International Journal of Environmental Impacts
Vol. 8, No. 3, June, 2025, pp. 615-625
Journal homepage: http://iieta.org/journals/ijei

Adaptive Governance in Environmental Issue: Systematic Literature Review

Yulianto Yulianto[1], Feni Rosalia[2], Simon Sumanjoyo Hutagalung[3*]

[1] Department of Public Administration, Universitas Lampung, Bandar Lampung 35141, Indonesia
[2] Department of Government Studies, Universitas Lampung, Bandar Lampung 35141, Indonesia
[3] Doctoral Program of Development Studies, Universitas Lampung, Bandar Lampung 35141, Indonesia

Corresponding Author Email: simon.sumanjoyo@fisip.unila.ac.id

https://doi.org/10.18280/ijei.080319

Received: 16 January 2025
Revised: 4 March 2025
Accepted: 17 April 2025
Available online: 30 June 2025

Keywords:
adaptive governance, environmental management, resilience, multilevel governance, climate change adaptation

ABSTRACT

Adaptive governance makes it possible to have a collaborative and flexible approach to resolve intricate environmental problems. This systematic literature review (SLR) was intended to understand some aspects of the framework such as its concepts, methodology, policy dimensions, and its contribution to resilience and sustainability. This SLR utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology to analyze 19 selected high-quality papers from the Scopus database to identify principal trends, challenges, and research deficiencies. The findings suggest that adaptive governance is practiced in diverse settings, such as water resource management, biodiversity conservation, and climate change adaptation, using polycentric and co-management approaches. Institutional rigidity, environmental uncertainty, and deficiencies of long-term evaluation systems still prevail. While cooperation is promoted multilevel governance still requires the involvement of conservative institutions and extensive use of digital technologies. Inclusionary policies and defined evaluation criteria are means through which effectiveness is facilitated, hence strengthening adaptive governance. The practical recommendations in this assessment will help policymakers and practitioners implement an environmental governance strategy that increases the resilience of environmental management.

1. INTRODUCTION

The growing complexities of global environmental issues have made the interplay between politics and the environment a crucial topic of discussion in the present era [1, 2]. Addressing these concerns requires alterations in the governance structures to operate in fluid and volatile conditions created by the interdependence of ecosystems and socio-economic systems. Adaptive governance offers a potential remedy due to its inherent flexibility and responsiveness to change [3, 4]. By facilitating institutions' ability to adjust to new ecological, social, and economic conditions, adaptive governance increases the capacity of regimes to deal with current and future environmental issues. This increases the resilience for the system as a whole [5, 6].

Adaptive government is a non-static model that incorporates the concepts of adapting, working in teams, and learning on the go. Integrating knowledge systems and encouraging collaboration to tackle multifaceted environmental problems in regions that are uncertain is significant [7, 8]. Adaptive governance assists organizations and communities in creating innovative solutions and strategies through participation, local knowledge, and collective resilience [9, 10]. The research data suggests that "experimentation" in public policy is a central approach to evaluating and advancing sustainable initiatives as it enables institutions to formulate optimal solutions in diverse ecological and socio-economic settings [11, 12].

This review focuses on ecological systems and the multi-level governance model and aims to illustrate the underpinnings of adaptive management for the ecological context. By carefully reviewing many academic documents, this review attempts to show the key trends, structures the theoretical framework, and evaluates the effectiveness of adaptive governance in different adaptive governance in different areas. In addition, it provides useful recommendations for policymakers and other practitioners who in many cases write off the increasing multi-level complexities of adaptive governance for dealing with pressing environmental problems [13]. Even while adaptive governance is gaining popularity, there are still significant unexplored gaps, particularly in terms of policy dimensions, implementation, and the challenges in actual applications. Regarding implementation, few research on the scalability of successful adaptive governance models in different socio-ecological surroundings exists [14]. Furthermore, studies often highlight localized case studies, hence lacking comparative studies examining the effectiveness of adaptive governance in many institutional, cultural, and environmental settings.

From a policy perspective, gaps persist in understanding how multilevel governance systems can be better integrated to support adaptive governance [15]. Existing research lacks a

thorough examination of policy coherence between local, national, and international levels, as well as the role of informal governance networks in bridging institutional silos [16]. Furthermore, there is a need to investigate how adaptive governance principles can be institutionalized within rigid, centralized governance systems to enhance flexibility and inclusivity [17]. Research on hurdles and impediments has mostly concentrated on technical and institutional ones, therefore neglecting socio-cultural aspects [18]. Still important obstacles needing more study are public trust deficits, opposition to change, and power imbalances among stakeholders [19]. Additionally, there is a limited exploration of how uncertainties, such as those posed by climate change and ecological disruptions, influence adaptive governance strategies and outcomes [20].

This review is organized by four themes: implementation, policy frameworks, issues, and future research. Examining real case studies of adaptive governance in various national and regional contexts is essential due to the increasing urgency of global environmental issues such as climate change, biodiversity decline, water scarcity, and urbanization. This study shows the framework's strengths, weaknesses, and flexibility in ecological, socioeconomic, and political environments, providing fresh insights into its operation [21, 22]. The resolution of these deficiencies can provide substantial opportunities for the development of adaptive governance and the establishment of resilience in the context of global environmental change.

Apart from offering a full knowledge of the possibilities of the system, the review reveals useful guidelines for environmental management [23]. Analyzing the achievements and difficulties of implementation across different nations helps legislators, professionals, and researchers to find context-specific innovations and transferable policies. This method emphasizes the important part adaptive governance plays in forming strong and sustainable systems able to negotiate the complexity of environmental change [24], hence the study of its implementation is a necessary and urgent task for worldwide sustainability projects. "How does adaptive governance contribute to addressing complex environmental challenges, and what factors influence its implementation, policy integration, and effectiveness across different socio-ecological contexts?" is the major research topic this paper may formulate. To explore the scope and impact of adaptive governance, this review is guided by the following table:

Table 1. Key research dimensions and questions on adaptive governance

Dimension	Research Questions
Implementation and Case Studies	a. How is adaptive governance implemented over several environmental problems including climate change adaptation, water management, and biodiversity preservation? b. From which noteworthy case studies can one learn the implementation of adaptive governance? c. In what ways may local communities, governments, businesses, and other stakeholders help to apply adaptive governance?
Policy Dimensions	a. Which laws and rules help to apply adaptive governance? b. How might local, national, international multilevel governance help to enable adaptive environmental management? c. In what nations had adaptive governance effectively been included into policy frameworks or governance systems?
Challenges and Barriers	a. Adopting adaptive governance at local, national, or worldwide levels presents mainly what difficulties? b. Which institutional, social, or cultural elements prevent adaptive governance from succeeding? c. In what ways may environmental uncertainty affect the execution of adaptive governance to solve challenging environmental problems?

