

Review

The Roles of Adaptive Water Governance in Enhancing the Transition towards Ecosystem-Based Adaptation

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Abstract: The growing realization of the inadequacies of the conventional approach to climate change adaptation has generated interest in sustainable forms of adaptation that could promote long-term ecosystem health and social equity. In this regard, the concept of ecosystem-based adaptation has been receiving attention as an integrative framework for maintaining healthy ecosystems, with the aim of building the resilience and reducing the vulnerability of social–ecological systems to climate change impacts. However, there is currently an inadequate understanding of the institutional requirements for the transition towards ecosystem-based adaptation. A promising institutional mechanism for addressing these governance challenges is adaptive governance, a governance mechanism that relies on flexible, multi-level institutions to connect actors across multiple scales in managing conflicting values and uncertainties in ecosystem-based management processes. This paper discusses four roles of adaptive governance in the transition of water resource systems towards ecosystem-based adaptation: (1) creating awareness about climate change through social learning and the integration of diverse sources of knowledge; (2) generating interest for policy change through the provision of economic and non-economic incentives; (3) creating opportunities for change through the promotion of vertical and horizontal interactions among actors; and (4) building capacities for change through enhanced access to relevant institutions and resources.

Keywords: adaptive capacity; climate change mitigation; indigenous knowledge; institutions; polycentric systems; resilience; social–ecological systems; sustainable development; transformation; vulnerability



Citation: Akamani, K. The Roles of Adaptive Water Governance in Enhancing the Transition towards Ecosystem-Based Adaptation. *Water* **2023**, *15*, 2341. <https://doi.org/10.3390/w15132341>

Academic Editor: Athanasios Loukas

Received: 15 April 2023

Revised: 12 June 2023

Accepted: 17 June 2023

Published: 24 June 2023



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1. Introduction

Recent decades have brought about increased knowledge of the observed and projected impacts of climate change, as well as the associated risks posed to ecosystems and human societies [1–3]. A recent report by the Intergovernmental Panel on Climate Change estimated that the global surface temperature has risen by 1.09 degrees Celsius in 2011–2020 above pre-industrial (1850–1900) levels. The report further estimated the likelihood of global warming exceeding 1.5 degrees Celsius in the near term to be at least greater than 50% [4]. These trends in global warming present significant risks of crossing multiple climate tipping points, thereby increasing the vulnerability of social and ecological systems through sea level rise, loss of biodiversity, and so forth [2]. The vulnerabilities associated with climate impacts are likely to be exacerbated by the incidence of compound extremes, involving the simultaneous occurrence and complex interactions among multiple climate hazards, such as wildfire, heat waves, drought, and extreme rainfall [3–5]. Interactions among climate hazards and the multiple non-climatic drivers of change, such as ecosystem degradation, over-consumption, rapid urbanization, growing inequality, and global pandemics, also add to the vulnerability of social and ecological systems [4,6,7]. These vulnerabilities are not evenly distributed, as rural communities and other marginalized groups around the world, especially those in the developing world, are more likely to be adversely impacted [4,7,8].

In the water sector, for instance, the adverse impact of ongoing changes in the climate system is increasingly being recognized as one of the greatest threats to the sustainable management of water resources [9–11]. The expected increase in the variability of the hydrologic cycle could have adverse implications for water quality and access, thereby presenting challenges for the attainment of water security [12–14]. An increase in the frequency and severity of extreme hydroclimatic events, such as floods and drought, as well as the uncertainties that characterize the patterns and impacts of these events, also presents challenges for current water management institutions that are built around the idea of stationarity [1,9,15]. Thus, addressing the complexity and risks associated with global warming and other drivers of change is becoming a central focus in water governance [16–18].

There is a growing realization among scientists and decision-makers that the conventional command-and-control paradigm of water resource management is ill-suited for dealing with the complexity of climate change [18,19]. Shortfalls of this management paradigm include flawed assumptions about the predictability of hydrologic systems, a lack of flexibility for responding to surprise, the neglect of cross-scale interactions, an overreliance on technical experts, and the failure to promote stakeholder engagement in the water management process [9,15,20]. In spite of the awareness about the shortfalls of the conventional paradigm, the water sector has been slow to transition toward innovative governance mechanisms for responding to climate change impacts [12,13,16]. The failure to adopt proactive and transformational adaptation policies in spite of the availability of relevant knowledge could be attributed to path dependencies created by established values, paradigms, and infrastructure, as well as by funding limitations and governance arrangements that constrain the capacity of actors to act [16,19,21–23]. This highlights the need for more research on the mechanisms for transformative change [22,24,25]. However, the governance and institutional dimensions of transformational change, defined as “a fundamental, society-wide reorganization across technological, economic and social factors and structures, including paradigms, goals and values” [26] (p. 20), have generally received little attention in the literature [27,28]. In the water sector in particular, there is a lack of clarity on the mechanisms by which transformational responses to novel climate change impacts could occur [13,16].

