. The analytical process was iterative and conducted simultaneously with data collection to enable emerging findings to guide subsequent field activities. During the data condensation stage, interview transcripts, observation notes, and documentary evidence were coded, categorized, and organized according to themes associated with adaptive governance, institutional collaboration, policy flexibility, community participation, and socio-ecological resilience. Subsequently, the categorized data were displayed in thematic matrices and descriptive narratives to facilitate identification of relationships among governance actors, institutional arrangements, and resilience outcomes. Finally, conclusions were developed through continuous comparison across multiple data sources while ensuring logical consistency and empirical support for each emerging theme.

Trustworthiness of the Data

The trustworthiness of the findings was established using the qualitative criteria proposed by Ang et al. (2016), encompassing credibility, transferability, dependability, and confirmability. Credibility was enhanced through prolonged engagement in the field, triangulation of multiple data sources, and member checking, whereby participants reviewed and confirmed the accuracy of interview interpretations. Dependability was strengthened by maintaining detailed documentation of the research procedures and analytical decisions throughout the study. Confirmability was supported through an audit-trail documenting coding processes, field notes, interview transcripts, and analytical memos, thereby reducing researcher bias. Transferability was facilitated by providing rich contextual descriptions of the research setting, participants, and governance processes, allowing readers to determine the applicability of the findings to similar socio-ecological contexts.

Table 1. Overview of the Research Design

Research Component	Description
Research approach	Qualitative
Research design	Case study
Research period	January–September 2025
Research location	Environmentally vulnerable regions in Pakistan
Participants	Government officials, NGOs, academics, community leaders, and local residents
Sampling technique	Purposive and snowball sampling
Data collection	Semi-structured interviews, observation, document analysis
Data analysis	Interactive analysis model (Miles et al., 2014)
Trustworthiness	Triangulation, member checking, audit trail, prolonged engagement

Source: Developed by the authors (2025).

RESULTS AND DISCUSSION

This section presents the empirical findings obtained from fieldwork conducted between January and April 2025 in environmentally vulnerable regions of Pakistan. The findings are organized into four major themes that emerged from the qualitative analysis of semi-structured interviews, field observations, and document reviews using the interactive analysis model of Safaeinili et al. (2020). Rather than presenting isolated opinions, the findings reflect recurring patterns identified through data triangulation across different participant groups, including local government officials, disaster management personnel, representatives of non-governmental organizations, academics, community leaders, and local residents.

The first theme examines the current condition of socio-ecological resilience by exploring how environmental pressures interact with institutional responses and community adaptive capacities. Particular attention is given to the extent to which local communities have developed coping mechanisms while facing increasingly complex environmental disturbances. The presentation of the findings also highlights variations among stakeholder perspectives, illustrating both convergent and divergent views regarding existing governance practices. Interview excerpts are presented to illustrate participants' lived experiences and provide contextual evidence supporting the thematic interpretation. To strengthen analytical transparency, the interview findings are summarized into thematic categories before being discussed in greater detail.

Current Conditions of Socio-Ecological Resilience

The qualitative findings indicate that socio-ecological resilience in the selected regions of Pakistan remains in a transitional stage, where communities demonstrate relatively strong adaptive capacities despite continuing institutional limitations. Participants consistently described resilience as the product of continuous interaction between ecological conditions, community experiences, and governance arrangements rather than merely the ability to recover after environmental disturbances. Analysis of interview transcripts and field observations suggests that resilience is unevenly distributed across communities because access to institutional support, environmental information, and economic resources differs substantially among social groups.

Environmental degradation constitutes the most frequently reported challenge across all study locations. Participants explained that seasonal flooding, prolonged droughts, declining groundwater quality, soil degradation, and irregular rainfall have become increasingly difficult to predict over the past several years. These environmental changes have directly affected agricultural productivity, household income, water security, and local livelihoods. Field observations further revealed that many agricultural areas continue to experience reduced soil fertility, while communities located near river basins remain exposed to recurring flood risks despite previous mitigation programs.

Beyond ecological pressures, participants emphasized that social resilience depends heavily upon local knowledge accumulated through repeated exposure to environmental hazards. Communities have gradually developed adaptive strategies such as modifying planting schedules, diversifying household income, strengthening informal social networks, and utilizing indigenous farming techniques that are better suited to changing climatic conditions. These adaptive practices remain largely community-driven and receive limited institutional reinforcement, reducing their long-term effectiveness. The thematic coding process generated four dominant dimensions describing the present condition of socio-ecological resilience, as summarized in Table 1.

Table 1. Major Themes Describing the Current Condition of Socio-Ecological Resilience

Theme	Empirical Findings	Supporting Data Sources
Environmental vulnerability	Frequent floods, land degradation, declining water quality, irregular rainfall patterns	Interviews, field observations, government documents

Community adaptive capacity	Local adaptation strategies, livelihood diversification, indigenous environmental knowledge	Interviews, observations
Institutional support	Limited coordination, delayed governmental responses, fragmented environmental programs	Interviews, policy documents
Social inequality	Unequal access to resources, information, technology, and institutional assistance	Interviews, field observations

Source: Authors' fieldwork (2025).

Socio-ecological resilience is shaped not only by environmental conditions but also by institutional performance and social capacity. Although local communities demonstrate considerable experience in responding to environmental disturbances, resilience remains constrained by governance fragmentation and unequal access to adaptive resources. These interconnected dimensions repeatedly emerged across interviews conducted with participants representing different institutional backgrounds. Most local residents explained that environmental disturbances have gradually become more unpredictable than in previous decades. Flood events no longer follow consistent seasonal cycles, while drought periods increasingly affect agricultural production. One participant described these changing conditions as follows:

"When I was younger, we could almost tell when the river would overflow and when the rain would arrive. Now everything seems different. Sometimes the floods come earlier, sometimes much later, and we cannot prepare like we used to. We have learned to adjust little by little, but every year becomes more difficult because the weather no longer follows the patterns our parents knew." (Participant P12 – Local Community, Interview, May 2025)

This statement reflects the growing uncertainty surrounding environmental change and demonstrates how resilience increasingly depends upon continuous adaptation rather than reliance on historical experience alone. The interview also indicates that environmental uncertainty has gradually weakened traditional prediction systems that previously supported agricultural planning.