By analyzing the theoretical foundations, pragmatic applications, and policy implications of adaptive governance, it is possible to gain a more comprehensive understanding of its capacity to address environmental issues. This study not only points up important research gaps and future directions but also provides a road map for advancing adaptive governance as the pillar of sustainable environmental management in the face of changing global challenges. The Table 1 outlines the key research dimensions and guiding questions that form the analytical foundation for exploring adaptive governance in various contexts.

2. THEORETICAL FRAMEWORK

Dealing with modern environmental challenges depends on an awareness of the theoretical framework of adaptive governance since it stresses the dynamic and cooperative character of decision-making procedures [25, 26]. Adaptive governance is based on the idea that more inclusive and adaptable governance structures are necessary to tackle complex environmental concerns rather than relying on old, hierarchical systems [27, 28]. This viewpoint emphasizes that successful adaptation requires the involvement of various stakeholders, such as government bodies, non-profit organizations, and local communities, fostering trust and collaborative partnerships. Policy forums act as essential platforms where diverse stakeholders gather to discuss solutions and exchange knowledge, ultimately strengthening governmental capabilities [29]. The literature highlights the necessity of developing a comprehensive research agenda that focuses on the connections between various governance systems and adaptation strategies to optimize environmental outcomes [30].

Adaptive governance is based on a number of well-established models that explain how it works to solve complicated environmental problems. Fundamental to adaptive governance is resilience theory, which places an emphasis on social-ecological systems' ability to endure disruptions without compromising their essential functions [31, 32]. Unlike rigid governance frameworks that struggle to keep pace with rapid changes, adaptive governance is rooted in

resilience theory and promotes institutional structures that foster continuous learning, innovation, and flexibility [33]. The ability to adapt is essential for tackling new environmental issues such as climate change and resource depletion, allowing governance frameworks to progress and remain effective in the face of uncertainty [20, 33, 34].

The Social-Ecological Systems (SES) Theory represents a crucial framework that highlights the interconnectedness of human and ecological systems. This perspective highlights the importance of integrating ecological and social elements into governance strategies to attain effective environmental management [35, 36]. Adaptive governance aligns closely with SES theory by advocating for participatory decision-making processes, knowledge-sharing networks, and decentralized governance structures that enhance system resilience [37]. Research has demonstrated that successful adaptive governance depends on fostering collaboration among diverse stakeholders, encouraging social learning, and enabling collective decision-making, which strengthens the adaptability of governance institutions to shifting environmental conditions [38].

A third key theoretical perspective informing adaptive governance is Polycentric Governance Theory, which argues that governance effectiveness is enhanced when multiple, overlapping decision-making centers work together [25, 39]. Unlike centralized governance models, which may be slow to respond to environmental crises, polycentric governance fosters flexibility by encouraging experimentation, learning, and localized solutions. This concept is exemplified by adaptive governance, which guarantees that governing solutions are customized to the unique environmental contexts by fostering coordination across multiple levels—local, national, and global. Additionally, the integration of feedback loops is a critical component of adaptive governance, as it enables the continuous evaluation and modification of policies in response to emergent data and observed outcomes. This iterative approach improves the resilience of governance institutions, enabling proactive adjustments to changing environmental challenges [40].

The integration of resilience theory, social-ecological systems theory, and polycentric governance theory in adaptive governance offers a comprehensive paradigm for addressing environmental uncertainty. It enables institutions to transition from inflexible, hierarchical decision-making frameworks to more adaptive, inclusive, and contextually aware methodologies. Theoretical underpinnings offer critical insights into the evolution of governance systems for effectively managing environmental challenges while maintaining sustainability and resilience.

3. RESEARCH METHOD

This research utilizes a Systematic Literature Review (SLR) methodology, adhering to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol to guarantee a rigorous, transparent, and reproducible process. PRISMA was selected due to its standardized framework for systematic reviews, which improves study credibility by minimizing bias and ensuring thorough literature coverage.

The literature was sourced from the Scopus database, a distinguished and credible academic repository [41]. The search strategy aimed to encompass multiple dimensions of adaptive governance through the use of terms including "adaptive governance," "environmental management," "climate change adaptation," "social-ecological systems," and "policy frameworks." Boolean operators (AND, OR) were employed to expand the range of search results. The literature was filtered according to the following criteria to ensure the relevance of the results: (a). Inclusion Criteria: Articles published in peer-reviewed journals, written in English, pertinent to the topic of adaptive governance, and published within the last decade. Exclusion Criteria: Articles that address non-environmental topics, unpublished policy reports, and articles lacking full access.

This study adheres to PRISMA guidelines to systematically identify, select, evaluate, and synthesize literature on adaptive governance in environmental issues, thereby ensuring methodological rigor and reliability. The selection process for the systematic literature review adhered to the PRISMA flowchart, guaranteeing a methodical and clear strategy for refining the pool of relevant studies. The procedure was executed in three distinct phases. Initially, a thorough search was performed in the Scopus database utilizing specific predefined terms during the identification phase. An initial pool of 150 articles was identified that seemed to satisfy the inclusion criteria. In the subsequent screening phase, a comprehensive review of the abstracts and titles of these articles was conducted to evaluate their pertinence to the subject of adaptive governance in environmental matters.

The selection process narrowed the pool down to 80 articles identified as pertinent for additional analysis. In the eligibility phase, a comprehensive examination of the complete texts of the 80 articles was performed to evaluate their methodological rigor and their correspondence with the research aims. The end dataset is made up of 19 carefully chosen articles that show high-quality studies that directly answer the research questions that were asked. To make the analysis more complete, important data was systematically gathered from the 19 chosen papers. The dataset had the names and titles of the authors and the papers they wrote, as well as research categories like case studies and quantitative studies and key focus areas like implementing adaptive governance, policy dimensions, and related challenges. Also, words from every article were written down so that main study trends and thematic patterns could be found in the dataset.

The selected publications were thematically analyzed for adaptive governance insights. The test included four dimensions. Adaptive governance was applied to water management and biodiversity conservation in the Implementation and Case Studies domain. The Policy Dimensions explored how regulations and multilevel governance frameworks promote adaptive governance. Institutional rigidity and environmental uncertainty were implementation challenges in the Challenges and Barriers dimension.

The chosen articles were subjected to a comprehensive quality evaluation to guarantee the dependability and accuracy of the results. The CASP and MMAT frameworks were utilized to evaluate research design, methodological rigor, and contributions to the literature. The validation process affirmed that the conclusions drawn from the review were founded on reliable and methodologically sound evidence. The evaluation utilizing CASP indicated that most of the chosen studies effectively defined their research objectives and utilized suitable methodologies. Several studies demonstrated limitations in justifying their methodological choices or offering thorough validity assessments. Additionally, the

MMAT assessment indicated that the majority of studies employed strong study designs and systematic data collection methods. Some studies, however, did not provide detailed descriptions of how their methodologies aligned with research objectives, which somewhat impacted their overall rigor. The dual-framework approach enabled a thorough and reliable evaluation of the selected studies, thus bolstering the credibility of the systematic review.