More recently, research and policy interest has been growing around the concept of transformative governance, defined as “the formal and informal (public and private) rules, rulemaking systems and actor networks at all levels of human society that enable transformative change” [26] (p. 21). The emerging literature suggests that transformative governance mechanisms need to be adaptive, integrative, and inclusive and must accommodate plural forms of knowledge [26,28]. These attributes of transformative governance are similar to those of adaptive governance, a concept that refers to institutional structures and decision-making processes that connect actors across multiple scales with the aim of managing the conflicting stakeholder values and uncertainties in knowledge that characterize the management of complex resource systems [29–31]. The literature on adaptive governance highlights the necessity of this governance mechanism in promoting transformational change [32,33]. Thus, adaptive governance could be posited as a means of realizing the aspirations of transformative governance. While much of the existing literature has been devoted to exploring the conditions for the emergence of adaptive governance [34–36], the specific roles of these governance approaches in enabling the process of transformative change have not yet been clearly articulated and empirically studied [36–38]. This manuscript seeks to address this knowledge gap by drawing from a review of the literature in discussing four roles of adaptive governance in the process of social–ecological transformation: creating awareness; generating interest; mobilizing resources; and providing opportunities for change. The discussion is supported with case studies on the implementation of ecosystem-based adaptation gathered from around the world [39–41]. The novelty of the paper lies in its integration of the theoretical arguments and empirical evidence in the existing literature to provide a coherent understanding of the

role of adaptive governance in social–ecological transformation processes, thereby laying the foundation for the subsequent development of generalizable conceptual models and effective policies to guide transitions towards sustainable futures. While this research draws from the broader literature on transformative change in social–ecological systems, the discussion focuses largely on the water sector. In this sense, the aspiration of the paper is modest, as it focuses on transition, which is concerned with change in a specific system or regime as opposed to transformation, which is about fundamental changes in the broader societal structures [42].

2. Evolving Climate Change Policies

Climate change mitigation and adaptation represent two broad categories of policy responses to climate change. Since the adoption of the United Nations' Framework Convention on Climate Change in 1992 and the Kyoto Protocol in 1997, international policy on climate change has focused largely on the mitigation of climate change with the aim of avoiding the crossing of thresholds that could result in catastrophic outcomes [43–45]. The focus of climate change mitigation policies is to limit climate change by reducing the emission of greenhouse gases [46]. Policies on climate change mitigation are essential in limiting climate-related risks and reducing the cost of adaptation [2,4]. For instance, the Paris Agreement seeks to limit global warming to well below 2 degrees Celsius and possibly below 1.5 degrees Celsius [45,47]. However, progress in the implementation of climate change mitigation policies at the global level has been slow [43,45,48]. Armstrong McKay et al. [2] recently concluded that the goals of the Paris Agreement are not ambitious enough as safeguards against the crossing of multiple climate tipping points. Commitments to greenhouse gas emission reduction expressed through Nationally Determined Contributions (NDCs) under the agreement have also been found to be inadequate in meeting these emissions goals [44]. Meanwhile, the implementation of NDCs in many countries has fallen behind schedule [45]. A range of challenges militate against the implementation of global mitigation policies in an effective, equitable, and efficient manner, including the political uncertainties that inhibit long-term commitment, uncertainties in the costs and benefits of climate change mitigation strategies, the unequal distribution of the costs and benefits of mitigation between industrialized and developing countries, the potential for free riding, inadequate resources, and difficulties in designing inclusive and deliberative processes to meaningfully engage all parties [43,44,49].