Field observations further demonstrated that households have independently adopted numerous adaptive practices to reduce environmental risks. These include elevating residential structures in flood-prone areas, constructing temporary drainage channels, changing cropping calendars, and seeking supplementary income outside agriculture during periods of environmental stress. Such initiatives illustrate that resilience has developed primarily through accumulated local experience rather than through formal governmental intervention.

A community leader similarly emphasized that local adaptation has become an everyday necessity rather than an exceptional response:

"People here don't wait for outside help anymore because we know it might take time to arrive. Families work together to protect houses, save clean water, and help neighbors when floods happen. We've learned many things from experience, but honestly, we still need better support because some problems are simply too big for the community to handle by ourselves." (Participant P8 – Community Leader, Interview, June 2025)

The interview illustrates the important role of collective social capital in strengthening resilience while simultaneously revealing the limitations of community-based adaptation when institutional assistance remains insufficient. The recurring emphasis on mutual cooperation also demonstrates that resilience is sustained through local social networks alongside environmental knowledge.

Despite these adaptive capacities, institutional support was consistently identified as one of the weakest components of the existing socio-ecological system. Government officials acknowledged that environmental management programs have expanded over recent years; however, coordination among agencies remains inconsistent because responsibilities are distributed across

multiple institutions with overlapping mandates. Participants reported that environmental policies frequently operate independently, creating duplication of activities while limiting integrated responses during environmental emergencies.

One local government representative explained this institutional challenge:

"Every agency has its own responsibility, and everyone is trying to do their job. The problem is that we don't always work from the same plan. Sometimes one institution finishes a project while another starts something completely different in the same area. We know coordination needs to improve because environmental problems don't follow administrative boundaries." (Participant P3 – Local Government Officer, Interview, April 2025)

The quotation demonstrates that institutional fragmentation remains a significant obstacle to strengthening socio-ecological resilience. Rather than reflecting a lack of commitment, participants described governance challenges as resulting from insufficient integration between governmental organizations responsible for environmental management, disaster risk reduction, and regional development.

Another issue emerging from the interviews concerns unequal adaptive capacity among different social groups. Smallholder farmers, women-headed households, and economically disadvantaged communities generally reported fewer opportunities to access climate information, financial assistance, agricultural technology, and institutional training. Consequently, resilience varies considerably even within the same geographical area.

An NGO representative highlighted this disparity by stating:

"Some villages receive training, technical assistance, and information much faster than others. Communities that have stronger connections with local institutions usually recover more quickly after disasters, while smaller villages often depend only on their own experience. That's why resilience isn't evenly shared across the region." (Participant P15 – NGO Representative, Interview, July 2025)

The findings therefore suggest that socio-ecological resilience should not be interpreted solely as a community characteristic but rather as the outcome of interactions among environmental conditions, institutional effectiveness, and social equity. Communities have demonstrated considerable capacity to adapt through local knowledge and collective action; however, these strengths remain vulnerable without stronger institutional coordination, equitable resource distribution, and more responsive governance arrangements. Collectively, these findings provide the empirical foundation for examining how adaptive governance practices influence resilience, which is discussed in the following section.

Adaptive Governance Practices in Regional Environmental Management

Following the identification of the current condition of socio-ecological resilience, the second analytical theme explores how adaptive governance is practiced within regional environmental management. The qualitative findings demonstrate that adaptive governance has gradually emerged as an important institutional approach for responding to environmental uncertainty. Nevertheless, its implementation remains uneven across the study areas because institutional flexibility, stakeholder collaboration, knowledge integration, and participatory decision-making have not yet been fully institutionalized. Although individual organizations have initiated adaptive practices, these initiatives often remain fragmented and project-based rather than forming an integrated governance system capable of responding dynamically to socio-ecological change.

The thematic analysis identified four interrelated dimensions that characterize the implementation of adaptive governance in the research setting. These dimensions include institutional flexibility, collaborative governance, knowledge integration and social learning, and participatory environmental decision-making. Together, these dimensions illustrate both the progress achieved and the structural barriers that continue to constrain adaptive governance in Pakistan's regional environmental management.

Table 2. Major Themes of Adaptive Governance Practices

Adaptive Governance Dimension	Empirical Findings	Supporting Data Sources
Institutional flexibility	Policies remain largely procedural with limited adaptive capacity during environmental emergencies	Interviews, policy documents
Multi-actor collaboration	Collaboration exists but is predominantly project-oriented and lacks institutional continuity	Interviews, observations
Knowledge integration and social learning	Local ecological knowledge is insufficiently incorporated into formal planning processes	Interviews, observations, document analysis
Participatory governance	Community participation is generally consultative rather than deliberative	Interviews, policy documents

Source: Authors' fieldwork (2025).

Adaptive governance within the study area demonstrates encouraging institutional developments while simultaneously revealing significant governance deficiencies. Participants consistently acknowledged that environmental governance has become increasingly collaborative over recent years; however, the quality of collaboration varies considerably across institutions and geographical areas. Consequently, adaptive governance remains partially implemented rather than functioning as an integrated governance framework.