The systematic literature review's findings were presented in a structured narrative format, which synthesized the important insights from the 19 articles. This analysis offers a comprehensive comprehension of adaptive governance by identifying trends, evaluating the implications of policy, and presenting evidence-based recommendations. This review addresses substantial voids in the literature, thereby advancing research on adaptive governance and offering actionable insights for policymakers and practitioners confronting intricate environmental challenges.

4. RESULT AND DISCUSSION

Table 2. Selected articles on adaptive governance in environmental issues

No.	Authors	Title	Rsearch Categories	Keywords
1	Tuda et al. [26]	Polycentricity and adaptive governance of transboundary marine socio-ecological systems	Case Study	Adaptive governance; Co-management; Polycentrism; Social network analysis; Transboundary systems
2	Armitage et al. [43]	Early-stage transformation of coastal marine governance in Vietnam	Case Study	Adaptive governance; Coastal management; Vietnam
3	Valman et al. [44]	Adaptive governance of the Baltic Sea – Lessons from elsewhere	Comparative Study, Qualitative	Adaptive governance; Baltic Sea; Ecosystem approach; HELCOM
4	Greenhill et al. [45]	Adaptation to climate change–related ocean acidification: An adaptive governance approach	Case Study	Adaptive governance; Climate change adaptation; Ocean acidification
5	Ramos-Santiago L.E. et al. [46]	Green area loss in San Juan's inner-ring suburban neighborhoods	Mixed Methods	Green area loss; Social-ecological; Urban dynamics; Sustainability
6	Olsson et al. [47]	Social-ecological transformation for ecosystem management: The development of adaptive co-management	Case Study	Adaptability; Ecosystem management; Resilience; Social-ecological systems
7	Raatikainen [48]	The importance of engaging local people in landscape management	Case Study	Adaptive co-management; Agri-environment scheme; Landscape management
8	Huber-Stearns and Cheng [49]	The evolving role of government in the adaptive governance of freshwater social-ecological systems in the western US	Case Study	Adaptive governance; Water governance; Social-ecological systems; Western US
9	Larson et al. [50]	Decision-making under uncertainty for water sustainability and urban climate change adaptation	Case Study	Adaptive governance; Water resources; Climate change; Urban adaptation
10	Rawluk A et al. [51]	Enacting shared responsibility in biosecurity governance: insights from adaptive governance	Case Study	Adaptive governance; Biosecurity; Shared responsibility; Social-ecological systems
11	Sanchez-Plaza et al. [52]	Analytical framework to assess the incorporation of climate change adaptation in water management	Framework Development, Qualitative	Adaptive governance; Climate change; River basin; Water management
12	Gaudreau and Cao [53]	Political Constraints on Adaptive Governance: Environmental NGO Networks in Nanjing, China	Case Study	Adaptive governance; China; Corporatism; Politics; Networks
13	Salajegheh et al. [54]	Modeling the impact of social network measures on institutional adaptive capacity	Quantitative Study	Adaptive capacity; Social network analysis; Water governance
14	Westerink J. et al. [55]	Collaborative governance arrangements to deliver spatially coordinated agri-environmental management	Case Study	Adaptive governance; Agri-environment schemes; Landscape approach; Farmer collaboration
15	van Oosterzee et al. [56]	Integrating agriculture and climate change mitigation at landscape scale	Case Study	Adaptive governance; Natural resource management; Climate change mitigation
16	Jacob et al. [57]	Not just an engineering problem: The role of knowledge and understanding	Case Study	Adaptive governance; Coastal erosion; Ecosystem services

		of ecosystem services for adaptive management of coastal erosion		
17	Armitage et al [58].	Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic[2]	Case Study	Co-management; Knowledge integration; Social learning; Arctic
18	Kahui and Richards [59]	Lessons from resource management by indigenous Maori in New Zealand	Case Study	Adaptive governance; Indigenous knowledge; Ecosystem-based management
19	Mian [60]	Pakistan's Flood Challenges: An assessment through the lens of learning and adaptive governance	Case Study	Adaptive governance; Floods; Social learning; Pakistan

Case studies provide critical insights into the efficacy of various solutions employed across diverse situations, elucidating the intricacies of adaptive governance in environmental management. These case studies demonstrate that adaptive governance is a dynamic process, distinguished by active stakeholder engagement and continuous learning, rather than a static framework. The systematic literature review highlights that adapting to environmental changes requires governance that is both flexible and responsive to evolving socio-ecological conditions [30]. Furthermore, the findings highlight that the significance of follow-up and monitoring in impact assessments is paramount; these practices are crucial for maintaining ongoing compliance and fostering public trust [42]. By analyzing these cases, one can discern best practices and delineate strategies for establishing adaptive governance, so improving responses to new environmental concerns. A thorough comprehension is vital for advancing effective and sustainable environmental management systems. The following Table 2 presents selected articles that discuss adaptive governance within the context of environmental issues, highlighting key themes, methodologies, and contributions to the field.

Implementation and Case Studies

Adaptive governance is utilized in a range of environmental challenges using a variety of methods. In Kenya and Tanzania, a system of polycentric governance is employed to oversee transboundary water resources [26]. The utilization of social networks in these two countries facilitates a dynamic approach for local and national actors to work together in tackling cross-border challenges. Nonetheless, the prevailing influence of central authorities in specific areas continues to pose a considerable challenge, underscoring the necessity for policies that more effectively facilitate cross-sectoral cooperation and enhance local self-governance. In Sweden, the application of adaptive governance is clearly demonstrated in the management of wetland landscapes via an adaptive co-management strategy [47, 48]. Transforming landscape governance in this region requires the engagement of various local actors, spearheaded by influential individuals who can foster trust and activate social networks. This process illustrates that the effectiveness of adaptive governance is significantly dependent on forward-thinking local leaders and the backing of adaptable institutional structures.