Climate change adaptation policies have also been receiving attention since the early 2000s, but especially following the adoption of the Paris Agreement in 2015 [44]. Recent years have focused on the search for climate change adaptation policies that are effective and equitable [4,8]. Climate change adaptation focuses on the processes through which societies learn and adjust in order to reduce the adverse impacts of climate change and to take advantage of opportunities [7,47,50,51]. Climate change adaptation strategies in specific contexts may be classified as planned or autonomous, anticipatory or reactive, or incremental or transformational [4,16,46,51,52]. Adaptive capacity, “the preconditions necessary to enable adaptation and the ability to mobilize these elements” [6] (p. 758), is dependent on the scale and context of analysis [8,52]. Nonetheless, the determinants of adaptive capacity often include the availability of various physical and financial resources, social capital, information, as well as effective institutional mechanisms [8,46,47,53,54]. While developed countries are often assumed to have higher adaptive capacities than their developing country counterparts, the experience of climate change impacts in recent years has generated interest in understanding adaptation limits in developed and developing countries [4,55,56]. Existing studies also highlight the shortfalls of the current adaptation policies, including a narrow framing of the adaptation problems that focus on specific sectors and particular risks, an over-emphasis on technological fixes, a neglect of the social sciences, and the use of top-down institutional mechanisms [6–8,57]. Adaptation policies have also been found to focus predominantly on incremental responses to climate change impacts on small scales to the neglect of broader transformational responses [4,58].

Concerns have also been raised about the potential of adaptation policies to contribute to widening inequalities [45], as well as leading to maladaptive outcomes and the erosion of social–ecological resilience [6,59].

In view of these insights, the need for more integrative approaches to promoting climate change mitigation and adaptation, as well as other sustainability goals, has also been receiving attention among scientists and decision-makers [51,60–62]. Ecosystem-based adaptation is one of the emerging concepts that promise to promote a holistic approach to addressing the climate challenge. With its roots in the older ecosystem management concept [63,64] and constituting part of the broader category of nature-based solutions [57,65,66], ecosystem-based adaptation adopts a multi-sectoral approach to maintaining healthy ecosystems as a means of building resilience and reducing the vulnerability of social and ecological systems to climate change impacts [7,57,60]. Ecosystem-based adaptation seeks to harness various ecosystem services to achieve a range of objectives, including poverty reduction, livelihood enhancement, biodiversity conservation, as well as climate change mitigation and adaptation [67–69]. Key features of ecosystem-based adaptation include the recognition of the complex interactions among climate, ecosystems, and human societies [63,68], the integration of diverse forms of knowledge, including local and traditional knowledge in adaptation processes [39,63], the promotion of integrated management goals through a diverse range of management practices that minimize trade-offs and enhance the synergies among diverse values [60,64,69], and the utilization of different types of institutional mechanisms for engaging stakeholders, managing conflicts, and responding to uncertainties [7,57,68]. In spite of its promise, the implementation of the ecosystem-based adaptation approach is being hampered by a lack of consensus on the defining features of the concept, limited monitoring of the outcomes, challenges in the coordination of implementation efforts at smaller and larger scales, and the lack of governance mechanisms for meaningful stakeholder engagement [57,67,69]. Importantly, the conceptual frameworks and institutional mechanisms for facilitating the mainstreaming of ecosystem-based adaptation have not received enough attention [7,70]. Although adaptive governance has been suggested as a useful institutional mechanism for implementing ecosystem-based adaptation [71], this potential has not been fully explored. The next section of the manuscript draws from the resilience literature to further elaborate on the challenges in promoting transformative change towards ecosystem-based adaptation.

3. Resilience and Social–Ecological Transformation

Contemporary approaches to managing natural resources have often sought to maintain stability and reduce variability in ecosystems based on the assumption that ecosystems fluctuate around a single equilibrium and respond to human impacts in a linear, predictable, and controllable manner [72,73]. Understanding of the complex interactions between social and ecological systems has also been hampered by the traditional separation of the social and ecological sciences [20,74]. The emergence of resilience research in the field of ecology in the 1970s, coupled with decades of interdisciplinary efforts in the study of human–environment interactions, has shed light on the complex interdependence between social and ecological systems, as well as the attributes they exhibit [32,74]. The concept of social–ecological systems is now widely used to depict integrated systems of humans and nature with reciprocal feedback and interdependence between them [75]. Social–ecological systems around the world have been found to exhibit attributes, such as nonlinearity, thresholds, surprises, and path dependence [73,74]. As such, social–ecological systems have also been described as complex adaptive systems [29,76,77]. Another way of characterizing the complexity of social–ecological systems is through the panarchy concept [78], which depicts a social–ecological system as a hierarchically nested set of adaptive cycles that interact with one another across multiple spatial and temporal scales, with each adaptive cycle going through the four phases of exploitation, conservation, release, and re-organization [79].