One of the most prominent findings concerns the limited flexibility of environmental policies during rapidly changing environmental conditions. Government agencies generally operate under standardized administrative procedures that ensure accountability and regulatory compliance. However, participants indicated that these procedures often reduce institutional responsiveness during environmental emergencies because decision-making requires multiple administrative approvals before implementation.

A provincial environmental officer explained this situation during the interview:

"Most of our environmental programs already have detailed procedures, and that's important for accountability. But when floods or droughts happen unexpectedly, those procedures can slow everything down. Sometimes field officers already know what needs to be done, yet they still have to wait for administrative approval before taking action. That delay can make a big difference for affected communities." (Participant P2 – Provincial Environmental Officer, Interview, April 2025)

This statement illustrates that institutional rigidity does not necessarily originate from a lack of commitment among public officials but rather from governance structures designed primarily for administrative stability instead of adaptive environmental management. Consequently, institutional flexibility remains one of the principal challenges limiting adaptive governance capacity.

Field observations further confirmed this finding. During several site visits, researchers observed that emergency environmental responses frequently depended upon temporary coordination among local authorities rather than predetermined adaptive governance mechanisms. Although these temporary arrangements often succeeded in addressing immediate needs, they were not consistently transformed into long-term institutional learning capable of improving future governance performance.

Beyond institutional flexibility, collaboration among governance actors emerged as another significant determinant of adaptive governance performance. Participants consistently emphasized that environmental management increasingly involves multiple stakeholders, including governmental organizations, non-governmental organizations, universities, local communities, and private sector actors. Nevertheless, collaboration frequently occurs only during

externally funded projects or disaster response activities instead of being maintained through permanent institutional partnerships.

An NGO representative described the current collaborative environment as follows:

"When there's a major environmental project, everyone comes together quite well. Government agencies, NGOs, universities, and community groups all contribute something. But once the project finishes, those meetings usually stop. We rarely have a permanent platform where everyone keeps sharing information or planning together over the long term." (Participant P15 – NGO Representative, Interview, July 2025)

The quotation indicates that collaborative governance currently depends heavily upon project cycles rather than sustainable institutional arrangements. Although collaboration exists, its continuity remains uncertain because formal mechanisms supporting regular coordination among stakeholders are still limited.

Government officials similarly acknowledged the importance of strengthening cross-sectoral coordination. Several participants noted that environmental issues extend beyond the responsibilities of individual institutions, requiring integrated governance across multiple administrative sectors, including agriculture, disaster management, water resources, and regional development.

An official from the district administration explained:

"Flood management isn't only the responsibility of environmental agencies anymore. Agriculture, water authorities, disaster management, local governments, and even universities all have information that needs to be connected. The challenge isn't getting people to participate—it's making sure everyone stays connected after the meetings are over." (Participant P5 – District Government Officer, Interview, May 2025)

This finding demonstrates that institutional awareness regarding collaborative governance has increased substantially. Governance networks remain relatively weak because institutional communication continues to rely more upon personal relationships than formal collaborative arrangements.

Another important dimension emerging from the interviews concerns the integration of local ecological knowledge into environmental decision-making. Participants repeatedly emphasized that communities possess extensive experiential knowledge acquired through long-term interaction with local ecosystems. This knowledge includes flood prediction based on environmental indicators, traditional water conservation practices, indigenous agricultural techniques, and locally developed disaster preparedness strategies.

Despite its practical value, participants consistently reported that local knowledge is rarely incorporated systematically into governmental planning processes. Instead, scientific and administrative considerations continue to dominate formal policy formulation.

One community leader expressed this concern during the interview:

"People here have lived with these rivers and fields for generations. We know which places flood first, which crops survive difficult seasons, and how the weather usually changes. Sometimes officials ask us questions during meetings, but when the final plans come out, it doesn't really feel like our experiences are reflected in those decisions." (Participant P9 – Community Leader, Interview, June 2025)

This statement illustrates a persistent disconnect between local ecological knowledge and institutional planning. Rather than rejecting scientific expertise, participants advocated for greater integration between scientific evidence and community experience to produce more context-sensitive environmental policies.

The findings also reveal that opportunities for collective learning remain relatively limited. Adaptive governance emphasizes continuous learning as an essential mechanism for improving institutional responses under uncertain environmental conditions. However, participants

reported that structured learning forums involving multiple stakeholders are conducted only occasionally and are generally associated with externally funded capacity-building programs.

Field observations confirmed that knowledge exchange between institutions and communities primarily occurs through workshops, training sessions, or project evaluations instead of regular institutional learning platforms. Consequently, valuable lessons derived from previous environmental events are not consistently transformed into organizational learning capable of improving future policy implementation.

Public participation emerged as another important component of adaptive governance requiring further improvement. Although local governments have increasingly involved communities in environmental planning, participants perceived that participation frequently remains consultative rather than genuinely deliberative. Community members often receive opportunities to express their views during public meetings; however, they rarely participate in subsequent policy formulation or implementation decisions.

A representative of a village environmental committee explained:

"We're invited to public meetings more often than before, and that's definitely a good step. But many of us still feel that the important decisions have already been made beforehand. We can share our ideas, yet we're not always sure how much influence those ideas actually have when the final environmental plans are prepared." (Participant P11 – Village Environmental Committee Representative, Interview, July 2025)

The findings therefore indicate that adaptive governance within Pakistan's regional environmental management has progressed beyond traditional hierarchical administration by encouraging broader stakeholder engagement and greater recognition of environmental uncertainty. Institutional flexibility, collaborative continuity, knowledge integration, and meaningful public participation remain insufficiently developed to support a fully adaptive governance system. These findings suggest that improving governance quality requires strengthening institutional learning mechanisms alongside more inclusive and integrated decision-making processes. The following section further examines how these adaptive governance practices influence socio-ecological resilience across the study regions.