In Puerto Rico, adaptive governance is utilized to tackle the decline of green spaces in urban environments. Modifications in land use are implemented to preserve green ecosystems that are essential for socio-ecological stability [46]. This method brings together community members, governmental bodies, and scholars to collaboratively navigate intricate environmental challenges. An important takeaway from these cases is that achieving effective adaptive governance hinges on the collaboration of various stakeholders, the presence of institutional flexibility, and the capacity to respond to continuously evolving environmental circumstances. The roles of stakeholders in the implementation of adaptive governance exhibit significant diversity. Local communities play a pivotal role in collaborative projects, such as in Finland and Puerto Rico [44], where community involvement significantly contributes to local decision-making. Authorities, at both local and national tiers, hold the duty of establishing regulatory frameworks and promoting coordination across various sectors. The private sector, conversely, fosters innovation and provides financing, as evidenced by climate adaptation initiatives in Scotland. Below is an analytical table for the subchapter on Implementation and Case Studies:

The analysis of the table highlights emerging trends in the application of adaptive governance, emphasizing its versatility in addressing diverse environmental issues across varying contexts. A significant trend is the increasing reliance on polycentric and collaborative governance frameworks [26]. These frameworks enable multiple actors—ranging from governments and local communities to private sectors and academic institutions—to work together effectively, tailoring solutions to complex socio-ecological problems [49]. One prominent theme is the role of polycentric governance in transboundary resource management, such as in Kenya and Tanzania [26]. Here, local and national governments collaborate with communities and cross-sectoral actors to manage marine resources. While this governance approach provides flexibility and adaptability, the table reveals a recurring challenge: central government dominance often limits the effectiveness of collaborative efforts. This underscores the importance of balancing authority and empowering local stakeholders to foster inclusive decision-making [50]. The following Table 3 provides an analysis of adaptive governance applications, detailing key issues addressed, stakeholder roles involved, and lessons learned from various case studies.

Table 3. Analysis of adaptive governance applications: Issues, stakeholder roles, and lessons learned

No.	Form of Adaptive Governance	Analyzed Issue	Stakeholder Roles	Lesson Learned
1	Polycentric governance in	Management of transboundary marine	Local and national governments collaborate; local communities	Polycentric governance supports flexibility, but central

	cross-border management	resources in Kenya-Tanzania	provide input; cross-sectoral actors work together.	government dominance can hinder effective collaboration.
2	Adaptive co-management	Management of wetland landscapes in Sweden	Local leaders mobilize actors; local communities participate in co-management; government supports policy frameworks.	The success of adaptive governance heavily relies on local leaders and the integration of cross-sectoral actors.
3	Socio-ecological governance	Loss of green spaces in urban areas in Puerto Rico	Local communities maintain green spaces; local government formulates land-use policies; academics provide data and analysis.	Socio-ecological governance helps preserve green spaces but requires support from sustainable adaptive policies.
4	Biosecurity risk management	Prevention of invasive species spread in Australia	The government collaborates with local communities through shared responsibility schemes.	Clear collaboration structures between government and communities are necessary for effective implementation.
5	Ecosystem-based co-management	Restoration of Guadalquivir wetlands in Spain	Governments, local communities, and academics engage in action research for adaptive governance.	Action research-based approaches can help address rigid institutions and promote flexible governance.
6	Integration of climate change adaptation	Ocean acidification in Scotland	National and local governments coordinate; the private sector supports innovation in aquaculture adaptation.	Iterative, learning-based adaptation is necessary to manage high environmental uncertainty

Another noticeable trend is the focus on adaptive co-management, as seen in Sweden's wetland landscape management [47, 48]. The integration of local leaders, community participation, and supportive governmental policies demonstrates the strength of this approach in managing natural resources. It is suggested that adaptive co-management thrives on strong local leadership and cross-sectoral collaboration, providing lessons for its broader application in other regions [34]. It also highlights the significance of socio-ecological governance in urban settings, such as the preservation of green spaces in Puerto Rico [46]. This governance framework combines local community stewardship, government-led land-use policies, and academic support to address urban environmental challenges. However, the findings indicate that sustainable outcomes require long-term policy support and adaptive mechanisms to maintain green spaces amidst urbanization pressures. In the case of biosecurity risk management in Australia, the trend emphasizes shared responsibility between governments and communities [51]. This approach demonstrates the necessity of clear collaboration structures to effectively manage invasive species risks. The lesson learned here is that well-defined roles and responsibilities among stakeholders enhance the success of adaptive governance strategies.

Ecosystem restoration efforts in Spain provide an example of ecosystem-based co-management, where governments, communities, and academics engage in action research to restore the Guadalquivir wetlands [52]. The use of action research not only addresses institutional rigidity but also fosters adaptive and flexible governance systems. This trend highlights the value of integrating research-driven methodologies into governance to address complex ecological challenges. Lastly, the integration of climate change adaptation strategies is illustrated by the response to ocean acidification in Scotland [45]. Adaptive governance in this context involves coordination between national and local governments, alongside private sector innovation in aquaculture. It points to the necessity of iterative, learning-based approaches to manage high levels of environmental uncertainty. This iterative process allows stakeholders to adjust strategies as new information emerges, ensuring resilience in the face of unpredictable environmental changes. The trends revealed the adaptive capacity of governance frameworks to address diverse environmental challenges, from polycentric systems and co-management models to socio-ecological and ecosystem-based approaches. The success of adaptive governance relies heavily on stakeholder collaboration, local empowerment, and iterative learning. As environmental uncertainties grow, these lessons underline the need for flexible and inclusive governance strategies that integrate research, policy, and practice across multiple scales and contexts.

Policy Dimensions

Policies and regulations play a critical role in supporting the implementation of adaptive governance. In Finland, environmental payment schemes are used as financial incentives to support the management of traditional landscapes [48]. These policies not only help preserve biodiversity but also encourage local community participation in environmental management. In Kenya and Tanzania, cross-border co-management systems demonstrate that cross-sectoral collaboration, facilitated by transboundary policies, can enhance adaptation to environmental changes [26]. The role of multilevel governance is essential in adaptive governance. At the local level, communities have the autonomy to make decisions tailored to their specific needs, as seen in landscape management in Finland [47].

At the national level, governments provide policy frameworks that enable cross-sectoral collaboration. Meanwhile, at the international level, cross-border cooperation, such as in the Baltic Sea region, strengthens global adaptive capacity [44]. Successful adaptive governance frameworks include Sweden’s Ecomuseum Kristianstads Vattenrike, a flexible organization bridging local actors and the government in managing wetland landscapes [45]. In Spain, the Guadalquivir wetland restoration program employs an adaptive management approach based on action research to create more flexible and responsive governance structures [52]. From these various cases, the Policy Types, Multilevel Governance Roles, and Adaptive Governance Frameworks

can be analyzed as shown in the following Table 4.