These theoretical insights about the complexity of social–ecological systems have given rise to the concept of resilience as a framework for enhancing sustainable human–

environment interactions [80–90]. Based on the assumption of the existence of multiple equilibria, as opposed to a single equilibrium, resilience has been defined as the amount of disturbance a system can absorb before flipping from one stable equilibrium to another [91,92]. Building on this definition, Walker et al. [85] defined resilience as “the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity” (p. 2). For coupled social–ecological systems, resilience comprises the amount of disturbance the system can absorb while retaining its structure and function, the ability to self-organize, and the capacity for learning and adaptation [32,76,79].

From the resilience perspective, coping, adaptability, and transformability represent a spectrum of responses to drivers of change in social–ecological systems [22,73,80]). Coping mechanisms involve short-term responses employed by actors to reduce the impacts of drivers of change on their well-being [80]. Coping mechanisms allow actors to maintain the persistence of the existing system while addressing the drivers of change that fall within their historical experience [80,81]. Adaptability is needed when the coping ability of actors is exceeded [81], and it is concerned with the capacity of social–ecological systems to learn and adjust in response to various drivers of change while remaining within the critical thresholds of the existing system [75,82,89]. Thus, adaptive strategies generally involve incremental changes aimed at maintaining or returning a system to its pre-disturbance condition [84]. Given its orientation towards the maintenance of the status quo, the implementation of resilience policies in the form of adaptation are likely to be more politically favorable [84]. The factors influencing adaptability in the resilience literature are similar to those influencing adaptive capacity in the climate change literature, and they include high levels of capital assets, as well relevant institutions and governance mechanisms [85,86].

Transformability is the other critical dimension of the resilience concept that has received relatively little attention until recently [32]. Walker et al. [87] defined transformability as “the capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable” (p. 3). Unlike the incremental change entailed in adaptation, transformability involves a more radical and pervasive reorganization of the existing social–ecological system [82,84,88], and it involves the crossing of thresholds and moving the social–ecological system into new development trajectories [89]. Transformational changes may entail fundamental alteration of the existing institutions and organizations, values and belief systems, technological innovations, behavioral patterns, and so forth [75,76,90]. While transformability is often posited as an appropriate response to perceptions of major threats, such as the impacts of climate change, failures in the existing system, or changing social values [84,85], deliberate transformational change at larger scales that involves all the components of the existing social–ecological system is likely to be associated with high levels of cost, risk, and uncertainty and, hence, less likely to be politically palatable [75,81,84]. However, the existing literature provides evidence that transformational change can occur when certain conditions are right, such as the presence of effective leadership, enabling legislation, arenas for deliberation, capital assets, and relevant knowledge [34,75,84,93,94]. Others also characterize the determinants of transformability in terms of awareness, motivation, ability, and opportunity [85,86,90]. Although there is empirical support for these determinants in the existing literature, a coherent theoretical formulation on the process of social–ecological transformation is yet to be developed [94,95]. Importantly, as noted previously, the governance mechanisms for navigating the process of social–ecological transformation have not received enough research attention [27]. The ensuing section addresses this gap using the adaptive governance literature.

4. Adaptive Water Governance and Social–Ecological Transformation

Given the urgency expressed about the need for transformational change as a means of achieving sustainable development and responding to climate change impacts [4,37], adaptive governance has been gaining prominence as an appropriate mechanism for navi-

gating the transformation process [32,33]. Like adaptive co-management [96], the adaptive governance concept integrates perspectives from social–ecological systems research and the governance of common pool resources [97,98]. Adaptive governance has been defined as “flexible and learning-based collaborations and decision-making processes involving both state and nonstate actors, often at multiple levels, with the aim to adaptively negotiate and coordinate management of social-ecological systems and ecosystem services across landscapes and seascapes” [99] (p. 7369). The adaptive governance concept captures the decision-making processes and institutional structures that enable actors to manage complex social–ecological systems in settings that are characterized by conflicts and uncertainty, and it is considered to be particularly useful in times of abrupt change [30,100]. In their seminal article, Dietz et al. [29] contended that the governance of complex environmental problems requires the provision of information, facilitation of mechanisms for handling conflict, enhancement of rule compliance, provision of infrastructure, and preparedness for change. The authors proposed three governance strategies for meeting these requirements: analytic deliberation; nested institutions; and institutional variety. Other defining attributes of the adaptive governance approach that have since emerged in the literature include the recognition of complexity, the promotion of adaptive and integrated management goals, and the utilization of diverse forms of knowledge [20,76,99].