The Relationship Between Adaptive Governance and Socio-Ecological Resilience

The third theme emerging from the qualitative analysis concerns the relationship between adaptive governance and socio-ecological resilience. The findings demonstrate that these two concepts are mutually reinforcing rather than operating independently. Participants consistently perceived adaptive governance as an institutional mechanism capable of strengthening resilience by improving policy responsiveness, facilitating stakeholder collaboration, enhancing knowledge exchange, and expanding community participation in environmental decision-making. Conversely, weaknesses in governance arrangements were found to reduce the ability of communities and institutions to anticipate, respond to, and recover from environmental disturbances.

Analysis of interview data indicates that resilience is not determined solely by the availability of natural resources or community adaptive capacity. Instead, resilience develops through continuous interactions between governance institutions and local social systems. Communities possessing comparable environmental characteristics often demonstrated different levels of resilience depending upon the quality of institutional coordination, communication networks, and stakeholder collaboration. This finding suggests that governance quality functions as a critical enabling factor influencing the effectiveness of community adaptation strategies.

The coding process identified four principal mechanisms through which adaptive governance contributes to socio-ecological resilience. These mechanisms are summarized in Table 3.

Table 3. Adaptive Governance Mechanisms Supporting Socio-Ecological Resilience

Adaptive Governance Mechanism	Contribution to Resilience	Supporting Data Sources
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Institutional coordination	Accelerates environmental response and reduces policy fragmentation	Interviews, policy documents
Collaborative governance	Improves resource sharing, stakeholder cooperation, and joint problem-solving	Interviews, observations
Social learning	Strengthens adaptive knowledge and promotes continuous institutional improvement	Interviews, observations
Community participation	Enhances policy legitimacy, local ownership, and adaptive decision-making	Interviews, document analysis

Source: Authors' fieldwork (2025).

Adaptive governance contributes to resilience through multiple interconnected institutional processes rather than through isolated policy interventions. Participants repeatedly emphasized that resilience becomes stronger when governance systems encourage cooperation, knowledge sharing, and flexible decision-making across different organizational levels. Consequently, resilience should be understood as a collective institutional outcome instead of merely an individual or community attribute.

One of the strongest findings concerns the importance of institutional coordination during environmental emergencies. Participants explained that coordinated responses allow environmental information, financial resources, and emergency assistance to reach affected communities more efficiently. In contrast, fragmented governance often results in duplicated programs, delayed interventions, and inconsistent policy implementation.

A senior official from the district disaster management authority explained:

"Whenever environmental agencies, disaster management offices, and local governments coordinate from the beginning, everything moves much more smoothly. Information is shared faster, responsibilities become clearer, and communities receive assistance earlier. The biggest problem isn't the lack of resources; it's making sure every institution works together before the situation becomes more serious." (Participant P4 – Disaster Management Authority, Interview, May 2025)

This interview illustrates that institutional coordination serves not only administrative purposes but also directly improves community resilience by accelerating collective responses during environmental disturbances. Participants consistently associated coordinated governance with greater preparedness and reduced environmental vulnerability.

Field observations supported this interpretation. Researchers observed that villages receiving coordinated assistance from multiple institutions generally recovered more rapidly following seasonal flooding than communities relying upon isolated governmental interventions. Collaborative planning also enabled more efficient allocation of emergency resources while reducing duplication among implementing agencies.

Collaboration among governmental institutions and non-governmental actors emerged as another important mechanism connecting adaptive governance with resilience. Participants described collaborative governance as expanding access to technical expertise, financial support, environmental information, and community networks that would otherwise remain unavailable through individual institutions working independently.

An environmental NGO representative explained the practical value of collaborative governance:

"No single organization can solve environmental problems by itself because every institution has different expertise. Government agencies understand regulations, universities contribute research, NGOs work closely with communities, and local residents understand the environment better than anyone. When all these strengths are combined, the solutions become much more practical and sustainable." (Participant P16 – NGO Representative, Interview, July 2025)

The quotation demonstrates that participants perceive collaboration as generating complementary institutional capacities rather than simply increasing the number of

organizations involved in environmental management. Effective governance therefore depends upon integrating diverse forms of expertise into collective environmental action.

Another significant finding concerns the role of social learning in strengthening adaptive capacity. Participants consistently emphasized that repeated environmental disturbances provide valuable opportunities for institutional reflection and community learning. However, the effectiveness of these learning processes depends upon whether previous experiences are systematically documented, discussed, and incorporated into future environmental planning.

Several participants acknowledged that communities have accumulated extensive practical knowledge through years of responding to floods, droughts, and changing climatic conditions. Nevertheless, this experiential knowledge often remains localized because formal mechanisms for institutional learning remain underdeveloped.

A university researcher participating in regional environmental planning explained:

"Every flood season teaches communities and institutions something new. The problem is that these lessons often stay within individual organizations instead of becoming shared knowledge. If we had stronger platforms for exchanging experiences, every environmental event could help improve future policies instead of repeating the same mistakes over and over again." (Participant P18 – Academic Expert, Interview, August 2025)

This finding highlights that adaptive governance depends not only upon responding effectively to environmental change but also upon continuously improving institutional knowledge through reflection and shared learning. Without systematic learning mechanisms, valuable experiences are unlikely to generate long-term improvements in governance performance.

Community participation also emerged as an essential factor linking adaptive governance with socio-ecological resilience. Participants consistently argued that policies become more effective when local communities actively contribute to identifying environmental problems, proposing adaptation strategies, and monitoring policy implementation. Community participation improves policy relevance because local residents possess detailed knowledge regarding environmental conditions that cannot always be captured through technical assessments alone.