Table 4. Policy types, multilevel governance roles, and adaptive governance frameworks

No.	Policy Type	Role of Multilevel Governance	Adaptive Governance Framework
1	Environmental payment schemes	Local governments provide financial incentives to support traditional landscape management.	Adaptive co-management in Finland, involving local communities and the private sector in inclusive management.
2	Cross-border policies	Local and national governments collaborate in cross-sectoral management on an international scale.	Cross-border co-management systems in Kenya-Tanzania to support cross-sectoral integration.
3	Climate change adaptation planning	National and local governments in Scotland coordinate to integrate adaptation into regional policies.	Regional planning models based on iterative learning to address ocean acidification impacts.
4	Ecosystem-based landscape management	Local governments and communities collaborate to sustain ecosystems with local autonomy.	Ecomuseum Kristianstads Vattenrike in Sweden, bridging local actors and national government.
5	Wetland restoration programs	Local governments coordinate environmental restoration through action research-based adaptive approaches,	Action research-based approaches to overcome institutional rigidity and promote flexible governance.
6	Maritime governance collaboration	Regional and international governments collaborate to manage cross-border marine ecosystems.	HELCOM in the Baltic Sea, utilizing an ecosystem-based approach to support cross-border adaptation.

The table highlights several trends in the application of adaptive governance across various policy types, showcasing the integration of multilevel governance and innovative frameworks to address complex environmental challenges. These trends illustrate the growing recognition of the need for flexible, inclusive, and context-specific approaches in environmental policy and governance. A notable trend is the increasing reliance on multilevel governance structures to facilitate collaboration across local, national, and international levels. For instance, in environmental payment schemes in Finland, local governments provide financial incentives to engage local communities and the private sector in adaptive co-management [48]. This demonstrates the ability of local-level governance to directly involve communities and stakeholders in environmental stewardship. Similarly, ecosystem-based landscape management in Sweden highlights how local autonomy, supported by national frameworks, fosters collaboration between communities and government entities to sustain ecosystems [45].

Another key trend is the emphasis on cross-border policies and regional collaborations, as seen in Kenya-Tanzania and the Baltic Sea. In Kenya and Tanzania, cross-border co-management integrates local and national efforts to address shared marine resource challenges. This model of cross-sectoral integration illustrates how transboundary governance can enhance adaptive capacity [26]. Similarly, maritime governance collaboration in the Baltic Sea, facilitated by HELCOM, utilizes an ecosystem-based approach to manage cross-border marine ecosystems, showcasing the effectiveness of regional cooperation in addressing transnational environmental issues [44]. Climate change adaptation planning emerges as a recurring focus, particularly in Scotland, where national and local governments coordinate to integrate adaptation strategies into regional policies. The iterative, learning-based regional planning models developed in Scotland emphasize the importance of flexible governance that can evolve with changing climate conditions, such as ocean acidification [45]. This trend reflects the increasing need for dynamic frameworks that enable governments to adapt policies to unforeseen environmental challenges. The application of action research-based approaches in wetland restoration programs, as exemplified in Spain, highlights the value of integrating research into governance [52]. This approach not only addresses institutional rigidity but also fosters adaptive governance practices that are responsive to local needs and ecological conditions. Action research strengthens governance by ensuring that policies and management practices are informed by empirical data and iterative learning.

Lastly, the use of ecosystem-based approaches in both terrestrial and marine contexts demonstrates a growing shift towards holistic governance frameworks. From the Ecomuseum Kristianstads Vattenrike in Sweden to HELCOM in the Baltic Sea, these frameworks prioritize the interdependence of social and ecological systems, bridging the gap between local actors and larger governance structures [45]. This trend underscores the importance of viewing ecosystems as integrated units that require collaborative and adaptive management across multiple levels. The trends emphasize the importance of multilevel governance, cross-border collaboration, and research-driven frameworks in adaptive governance. These approaches not only enhance the flexibility and inclusiveness of governance systems but also ensure that policies remain responsive to evolving environmental challenges. As the global environmental landscape becomes increasingly complex, these trends point to the growing need for adaptive, ecosystem-based governance that integrates local actions with broader regional and international efforts.

Challenges and Barriers

Adaptive governance faces numerous challenges, particularly the high level of environmental uncertainty. For example, in the case of ocean acidification in Scotland, the difficulty in predicting the impacts of environmental changes poses a significant barrier to implementing adaptive measures [45]. Additionally, institutional barriers frequently emerge, such as in Nanjing, China, were rigid institutional structures limit flexibility and innovation in governance. Social and cultural factors also present significant barriers [53]. Central government dominance, as seen in Kenya and Tanzania, hampers collaborative decision-making involving diverse

actors [26]. Furthermore, the lack of adaptive capacity among local and national actors constrains governance effectiveness, as observed in Iran [54]. These challenges underscore the need for profound structural changes in both institutional frameworks and governance culture to ensure the success of adaptive governance. The following Table 5 summarizes the key challenges, barriers, and influencing factors that affect the implementation and effectiveness of adaptive governance across different contexts.

Table 5. Challenges, barriers, and influencing factors in adaptive governance

No.	Type of Challenge	Type of Barrier	Influencing Factors
1	Environmental uncertainty	Uncertainty in climate change impacts	Difficulty in predicting impacts, such as ocean acidification, affects evidence-based decision-making.
2	Rigid institutional structures	Institutional barriers	Central government dominance reduces flexibility in cross-sectoral governance, as seen in Nanjing, China.
3	Limited adaptive capacity	Operational barriers	Lack of connectivity between actors and limited access to information resources in Iran.
4	Social resistance to change	Social and cultural barriers	Public distrust in government policies or new governance actors.
5	Dependence on short-term projects	Systemic barriers	Reliance on projects with limited duration, lacking policy continuity in Finland.
6	Lack of long-term evaluation	Evaluation barriers	Absence of mechanisms to assess the long-term impacts of adaptation policies in Puerto Rico.

The analysis of the table reveals key trends that underscore the persistent challenges and barriers to implementing adaptive governance effectively. These trends highlight the interconnected nature of environmental, institutional, operational, and socio-cultural dynamics that influence governance systems' ability to adapt to complex and evolving challenges. One prominent trend is the pervasive impact of environmental uncertainty on governance systems. The unpredictable nature of climate change impacts, such as ocean acidification, complicates evidence-based decision-making. This uncertainty underscores the need for governance frameworks that are iterative and flexible, allowing for continuous learning and adaptation as new data emerges. Tools like scenario planning and predictive modeling are increasingly essential to help policymakers and stakeholders navigate these uncertainties and develop more resilient governance strategies. Institutional rigidity emerges as another significant barrier to adaptive governance. The dominance of centralized governance structures, as observed in cases like Nanjing, China, limits the flexibility needed for cross-sectoral collaboration and innovation [53]. This rigidity underscores the ongoing struggle within governance systems to balance centralized authority with decentralized decision-making processes. Polycentric governance, which allows for multiple levels of authority and localized decision-making, is increasingly recognized as a promising solution to overcome such constraints, fostering inclusivity and dynamism in environmental management [26].