Adaptive governance was initially proposed as an approach to ecosystem-based management [30], but it has also been applied to specific resource management arenas, such as energy policy [101], protected areas management [102,103], forest policy [104,105], and land tenure systems [106]. In the field of water governance, adaptive governance is increasingly considered as an appropriate response to the failures of the command-and-control paradigm in addressing complexity and integrating the human dimensions into the management process [20,36,107,108]. Much of the existing research has focused on characterizing the attributes of adaptive governance [20,76] and exploring the factors accounting for its emergence [35,36,109]. Other researchers have also highlighted the utility of adaptive governance as a mechanism for building resilience, promoting sustainability, and advancing the principles of good governance [20,32,98,102,109,110]. However, the mechanisms by which the attributes of adaptive governance enable transformative change have not yet been adequately analyzed [37,38]. In the remaining sections of this manuscript, the various attributes of the adaptive governance approach and their roles in meeting the requirements of social–ecological transformation are discussed (Table 1). While the literature depicts diverse ways of categorizing the requirements of social–ecological transformation, the ensuing discussion focuses on awareness, motivation, ability, and opportunity [7,85,86,111].

4.1. Awareness

Recent years have seen an appreciation of the complexity of climate change impacts, such as the compounding and cascading risks resulting from interactions among multiple climatic and non-climatic drivers of change across multiple scales and sectors [3,4]. Awareness of the complex interactions among climate, ecosystems, and human societies as social–ecological systems is increasingly recognized as one of the essential requirements for the successful navigation of the transformation process [99,111,112]. As knowledge gained from experience of historical conditions is often not enough to manage this complexity, navigating transformational change in complex social–ecological systems calls for the use of active adaptive management for generating knowledge through experiments [73,113,114]. Deliberate transformation also requires the availability of relevant information for analyzing existing problems, opportunities, and constraints, as well as for assessing the impacts of alternative courses of action [37,73,84,115]. Other researchers have also highlighted the need for modification of existing information systems to ensure that knowledge is inclusive of scientific and non-scientific forms of knowledge [37] while meeting requirements, such as trustworthiness, saliency, credibility, legitimacy, and relevance to the scale of analysis [29,37]. Yet, recent studies have shown that the implementation of

nature-based solutions, including ecosystem-based adaptation, tends to pay inadequate attention to the issues of complexity and uncertainty, as well as the need for monitoring long-term system dynamics [40,65,67]. The need for greater recognition of local knowledge in ecosystem-based adaptation processes has also been highlighted [7,39,68].

Table 1. Adaptive governance and transitions towards ecosystem-based adaptation.

Requirements of Transformation	Roles of Adaptive Governance
Awareness	• Recognizing social–ecological complexity • Prioritizing monitoring and adaptive management • Promoting disciplinary collaboration across the social and biophysical sciences • Integrating scientific and traditional knowledge • Promoting social learning and knowledge co-production processes
Motivation	• Integrating social, economic, and ecological values • Managing synergies and trade-offs through political processes, such as analytic deliberation • Promoting vertical and horizontal linkages that nurture social capital and shared meanings • Employing diverse mechanisms for enhancing rule compliance
Ability	• Facilitating the mobilization and sharing of various forms of capital assets • Enhancing the effectiveness of institutions at appropriate scales by addressing scale mismatches • Utilizing diverse institutions to provide redundancies that reduce the risk of institutional failure • Building capacities for conflict management through analytic deliberation processes
Opportunity	• Providing avenues for meaningful stakeholder engagement and representation of marginalized interests through analytic deliberation processes • Empowering local institutions through the principle of subsidiarity that entails the allocation of decision-making authority at appropriate levels • Facilitating experiments at lower scales within a polycentric institutional structure

Policies informed by the principles of adaptive governance, such as analytic deliberation, diverse knowledge systems, and adaptive management, could help meet the knowledge requirements in the transition towards ecosystem-based adaptation. First, the adaptive governance approach explicitly embraces the complexity of social–ecological systems and prioritizes the need to manage uncertainties using adaptive management [30,76,103]. As such, adaptive governance is often depicted as a mechanism for providing a favorable institutional context for the successful implementation of adaptive management [33,100,116–118]. While different types of adaptive management exist, active adaptive management entails a systematic process of experimentation and monitoring aimed at testing alternative policy options [9,20,73,119,120]. New knowledge derived from such an increased focus on monitoring and adaptive management will be essential for managing uncertainties in the transition towards ecosystem-based adaptation [39,40,60]. In Madagascar, for instance, a series of pilot tests were conducted across the country to evaluate various adaptation recommendations with the aim of scaling up promising ecosystem-based adaptation options within and outside that country [121]. Although these pilot tests may not necessarily meet the requirements for active adaptive management, they do offer opportunities for learning to address some of the uncertainties that characterize ecosystem-based adaptation.