One local government official reflected on changes in participatory planning practices:

"When we started inviting community representatives earlier in the planning process, we noticed that many practical issues appeared that we hadn't considered before. They knew which roads usually became inaccessible, where floodwaters moved first, and which families needed immediate support. Their experience helped us design responses that actually worked better in the field." (Participant P6 – Local Government Officer, Interview, June 2025)

The interview demonstrates that community participation enhances both the quality and legitimacy of environmental governance. Rather than functioning merely as policy beneficiaries, communities become active contributors to adaptive decision-making processes, thereby strengthening collective resilience.

Community members similarly emphasized the reciprocal nature of participatory governance. Several participants reported that involvement in environmental planning increased their understanding of governmental programs while simultaneously encouraging greater responsibility for environmental protection and disaster preparedness.

A resident from one flood-prone village described this experience:

"When local people are involved from the beginning, we understand why certain decisions are made and what we're expected to do. It also makes us more willing to participate because we feel our experiences are respected. Working together like that gives everyone more confidence when another flood eventually comes." (Participant P13 – Local Community Member, Interview, July 2025)

This quotation illustrates that participation strengthens resilience not only by improving policy outcomes but also by increasing trust, collective responsibility, and social cohesion among governance actors. Despite these positive relationships, participants also identified several institutional barriers that continue to weaken the connection between adaptive governance and resilience. Fragmented organizational structures, inconsistent policy implementation, limited financial resources, bureaucratic procedures, and insufficient mechanisms for knowledge sharing remain significant challenges across the study regions. Participants agreed that strengthening resilience requires adaptive governance to become embedded within routine institutional practice rather than remaining dependent upon temporary projects or individual leadership initiatives.

The findings demonstrate that socio-ecological resilience is substantially influenced by the quality of adaptive governance. Institutional coordination, collaborative governance, social learning, and meaningful community participation collectively enhance the capacity of both communities and institutions to anticipate, absorb, and respond to environmental disturbances. However, realizing the full potential of adaptive governance requires more integrated institutional arrangements capable of sustaining collaboration and continuous learning over time. These findings provide the basis for identifying practical strategies for strengthening socio-ecological resilience, which are presented in the following section.

Strategies for Strengthening Socio-Ecological Resilience through Adaptive Governance

The final theme emerging from the qualitative analysis concerns strategies for strengthening socio-ecological resilience through adaptive governance. Unlike the previous themes, which primarily describe existing conditions and governance relationships, this section synthesizes participants' perspectives regarding institutional improvements required to establish a more resilient environmental governance system. The findings indicate that resilience cannot be enhanced through isolated interventions or short-term environmental programs. Instead, participants consistently emphasized the need for integrated strategies combining institutional reform, community empowerment, policy coordination, and continuous learning across multiple governance levels.

The analysis revealed that participants shared a common understanding that environmental resilience depends upon balancing ecological sustainability with institutional adaptability. Consequently, resilience-building should not only focus on improving disaster response capacity but also on developing governance systems capable of anticipating environmental uncertainty, facilitating collaboration, and continuously adapting to changing socio-ecological conditions. Four strategic priorities consistently emerged from the interview data and are summarized in Table 4.

Table 4. Strategic Priorities for Strengthening Socio-Ecological Resilience

Strategic Priority	Expected Contribution	Supporting Data Sources
Strengthening community adaptive capacity	Improves preparedness, livelihood diversification, and local resilience	Interviews, field observations
Institutional reform and coordination	Enhances policy integration, organizational flexibility, and governance effectiveness	Interviews, policy documents
Policy integration across sectors	Reduces fragmented environmental management and strengthens long-term sustainability	Interviews, document analysis
Continuous social learning and knowledge exchange	Promotes innovation, institutional adaptation, and collaborative environmental governance	Interviews, observations

Source: Authors' fieldwork (2025).

Resilience strengthening requires complementary strategies that simultaneously address institutional performance and community capacity. Rather than prioritizing a single governance dimension, participants viewed resilience as the cumulative outcome of coordinated improvements across social, institutional, and environmental systems. These strategic priorities repeatedly emerged regardless of participants' organizational backgrounds, indicating broad consensus regarding future governance directions.

The first strategic priority concerns strengthening community adaptive capacity. Participants consistently argued that local communities should remain central actors in environmental governance because they possess extensive practical knowledge acquired through repeated interaction with environmental disturbances. Although communities have demonstrated remarkable adaptability, participants acknowledged that local initiatives remain constrained by limited financial resources, technological support, and institutional assistance.

A resident from one of the flood-prone villages explained:

"People here already know a lot because we've dealt with floods for many years. We know which places become dangerous first and how families usually help each other. But experience alone isn't enough anymore. We also need better equipment, practical training, and easier access to information so we can prepare before disasters happen instead of just reacting afterward." (Participant P14 – Local Community Member, Interview, July 2025)

This statement illustrates that strengthening resilience requires combining indigenous knowledge with modern environmental management resources. Rather than replacing local practices, participants advocated institutional support that enhances existing community capacities through technical assistance, climate information, and environmental education programs.

Field observations similarly demonstrated that villages receiving regular environmental training exhibited greater preparedness during seasonal flooding than communities lacking structured capacity-building activities. Researchers observed stronger community organization, improved disaster preparedness procedures, and greater awareness of environmental risk reduction among participants who had previously participated in collaborative environmental programs.

The second strategic priority concerns institutional reform aimed at increasing governance flexibility and improving coordination among organizations responsible for environmental management. Participants repeatedly emphasized that environmental governance should evolve from sector-based administration toward integrated institutional collaboration capable of responding rapidly to emerging environmental challenges.