The limited adaptive capacity of governance systems also presents a critical challenge. Operational barriers, such as insufficient connectivity among actors and restricted access to vital information, hinder effective collaboration and response. The situation in Iran illustrates how these limitations reduce the overall resilience of governance systems [54]. Addressing this issue requires enhancing social networks, improving information-sharing mechanisms, and leveraging digital tools to facilitate collaboration among diverse stakeholders. These measures are vital for building a robust adaptive governance infrastructure. Social resistance to change represents another complex barrier to adaptive governance [55]. Public distrust in government policies or unfamiliar governance actors can impede the implementation of adaptive strategies [56]. This resistance highlights the importance of fostering trust, transparency, and community engagement in governance processes. Building strong relationships with local communities and ensuring their meaningful participation in decision-making processes are essential for overcoming these socio-cultural barriers and ensuring the success of adaptive governance initiatives.

A systemic challenge identified in the analysis is the reliance on short-term projects without long-term policy continuity. This dependency, as seen in Finland, undermines the sustainability of governance efforts [48]. Adaptive governance frameworks must therefore be embedded within institutional structures that prioritize longevity and scalability beyond the lifespan of individual projects. Strategic planning, sustained investment, and institutional commitment are critical to ensuring the durability and impact of governance systems over time. The lack of mechanisms for long-term evaluation further compounds these challenges. As demonstrated in Puerto Rico, the absence of robust frameworks to assess the long-term impacts of adaptation policies limits the ability to gauge their effectiveness and refine strategies [46]. Developing standardized metrics and integrating monitoring and evaluation systems into governance processes are crucial steps toward addressing this gap. These tools provide the foundation for evidence-based policy adjustments and continuous improvement.

The trends highlighted the complex interplay of uncertainties, institutional constraints, operational inefficiencies, socio-cultural dynamics, and systemic limitations that adaptive governance must navigate. To address these challenges, governance systems must evolve to embrace iterative and flexible approaches, foster decentralization and collaboration, enhance connectivity and trust, and embed long-term evaluation mechanisms. By addressing these barriers, adaptive governance can become a more effective tool for managing environmental complexities and achieving sustainable outcomes in a rapidly changing world.

5. CONCLUSION

Adaptive governance is vital for addressing complex environmental challenges, emphasizing flexibility, collaboration, and learning. Its application across diverse contexts—such as water governance, urban green spaces, climate change adaptation, and ecosystem restoration—demonstrates its versatility and potential. Success hinges on integrating local communities, governments, and private sectors, with polycentric and co-management models proving effective. However, challenges such as centralization, short-term focus, and limited evaluation mechanisms highlight the need for more decentralized, inclusive, and long-term approaches. Multilevel governance systems that integrate local, national, and international efforts are crucial in fostering resilience. Examples like Finland's environmental payment schemes and the Baltic Sea's ecosystem-based policies illustrate how collaboration enhances adaptive capacity. Yet, barriers like institutional rigidity, environmental uncertainty, and social resistance persist, requiring structural reforms, enhanced stakeholder connectivity, and standardized evaluation frameworks. Future research must focus on creating robust evaluation frameworks, leveraging big data, empowering local communities, and ensuring policy continuity. Establishing global success indicators will further enhance scalability and comparability. In summary, adaptive governance offers a transformative approach to environmental management. Addressing systemic barriers and bridging research gaps will unlock its potential as a critical tool for achieving sustainability and resilience in the face of global environmental challenges.

The analysis highlights the need for both research and policy to address critical gaps in adaptive governance and enhance its effectiveness. Future research should focus on developing long-term evaluation frameworks to measure ecological and socio-economic impacts, integrating adaptive principles into rigid institutional structures, and leveraging digital technologies like big data and AI to improve decision-making and collaboration. Additionally, empowering local communities through participatory models and ensuring the scalability and sustainability of policies beyond short-term projects are essential directions for future studies. On the policy front, adaptive governance must be embedded within institutional frameworks to promote flexibility, iterative learning, and decentralized decision-making. Policies should encourage multilevel collaboration, integrating local, national, and international efforts to foster resilience. Investments in digital infrastructure and incentives for community participation can further strengthen governance systems. Establishing global evaluation standards will also ensure consistency, allowing for the comparison and adoption of best practices across different contexts. By addressing these priorities, research and policy can work together to refine adaptive governance, making it a robust and scalable tool for managing environmental challenges and achieving sustainable outcomes.

REFERENCES

[1] Adanma, U.M., Ogunbiyi, E.O. (2024). Evaluating the effectiveness of global governance mechanisms in promoting environmental sustainability and international relations. Finance & Accounting Research Journal, 6(5): 763-791. https://doi.org/10.51594/farj.v6i5.1151

[2] Szpilko, D., de la Torre Gallegos, A., Jimenez Naharro, F., Rzepka, A., Remiszewska, A. (2023). Waste management in the smart city: current practices and future directions. Resources, 12(10): 115. https://doi.org/10.3390/resources12100115

[3] Cosens, B., Ruhl, J.B., Soininen, N., Gunderson, L., et al. (2021). Governing complexity: Integrating science, governance, and law to manage accelerating change in the globalized commons. Proceedings of the National Academy of Sciences, 118(36): e2102798118. https://doi.org/10.1073/pnas.2102798118

[4] Yasmin, T., Farrelly, M., Rogers, B.C. (2020). Adaptive governance: A catalyst for advancing sustainable urban transformation in the global South. International Journal of Water Resources Development, 36(5): 818-838. https://doi.org/10.1080/07900627.2019.1611548

[5] Ansell, C., Sørensen, E., Torfing, J. (2023). Public administration and politics meet turbulence: The search for robust governance responses. Public Administration, 101(1): 3-22. https://doi.org/10.1111/padm.12874

[6] Eshuis, J., Gerrits, L. (2021). The limited transformational power of adaptive governance: A study of institutionalization and materialization of adaptive governance. Public Management Review, 23(2): 276-296. https://doi.org/10.1080/14719037.2019.1679232

[7] Alexandra, C., Wyborn, C., Munera Roldan, C., van Kerkhoff, L. (2023). Chapter 5: Futures-thinking: concepts, methods and capacities for adaptive governance. In Handbook on Adaptive Governance. Cheltenham, UK: Edward Elgar Publishing. https://doi.org/10.4337/9781800888241.00015

[8] Lescrauwaet, L., Wagner, H., Yoon, C., Shukla, S. (2022). Adaptive legal frameworks and economic dynamics in emerging tech-nologies: Navigating the intersection for responsible innovation. Law and Economics, 16(3): 202-220. https://doi.org/10.35335/laweco.v16i3.61

[9] Rashidfarokhi, A. (2024). Resilience by whom and for whom? Empowering local communities for community-led resilience-building. Real Estate and Sustainable Crisis Management in Urban Environments, 39. https://doi.org/10.1201/9781003474586-3