Second, in view of its recognition of complexity, adaptive governance promotes an anti-reductionist approach to knowledge that favors the integration of diverse forms of knowledge across the social and biophysical sciences [20,30,122]. Similarly, the integration of scientific knowledge with traditional knowledge is strongly promoted in adaptive governance processes [20,107,123]. In Australia, for instance, the implementation of the

West Arnhem Land Fire Abatement Project entailed the harnessing of Aboriginal indigenous knowledge in community-based forest fire management. The project resulted in a reduction in the incidence of destructive wildfires and enhanced the preservation of cultural and ecosystem services while providing employment opportunities and avenues for the inter-general transmission of indigenous knowledge among Aboriginal communities [39].

Finally, another attribute of adaptive governance that facilitates the mobilization of relevant information is analytic deliberation, a structured decision process involving scientists, decision-makers, and other stakeholders that facilitates the management of conflicting values and knowledge uncertainties [29,31,124]. By providing opportunities for meaningful stakeholder engagement, adaptive governance holds promise as a mechanism for enhancing social learning and knowledge co-production [30,101]. Given that the fragmentation of data across scales and sectors continues to hinder the implementation of ecosystem-based adaptation measures [69], the integrative and participatory approach to knowledge entailed in adaptive governance could facilitate the transition process. For instance, the implementation of the IUCN's Climate Change and Development project in Eastern and Southern Africa involved the use of a participatory approach in conducting vulnerability assessments across a range of local livelihoods. The process resulted in an enhanced local capacity for vulnerability assessment and ultimately led to the implementation of various ecosystem-based adaptation practices, including reforestation and the use of non-timber forest products [39].

4.2. Motivation

Lambin [125] identified multiple dimensions of motivation that shape human behavior, including cultural, economic, policy, conflict, and institutional dimensions. Insights from the literature on common pool resources also suggest that the decision to act is usually based on the actors' computation of the costs and benefits of their actions [126], and this computation is influenced by a broad range of factors, including discount rates, internalized social norms, and so forth [127]. Dietz et al. [29] highlighted the need for using diverse formal and informal mechanisms for inducing rule compliance in the governance of complex social–ecological systems, such as financial instruments, government regulations, community-based institutions, and voluntary mechanisms based on information communication. The existing literature highlights several constraints that limit the motivation of actors to participate in ecosystem-based adaptation initiatives, such as the lack of information about the costs and benefits of ecosystem-based adaptation projects, land use conflicts, and other sources of community opposition [39,41,63]. To overcome some of these challenges, several researchers have called for the pursuit of a multi-sectoral approach that integrates ecosystem-based adaptation within broader adaptation strategies, as well as other conservation and development agendas [39,68].

One attribute of adaptive governance that could generate stakeholder interest in the transition towards ecosystem-based adaptation is the pursuit of integrated management goals that address social, economic, and ecological values of diverse stakeholders [36,100,128]. Such an integrative agenda could help prioritize the livelihoods, sustainability, and other concerns of less powerful stakeholders, such as indigenous peoples and local communities [102,129]. For instance, the implementation of the IUCN's Climate Change and Development project in Eastern and Southern Africa aimed to enhance the role of forests and water resources in securing local livelihoods as part of climate change adaptation efforts [39]. Similarly, the implementation of the Integrated National Adaptation Plan in Colombia aimed at cross-sectoral integration between climate change adaptation and sustainable development through the application of ecosystem-based adaptation principles in regional planning processes, such as municipal and watershed planning [39].

In addition to its holistic scope, the reliance of adaptive governance on diverse and nested institutional structures makes it a promising mechanism for enhancing synergies and reducing trade-offs through effective coordination and policy coherence across scales and sectors [102,107,123]. In Fiji, an integrated water resources management approach was

employed in the Nadi River Basin to enhance flood preparedness, livelihood security, and other goals through the coordinated management of land and water resources. In this regard, the formation of the Nadi Basin Catchment Committee provided an institutional mechanism for multi-sectoral coordination by engaging stakeholders from relevant sectors, such as forestry, water, land tenure, and land use [130].