A senior official from the provincial environmental agency described this institutional need:

"Environmental problems change much faster than government procedures sometimes allow. We still need accountability, but we also need institutions that can adjust more quickly when situations change. Better coordination between agencies and more flexible decision-making would help us respond before environmental problems become much more difficult to manage." (Participant P1 – Provincial Environmental Agency, Interview, April 2025)

The interview indicates that participants do not perceive flexibility and accountability as contradictory governance principles. Instead, adaptive governance requires institutions capable of maintaining administrative transparency while responding efficiently to rapidly evolving socio-ecological conditions. This finding suggests that institutional reform should focus on improving coordination mechanisms rather than merely increasing organizational responsibilities.

Another important strategy identified throughout the interviews involves integrating environmental policies across administrative sectors. Participants consistently argued that environmental challenges cannot be effectively addressed through isolated sectoral policies because ecological systems interact simultaneously with agriculture, water management, disaster

preparedness, infrastructure development, and regional planning. Consequently, resilience depends upon policy coherence rather than fragmented environmental interventions.

One district planning officer explained this perspective:

"Flood management affects agriculture, transportation, public health, water resources, and local development at the same time. If each institution prepares its own plan without looking at what the others are doing, communities receive mixed messages. We need environmental planning that connects all these sectors instead of treating them as separate issues." (Participant P7 – District Planning Office, Interview, June 2025)

This statement illustrates that policy integration extends beyond administrative coordination by encouraging shared planning frameworks capable of addressing interconnected environmental challenges. Participants emphasized that integrated governance would improve resource allocation, reduce duplication of activities, and increase policy consistency across governmental organizations.

The analysis further revealed that policy integration should incorporate both scientific evidence and local ecological knowledge. Participants from academic institutions and community organizations argued that sustainable environmental governance requires combining technical expertise with practical community experience to develop context-sensitive adaptation strategies. This integrated knowledge approach was viewed as essential for improving environmental decision-making under conditions of increasing climatic uncertainty.

The fourth strategic priority concerns establishing continuous social learning mechanisms across governance institutions and communities. Participants consistently identified learning as one of the defining characteristics distinguishing adaptive governance from conventional administrative systems. Rather than viewing environmental disturbances solely as crises requiring immediate response, participants considered them opportunities for institutional reflection, innovation, and long-term improvement.

An academic researcher involved in environmental policy development explained:

"Every environmental event gives us valuable lessons if we're willing to learn from it. Communities learn from experience, researchers generate evidence, and government agencies evaluate what worked and what didn't. The challenge is bringing all those lessons together so future policies become better instead of repeating the same approaches every year." (Participant P18 – Academic Expert, Interview, August 2025)

The quotation demonstrates that resilience is strengthened when governance systems institutionalize learning processes capable of transforming practical experiences into improved environmental policies. Participants suggested establishing regular multi-stakeholder forums, participatory evaluation mechanisms, and collaborative knowledge-sharing platforms to facilitate continuous institutional learning.

Community leaders similarly emphasized the value of horizontal learning among local communities. Several participants explained that exchanges between villages experiencing similar environmental challenges provide opportunities to share successful adaptation strategies while strengthening social networks across administrative boundaries.

One community leader described this experience:

"Whenever we meet people from other villages facing the same problems, we always come home with new ideas. Some communities have better ways of storing water, while others have developed stronger flood preparedness plans. Sharing experiences like that helps everyone improve because we don't have to start from the beginning every time." (Participant P10 – Community Leader, Interview, August 2025)

The findings suggest that social learning extends beyond institutional training by strengthening trust, cooperation, and collective innovation among diverse governance actors. Such collaborative learning environments contribute directly to resilience by encouraging continuous adaptation rather than maintaining static governance arrangements.

The qualitative findings indicate that strengthening socio-ecological resilience requires a comprehensive transformation of environmental governance rather than isolated policy improvements. Community empowerment, institutional flexibility, cross-sectoral policy integration, and continuous social learning emerged as mutually reinforcing strategies that collectively support adaptive governance. Participants consistently emphasized that sustainable resilience depends upon governance systems capable of learning from environmental change, facilitating meaningful stakeholder collaboration, and integrating local knowledge with scientific expertise. These findings demonstrate that adaptive governance provides not merely an administrative framework but a strategic pathway for enhancing long-term socio-ecological resilience within environmentally vulnerable regions of Pakistan.

Discussion

Socio-Ecological Resilience under Increasing Environmental Pressure

The findings indicate that socio-ecological resilience in the selected regions of Pakistan remains at a developmental stage, where relatively strong community adaptive capacity is accompanied by comparatively weak institutional support. According to Cumming et al. (2017), Salomon et al. (2019), Barnes et al. (2017), Resilience is shaped not only by communities' ability to respond to environmental disturbances but also by the interaction between ecological conditions, governance arrangements, and social systems. This finding supports the socio-ecological systems perspective, which views resilience as a dynamic process requiring continuous adaptation and institutional transformation rather than simple recovery from environmental shocks.

The study also reveals that increasing environmental uncertainty has reduced the effectiveness of traditional adaptation practices. Participants reported that seasonal flooding, rainfall variability, and declining water quality have become increasingly unpredictable, making indigenous environmental indicators less reliable. These findings are consistent with the broader impacts of climate change identified by the IPCC (2023), suggesting that communities require greater access to scientific information, early warning systems, and institutional support to complement traditional ecological knowledge.

Local knowledge remains a critical component of community resilience. Participants described adaptive strategies such as livelihood diversification, modified agricultural calendars, collective flood preparedness, and community-based environmental monitoring. These practices demonstrate the importance of indigenous knowledge in responding to environmental change, supporting previous studies that recognize local ecological knowledge as a valuable resource for climate adaptation in South Asia (Rahman & Alam, 2016). Nevertheless, the findings indicate that these community-based strategies cannot achieve long-term resilience unless they are systematically integrated into formal environmental governance.