[10] Zhang, L. (2011). Building communication capacity for good governance: A multileveled analysis. In China's Search for Good Governance (pp. 145-158). New York: Palgrave Macmillan US. https://doi.org/10.1057/9780230337589_10

[11] Chaiya, C. (2024). Policy paradoxes in environmental sustainability: The interplay of socioeconomic factors, policy innovations, and community forestry in Thailand. Journal of Ecohumanism, 3(4): 2503-2528. https://doi.org/10.62754/joe.v3i4.3772

[12] Zhu, H., Jiang, S. (2024). Navigating urban sustainable development: Exploring the impact of low carbon policies on the urban ecological carrying capacity. Journal of Cleaner Production, 469: 143162. https://doi.org/10.1016/j.jclepro.2024.143162

[13] Thompson, I., Shrestha, M., Chhetri, N., Agusdinata, D. B. (2020). An institutional analysis of glacial floods and disaster risk management in the Nepal Himalaya. International Journal of Disaster Risk Reduction, 47: 101567. https://doi.org/10.1016/j.ijdrr.2020.101567

[14] Bremer, S., Glavovic, B., Meisch, S., Schneider, P.,

Wardekker, A. (2021). Beyond rules: How institutional cultures and climate governance interact. Wiley Interdisciplinary Reviews: Climate Change, 12(6): e739. https://doi.org/10.1002/wcc.739
[15] Allain-Dupré, D. (2020). The multi-level governance imperative. The British Journal of Politics and International Relations, 22(4): 800-808. https://doi.org/10.1177/1369148120937984
[16] Westskog, H., Amundsen, H., Christiansen, P., Tønnesen, A. (2020). Urban contractual agreements as an adaptive governance strategy: Under what conditions do they work in multi-level cooperation? Journal of Environmental Policy & Planning, 22(4): 554-567. https://doi.org/10.1080/1523908X.2020.1784115
[17] van Assche, K., Valentinov, V., Verschraegen, G. (2021). Adaptive governance: Learning from what organizations do and managing the role they play. Kybernetes, 51(5): 1738-1758. https://doi.org/10.1108/K-11-2020-0759
[18] Hakiman, K., Sheely, R. (2023). Unlocking the potential of participatory planning: How flexible and adaptive governance interventions can work in practice. Studies in Comparative International Development, 60: 43-80. https://doi.org/10.1007/s12116-023-09415-x
[19] Bello, F.G., Lovelock, B., Carr, N. (2017). Constraints of community participation in protected area-based tourism planning: The case of Malawi. Journal of Ecotourism, 16(2): 131-151. https://doi.org/10.1080/14724049.2016.1251444
[20] Barnes, M.L., Wang, P., Cinner, J.E., Graham, N.A.J., Guerrero, A.M., Jasny, L., Lau, J., Sutcliffe, S.R., Zamborain-Mason, J. (2020). Social determinants of adaptive and transformative responses to climate change. Nature Climate Change, 10(9): 823-828. https://doi.org/10.1038/s41558-020-0871-4
[21] Colloff, M.J., Gorddard, R., Abel, N., Locatelli, B., Wyborn, C., Butler, J.R.A., Lavorel, S., van Kerkhoff, L., Meharg, S., Múnera-Roldán, C., Bruley, E., Fedele, G., Wise, R.M., Dunlop, M. (2021). Adapting transformation and transforming adaptation to climate change using a pathways approach. Environmental Science & Policy, 124: 163-174. https://doi.org/10.1016/j.envsci.2021.06.014
[22] Haasnoot, M., Di Fant, V., Kwakkel, J., Lawrence, J. (2024). Lessons from a decade of adaptive pathways studies for climate adaptation. Global Environmental Change, 88: 102907. https://doi.org/10.1016/j.gloenvcha.2024.102907
[23] Filho, W.L., Wolf, F., Moncada, S., Salvia, A.L., Balogun, A.L.B., Skanavis, C., Kounani, A., Nunn, P.D. (2022). Transformative adaptation as a sustainable response to climate change: Insights from large-scale case studies," Mitigation and Adaptation Strategies for Global Change, 27(3): 20. https://doi.org/10.1007/s11027-022-09997-2
[24] Carr, E.R. (2020). Resilient livelihoods in an era of global transformation. Glob. Environ. Change, 64: 102155. https://doi.org/10.1016/j.gloenvcha.2020.102155
[25] Partelow, S. Schlüter, A., Armitage, D., Bavinck, M., Carlisle, K., Gruby, R.L., Hornidge, A.K., Tissier, M.L., Pittman, J.B., Song, A.M., Sousa, L.P., Văidianu, N., Van Assche, K. (2020). Environmental governance theories: A review and application to coastal systems. Ecology and Society 25(4): 19. https://doi.org/10.5751/ES-12067-250419
[26] Tuda, A.O., Kark, S., Newton, A. (2021). Polycentricity and adaptive governance of transboundary marine socio-ecological systems. Ocean & Coastal Management, 200: 105412. https://doi.org/10.1016/j.ocecoaman.2020.105412
[27] Akamani, K. (2020). Integrating deep ecology and adaptive governance for sustainable development: Implications for protected areas management. Sustainability, 12(14): 5757. https://doi.org/10.3390/su12145757
[28] Ruane, S. (2019). Applying the principles of adaptive governance to bushfire management: A case study from the South West of Australia. Journal of Environmental Planning and Management, 63(7): 1215-1240. https://doi.org/10.1080/09640568.2019.1648243
[29] Fischer, H.W. (2021). Decentralization and the governance of climate adaptation: Situating community-based planning within broader trajectories of political transformation. World Development, 140: 105335. https://doi.org/10.1016/j.worlddev.2020.105335
[30] Driessen-Willems, M.D., Bartelink, N.H.M., Bessems, K.M.H.H., Kremers, S.P.J., Kintzen, C., van Assema, P. (2021). Co-creation approach with action-oriented research methods to strengthen "Krachtvoer"; A school-based programme to enhance healthy nutrition in adolescents. International Journal of Environmental Research and Public Health, 18(15): 7866. https://doi.org/10.3390/ijerph18157866
[31] Folke C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. Glob. Environ. Change, 16(3): 253–267. https://doi.org/10.1016/j.gloenvcha.2006.04.002
[32] Walker, B., Holling, C.S., Carpenter, S.R., Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. Ecology and Society, 9(2): 5. https://doi.org/10.5751/es-00650-090205
[33] Ali, M.S.S., Arsyad, M., Kamaluddin, A., Busthanul, N., Dirpan, A. (2019). Community based disaster management: Indonesian experience. IOP Conference Series: Earth and Environmental Science, 235: 012012. https://doi.org/10.1088/1755-1315/235/1/012012
[34] Armitage, D.R. Plummer, R., Berkes, F., Arthur, R.I., Charles, A.T., Davidson-Hunt, I.J., Diduck, A.P., Doubleday, N.C., Johnson, D.S., Marschke, M., McConney, P., Pinkerton, E.W., Wollenberg, E.K. (2009). Adaptive co-management for social–ecological complexity. Frontiers in Ecology and the Environment, 7(2): 95-102. https://doi.org/10.1890/070089
[35] Congleton, R.D. (2009). Elinor Ostrom, Understanding Institutional Diversity. Public Choice, 132: 509-511. https://doi.org/10.1007/s11127-007-9157-x
[36] Berkes, F. (2009). Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. Journal of Environmental Management, 90(5): 1692-1702. https://doi.org/10.1016/j.jenvman.2008.12.001
[37] Biggs, E.M., Bruce, E., Boruff, B., Duncan, J.M.A., Horsley, J., Pauli, N., McNeill, K., Neef, A., Van Ogtrop, F., Curnow, J., Haworth, B., Duce, S., Imanari, Y. (2015). Sustainable development and the water–energy–food nexus: A perspective on livelihoods. Environmental Science & Policy, 54: 389-397. https://doi.org/10.1016/j.envsci.2015.08.002