Finally, the analytic deliberation process of adaptive governance provides an effective mechanism for negotiated solutions to stakeholder conflicts [29,31]. This conflict management role, coupled with opportunities for vertical and horizontal interactions among stakeholders, makes adaptive governance a useful mechanism for promoting various forms of social capital, including bonding, bridging, and linking of social capital, all of which contribute to the actors' willingness to engage in collective action [30,98,118,131]. For instance, in their analysis of the implementation of the ecosystem-based management processes in Europe, Australia, and North America, Schultz et al. [99] highlighted the potential of adaptive governance to employ informal mechanisms beyond the use of regulations and incentives in promoting stakeholder motivation and rule compliance.

4.3. Ability

The capacity to act is considered to be one of the key requirements of adaptation and transformation processes [29,30,94,112,125,132]. Although this capacity is often posited as a function of access to various capital assets and institutions [85,133,134], it is also shaped in important ways by the subjective perceptions of actors about their circumstances [22,115]. Nevertheless, the absence of requisite financial, technical, institutional, and other capacities represents some of the major impediments to the widespread adoption of ecosystem-based adaptation initiatives [39–41,63,68]. A study on the adoption of ecosystem-based adaptation practices among smallholder farmers in Central America found that adoption rates were influenced by factors such as the farmers' level education, experience, and land ownership status [135]. Another study on the implementation of ecosystem-based adaptation projects in Sri Lanka revealed the potential for such projects to provide social co-benefits to marginalized groups where target-specific measures are employed [136]. These results highlight the need to pay attention to questions regarding winners and losers in the implementation of ecosystem-based adaptation initiatives [137]. Ecosystem-based adaptation policies that are informed by an adaptive governance approach have the potential to build adaptive and transformational capacities in an equitable manner by contributing to community assets and institutions [138].

Regarding assets, Plummer [139] illustrated the potential for adaptive co-management to contribute to the general resilience of communities to climate change impacts by building community capital assets. Similarly, the holistic scope of adaptive governance has the potential to contribute to the stock of capital assets, such as natural capital through enhanced ecosystem health and the provision of ecosystem services [99], as well as physical capital, such as urban green infrastructure [37,140]. Adaptive governance could also contribute to economic capital through an explicit focus on local sustainability issues [102] and the provision of an enabling institutional framework for the implementation of innovative funding mechanisms, such as payments for ecosystem services and the reduction of emissions from deforestation and forest degradation (REDD+) initiatives [7,141]. Moreover, adaptive governance has the potential to contribute to the accumulation of human capital through enhanced mobilization and the sharing of knowledge, its emphasis on leadership capacity [118,142], as well as building social capital through the facilitation of interactions among networks of diverse stakeholders within and across scales [30,98,118].

In addition to its role in the accumulation and sharing of various resources, the adaptive governance approach has the potential to enhance the effectiveness of institutions in the implementation of ecosystem-based adaptation in a number of ways. First, the nesting of institutions across multiple scales addresses the problem of scale mismatch by enhancing the fit between decision-making and the scales at which problems occur [30,117,143]. The emphasis on the local level within this multi-level institutional

structure makes adaptive governance particularly useful for building local institutional capacity [118]. Second, the utilization of diverse forms of institutional mechanisms, including states, the private sector, and communities, provides redundancies that reduce the risk of failures that could occur from a reliance on a single type of institution as panaceas [29,30,98]. Third, the emphasis of adaptive governance on monitoring and adaptive management enhances the flexibility and overall resilience of the system to handle the uncertainties that characterize the transformation processes [33,117]. Finally, the use of analytic deliberation processes within the adaptive governance approach enhances the capacity for conflict management and provides an efficient process for the actors to work towards wise and durable agreements that address their collective concerns in a fair and amicable manner [31,144]. For instance, in their analysis of ecosystem-based adaptation case studies across Europe, Naumann et al. [41] described how the use of extensive stakeholder engagement and consultation processes, combined with technical analysis of project proposals at the initial stages of project design on Wallasea Island in the United Kingdom, helped overcome negative public perceptions, resulting in an estimated 90% of stakeholders changing their positions to support the project.