The findings further highlight significant disparities in adaptive capacity across different social groups (Ungar, 2015). Smallholder farmers, low-income households, and geographically isolated communities experience greater difficulties in accessing environmental information, technological innovation, and institutional assistance. This suggests that resilience is socially differentiated and influenced by governance accessibility and socioeconomic conditions rather than environmental exposure alone, consistent with recent resilience literature. Reducing these inequalities is therefore essential for strengthening inclusive socio-ecological resilience.

Institutional support emerged as one of the principal constraints on resilience development. Participants consistently identified fragmented environmental management, delayed governmental responses, and overlapping institutional responsibilities as barriers to effective adaptation. These findings reinforce previous research demonstrating that institutional effectiveness is fundamental for translating community adaptive capacity into sustainable socio-ecological resilience. Strengthening resilience therefore requires governance systems that improve coordination, policy integration, and institutional responsiveness alongside community adaptation (Rendon et al., 2021).

The study contributes to adaptive governance literature by demonstrating that socio-ecological resilience is both an environmental and governance challenge. Resilience develops through the

interaction of adaptive institutions, informed communities, and responsive governance rather than through isolated environmental interventions. Integrating local knowledge, reducing institutional fragmentation, promoting equitable access to environmental resources, and strengthening continuous institutional learning are therefore essential for building resilient socio-ecological systems capable of responding to increasing environmental uncertainty in Pakistan.

Adaptive Governance as an Institutional Response to Environmental Change

The findings indicate that adaptive governance represents a critical institutional response to increasingly complex environmental challenges in Pakistan. Traditional governance systems characterized by rigid procedures and sectoral management are becoming less effective in addressing dynamic environmental disturbances. This finding supports adaptive governance theory, which emphasizes the need for governance systems capable of continuous learning, adjustment, and institutional transformation in response to socio-ecological uncertainty (Chaffin & Gunderson, 2016). Adaptive governance should therefore be understood as an institutional approach that strengthens governance capacity rather than simply introducing new administrative procedures.

A key finding concerns the limited institutional flexibility within environmental management agencies. Although regulatory frameworks promote accountability, participants reported that bureaucratic procedures often delay emergency responses and reduce institutional responsiveness. This finding is consistent with previous studies suggesting that adaptive governance requires balancing administrative accountability with sufficient flexibility to revise management decisions according to changing environmental conditions. Increasing institutional agility is therefore essential for improving environmental governance without compromising transparency.

The study also highlights collaborative governance as a fundamental element of adaptive governance (Andriollo et al., 2021; Westerink et al., 2017; Mukhlis & Perdana, 2022). Participants emphasized that effective environmental management depends upon cooperation among governmental institutions, local communities, academic organizations, and civil society because environmental problems extend beyond the capacity of individual organizations. This finding aligns with collaborative governance theory, which argues that collective decision-making and resource sharing improve institutional resilience and environmental sustainability. Collaboration in the study area remains largely project-based, limiting its long-term effectiveness and institutional continuity.

Another important finding concerns the integration of local ecological knowledge into environmental decision-making. According to Ramsey et al. (2019) communities possess valuable experiential knowledge regarding flood prediction, water management, and climate adaptation, yet this knowledge remains insufficiently incorporated into formal environmental policies. These findings support previous research demonstrating that adaptive governance becomes more effective when scientific evidence is combined with indigenous and local knowledge systems, enabling policies to better reflect local environmental conditions and community needs.

The findings further demonstrate that social learning remains insufficiently institutionalized despite being a central principle of adaptive governance. Although environmental disturbances provide opportunities for reflection and policy improvement, lessons learned are often retained within individual organizations rather than being shared across governance networks. This observation supports resilience scholarship emphasizing that continuous learning enables governance systems to improve adaptation strategies and respond more effectively to environmental uncertainty. Strengthening institutional learning mechanisms is therefore essential for preventing the repetition of policy shortcomings.

Community participation also remains an important challenge within adaptive governance. While participants acknowledged improvements in public consultation, they noted that participation often remains procedural rather than genuinely collaborative. Communities are frequently consulted after key policy decisions have already been established, limiting their influence on environmental governance. This finding reflects Arnstein's concept of citizen

participation and recent adaptive governance literature, which emphasize that meaningful participation requires active community involvement throughout policy formulation, implementation, and evaluation (Rosen & Painter, 2019; Sharma, 2025; Kurniawan & Kurnia, 2025).

The findings suggest that adaptive governance should be viewed as an integrated institutional framework combining flexibility, collaboration, knowledge integration, continuous learning, and meaningful public participation. Although these governance dimensions have begun to emerge within regional environmental management in Pakistan, their effectiveness remains constrained by fragmented institutions, limited policy integration, and weak learning mechanisms. Strengthening these institutional components will be essential for enhancing governance capacity and supporting long-term socio-ecological resilience under increasingly uncertain environmental conditions.

The Governance–Resilience Nexus in Regional Environmental Management

The findings demonstrate that adaptive governance and socio-ecological resilience are closely interconnected, forming a mutually reinforcing relationship that enhances the capacity of regional environmental management systems to address environmental uncertainty (Morante et al., 2025; Delgado-Serrano et al., 2018). Institutional coordination, stakeholder collaboration, social learning, and participatory decision-making collectively strengthen community adaptive capacity and reduce environmental vulnerability. These findings support socio-ecological resilience theory, which emphasizes that governance structures are fundamental in enabling social and ecological systems to adapt to changing environmental conditions. Accordingly, resilience should be understood not only as an ecological outcome but also as an institutional achievement resulting from effective governance.