[38] Shu, Y., Ma, Y., Li, W., Hu, G., Wang, X., Zhang, Q. (2024). Unraveling the dynamics of social governance innovation: A synergistic approach employing NLP and network analysis. Expert Systems with Applications, 255: 124632. https://doi.org/10.1016/j.eswa.2024.124632
[39] Ostrom, E., Cox, M. (2010). Moving beyond panaceas: A multi-tiered diagnostic approach for social-ecological analysis. Environmental Conservation, 37(4): 451-463. https://doi.org/10.1017/S0376892910000834
[40] Choudhury, M., Wu, H., Shahidullah, A.K.M. (2024). Improving the feedback loop between community- and policy-level learning: Building resilience of coastal communities in Bangladesh. Sustainable Development, 32(2): 1508-1524. https://doi.org/10.1002/sd.2686
[41] Baas, J., Schotten, M., Plume, A., Côté, G., Karimi, R. (2020). Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. Quantitative Science Studies, 1(1): 377-386. https://doi.org/10.1162/qss_a_00019
[42] Peterson, E. (2018). Collaborating with the enemy: How to work with people you don't agree with or like or trust, by Adam Kahane. World Futures, 75(3): 184–189. https://doi.org/10.1080/02604027.2018.1532724
[43] Armitage, D., Marschke, M., van Tuyen, T. (2011). Early-stage transformation of coastal marine governance in Vietnam? Marine Policy, 35(5): 703–711. https://doi.org/10.1016/j.marpol.2011.02.011
[44] Valman, M., Österblom, H., Olsson, P. (2015). Adaptive governance of the Baltic Sea – Lessons from elsewhere. International Journal of the Commons, 9(1): 440–465. https://doi.org/10.18352/bmgn-lchr.532
[45] Greenhill, L., Kenter, J.O., Dannevig, H. (2020). Adaptation to climate change–related ocean acidification: An adaptive governance approach. Ocean & Coastal Management, 191, 105176. https://doi.org/10.1016/j.ocecoaman.2020.105176
[46] Ramos-Santiago, L.E., Villanueva-Cubero, L., Santiago-Acevedo, L.E., Rodriguez-Melendez, Y.N. (2014). Green area loss in San Juan's inner-ring suburban neighborhoods: A multidisciplinary approach to analyzing green/gray area dynamics. Ecology and Society, 19(2).
[47] Olsson, P., Folke, C., Hahn, T. (2004). Social-ecological transformation for ecosystem management: The development of adaptive co-management of a wetland landscape in southern Sweden. Ecology and Society, 9(4): 2. https://doi.org/10.5751/es-00683-090402
[48] Raatikainen, K. (2018). The importance of engaging local people in landscape management – Experiences from an EU project. Landscape Online, 57. https://doi.org/10.3097/LO.201857
[49] Huber-Stearns, H.R., Cheng, A.S. (2017). The evolving role of government in the adaptive governance of freshwater social-ecological systems in the western US. Environmental Science & Policy, 77: 40-48.
[50] Larson, K.L., White, D.D., Gober, P., Wutich, A. (2015). Decision-making under uncertainty for water sustainability and urban climate change adaptation. Sustainability, 7(11): 14761-14784.
[51] Rawluk, A., Beilin, R., Lavau, S. (2021). Enacting shared responsibility in biosecurity governance: Insights from adaptive governance. Ecology and Society, 26(2): 18. https://doi.org/10.5751/es-12368-260218
[52] Sanchez-Plaza, A., Broekman, A., Paneque, P. (2019). Analytical framework to assess the incorporation of climate change adaptation in water management: Application to the Tordera River Basin Adaptation Plan. Sustainability, 11(3): 762. https://doi.org/10.3390/su11030762
[53] Gaudreau, M., Cao, H. (2015). Political constraints on adaptive governance: Environmental NGO networks in Nanjing, China. The Journal of Environment & Development, 24(4): 418–444. https://doi.org/10.1177/1070496515602044
[54] Salajegheh, S., Jafari, H.R., Pourebrahim, S. (2020). Modeling the impact of social network measures on institutional adaptive capacity needed for sustainable governance of water resources. Natural Resource Modeling, 33(4): e12277. https://doi.org/10.1111/nrm.12277
[55] Westerink, J., Jongeneel, R., Polman, N., Prager, K., Franks, J., Dupraz, P., Mettepenningen, E. (2017). Collaborative governance arrangements to deliver spatially coordinated agri-environmental management. Land Use Policy, 69: 176-192.
[56] Van Oosterzee, P., Dale, A., Preece, N.D. (2014). Integrating agriculture and climate change mitigation at landscape scale: Implications from an Australian case study. Global environmental change, 29: 306-317.
[57] Jacob, C., Bernatchez, P., Dupras, J., Cusson, M. (2021). Not just an engineering problem: The role of knowledge and understanding of ecosystem services for adaptive management of coastal erosion. Ecosystem Services, 51: 101349. https://doi.org/10.1016/j.ecoser.2021.101349
[58] Armitage, D., Berkes, F., Dale, A., Kocho-Schellenberg, E., Patton, E. (2011). Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. Global Environmental Change, 21(3): 995-1004. https://doi.org/10.1016/j.gloenvcha.2011.04.006
[59] Kahui, V., Richards, A.C. (2014). Lessons from resource management by indigenous Maori in New Zealand: Governing the ecosystems as a commons. Ecological Economics, 102: 1-7. https://doi.org/10.1016/j.ecolecon.2014.03.006
[60] Mian, S. (2014). Pakistan's flood challenges: An assessment through the lens of learning and adaptive governance. Environmental Policy and Governance, 24(6): 423-438. https://doi.org/10.1002/eet.1659