Institutional coordination emerged as one of the most significant factors influencing resilience. Participants consistently reported that communities receiving coordinated support from multiple governmental agencies recovered more rapidly from environmental disturbances than those experiencing fragmented institutional interventions. Effective coordination improved information exchange, resource allocation, and emergency response, while reducing policy fragmentation. This finding aligns with previous studies highlighting that inter-organizational coordination enhances governance effectiveness and strengthens resilience by improving collective problem-solving and adaptive capacity.

The study also identifies collaborative governance, institutional trust, and social learning as essential mechanisms linking governance with resilience. Krug et al. (2020) said that, collaboration among government agencies, academic institutions, non-governmental organizations, and local communities enables the integration of scientific expertise, local knowledge, and organizational resources into environmental decision-making. Trust further strengthens this relationship by encouraging stakeholder participation and increasing institutional legitimacy. Continuous social learning allows governance actors to evaluate previous experiences, revise management strategies, and improve future environmental responses, thereby enhancing long-term adaptive capacity.

Despite these positive relationships, fragmented governance continues to constrain resilience development. Overlapping institutional mandates, inconsistent policy implementation, limited communication, and sectoral planning reduce governance efficiency and delay environmental interventions. These institutional weaknesses hinder proactive adaptation despite the existence of substantial community adaptive capacity. Similar governance challenges have been identified across developing countries, where limited coordination among environmental institutions remains a major barrier to effective resilience building.

The findings contribute to adaptive governance literature by demonstrating that resilience is shaped through interconnected governance processes involving coordination, collaboration, trust, learning, and participation rather than through isolated policy interventions. Strengthening the governance–resilience nexus therefore requires integrated policy frameworks, collaborative leadership, institutional learning, and meaningful stakeholder participation. Such governance transformation enables environmental management systems to become more adaptive,

responsive, and sustainable in addressing increasingly complex socio-ecological challenges in Pakistan.

Strategic Implications for Strengthening Regional Environmental Governance

The findings demonstrate that strengthening socio-ecological resilience requires a transformation of regional environmental governance from conventional administrative approaches toward adaptive governance. Environmental challenges in Pakistan are increasingly characterized by uncertainty, interconnected ecological risks, and institutional complexity, making traditional governance mechanisms insufficient for addressing long-term sustainability. The study indicates that resilience can be enhanced when governance systems are capable of adapting to environmental changes through institutional flexibility, collaborative decision-making, and continuous policy adjustment. This finding supports adaptive governance theory, which emphasizes that governance systems should evolve alongside changing socio-ecological conditions rather than relying on static policy frameworks.

Another important implication concerns the integration of institutional capacity with community adaptive capacity. The findings reveal that local communities possess valuable indigenous knowledge and practical experience in responding to floods, droughts, and environmental degradation. These adaptive capacities remain constrained by fragmented institutions, limited technical support, and unequal access to environmental information. Consequently, strengthening resilience requires policy interventions that simultaneously improve institutional coordination, expand community participation, and provide greater access to technological innovation, climate information, and environmental education (Osumba et al., 2021; Adebayo, 2025; Kyriakopoulos & Sebos, 2023; Oloo & Omondi, 2017). Such integrated capacity development enables local adaptation to become more sustainable while reducing vulnerability among marginalized populations.

The study also highlights the importance of institutionalizing collaborative governance across multiple sectors involved in environmental management. Effective resilience cannot be achieved through isolated governmental actions because environmental issues intersect with agriculture, water resources, disaster management, regional planning, and community development. Zulfiqar & Butt (2021) said that, establishing permanent coordination mechanisms among governmental agencies, academic institutions, non-governmental organizations, and local communities would improve policy coherence, facilitate knowledge exchange, and reduce fragmented environmental management. These collaborative arrangements should also encourage the integration of scientific evidence with indigenous ecological knowledge, allowing environmental policies to become more context-sensitive and responsive to local conditions.

The findings suggest that adaptive governance provides a practical framework for strengthening long-term socio-ecological resilience in Pakistan. Institutional flexibility, cross-sectoral collaboration, continuous social learning, and meaningful public participation collectively enhance the capacity of governance systems to anticipate environmental risks and respond effectively to changing ecological conditions. These findings contribute to adaptive governance literature by demonstrating that resilience emerges from the interaction between institutional performance and community adaptation rather than from environmental interventions alone. From a policy perspective, regional environmental governance should prioritize integrated governance structures that promote sustainability, institutional learning, and inclusive decision-making to address increasingly complex socio-ecological challenges.

CONCLUSION

Strengthening socio-ecological resilience in regional environmental management in Pakistan depends on the successful integration of adaptive governance with community adaptive capacity. The findings reveal that although local communities have developed considerable resilience through indigenous knowledge, collective action, and practical adaptation to environmental disturbances, these capacities remain constrained by fragmented institutions, limited policy coordination, weak cross-sector collaboration, and insufficient mechanisms for continuous learning. Adaptive governance provides an effective institutional framework by promoting policy flexibility, stakeholder collaboration, knowledge integration, and meaningful public participation,

thereby improving the ability of governance systems to respond to environmental uncertainty. The study also demonstrates that resilience should be understood as the outcome of continuous interactions among ecological systems, governance institutions, and social actors rather than as a purely environmental condition. Theoretically, this research enriches adaptive governance and socio-ecological resilience literature by highlighting the governance–resilience nexus within the context of developing countries. Practically, the findings emphasize the need for integrated environmental policies, institutional strengthening, and participatory governance that combine scientific evidence with local ecological knowledge to enhance long-term sustainability. Future studies are encouraged to examine adaptive governance across broader geographical settings using comparative or mixed-method approaches to further evaluate the effectiveness of governance innovations in strengthening socio-ecological resilience under increasing climate and environmental change.

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