4.4. Opportunity

The opportunity to act, which is shaped by a range of contextual barriers and enabling conditions [22,94]), is an essential but often neglected determinant of adaptation and transformation processes. Boonstra et al. [145] referred to opportunities as the options from which actors can choose. Although the previous sections have highlighted the importance of awareness, motivation, and ability, their relevance depends on the availability of opportunities. Yet, the institutional mechanisms needed for providing the opportunities for meaningful stakeholder engagement and cross-sectoral integration in ecosystem-based adaptation processes remain poorly developed [57,70,146]). The existing literature on the emergence of adaptive governance highlights the importance of windows of opportunity in transitions towards adaptive governance [34,100,117]. However, Sharma-Wallace et al. [118] found in their review of the literature that although a large proportion of adaptive governance case studies were initiated in response to windows of opportunity created by social or ecological crises, reliance on these “opportunistic moments” were often not enough for successful transitions to adaptive governance. The authors concluded that the “contingent nature and potential costs of opportunity windows nevertheless renders them an unreliable and often undesirable means to adaptive governance” (p. 181). And yet, the role of governance mechanisms in creating opportunities for social–ecological transformation has not received explicit research attention. The analytic deliberation process of adaptive governance, coupled with its diverse and nested institutional structure, could potentially provide opportunities for actors to engage in collective action processes aimed at enhancing the transition towards ecosystem-based adaptation.

Analytic deliberation, if well executed on the basis of best practices, such as involvement of all stakeholders, involving stakeholders early in the process, involving stakeholders throughout the process, use of skilled facilitators and mediators, and making decisions on the basis of consensus, could contribute to providing opportunities for meaningful involvement of all participants, including traditionally marginalized groups [124,147–149]). Akamani and Wilson [98] elaborated on the capacity of adaptive governance to promote good governance principles, such as participation, accountability, and transparency, all of which are essential for ensuring meaningful stakeholder involvement in the implementation of ecosystem-based adaptation initiatives. In Tanzania, the Pangani River Basin Management Project was implemented in response to conflicts among water users stemming from water scarcity. The project combined environmental and climate vulnerability assessments with multi-stakeholder consultation processes to promote a flexible approach to water decision-making in the face of climate change impacts [39]. However, like other alternative dispute resolution mechanisms [150], analytic deliberation may not necessarily address the structural inequalities that may constrain the effectiveness of the conflict

management process. This shortfall is addressed through the institutional structure of adaptive governance.

As has been discussed in previous sections, the institutional structure of adaptive governance is composed of diverse institutions that are nested across multiple scales [29]. This institutional structure has often been described as polycentric [131,151]. Polycentric systems refer to governance mechanisms that are composed of multiple centers of decision-making authority, with some degree of autonomy at each level [48,49,152,153]. Within this polycentric institutional structure, opportunities for local community participation, an essential requirement for community-based adaptation and ecosystem-based adaptation processes [57], are created through the devolution of decision-making authority to lower levels in accordance with the principle of subsidiarity [98,154], as well as recognition of the legitimacy of local and traditional institutions through the accommodation of institutional variety [29]. Another key benefit of adaptive governance that emerges from its polycentric institutional structure is that it provides opportunities for learning and experimentation at lower levels of scale through which new ideas could be generated and tested during the adaptation and transformation processes [48,152]. In Indonesia, the implementation of the Green Coast project successfully employed a community-based approach to coastal habitat restoration in Aceh and Nias. Although the project was funded by external organizations, such as Oxfam, WWF, and IUCN, it was facilitated by dozens of local NGOs and directly involved local inhabitants in the tsunami-affected areas in the planning and implementation of the mangrove restoration projects [39]. The effectiveness of this locally led initiative differed radically from other restoration efforts where international aid organizations employed quick technological fixes, including the construction of miniature artificial reefs in the same tsunami-affected region of Indonesia [155].

5. Conclusions

Recent years have seen the emergence of the concept of ecosystem-based adaptation as a promising approach to climate change adaptation. However, the institutional mechanisms for navigating transformative change towards ecosystem-based adaptation have not received enough attention. This manuscript explored the role of adaptive governance in meeting key requirements for the transition towards ecosystem-based adaptation: awareness; motivation; ability; and opportunity. While the manuscript has explored the utility of the attributes of adaptive governance in meeting these requirements, it is worth noting that the adaptive governance concept itself is not without its critics. Some have highlighted the challenges in the emergence of adaptive governance, including path dependencies from old institutions and cultural traditions, as well as the role of vested interests [19,23,106], the challenges of coordination and allocation of responsibilities across scales, capacity constraints, potential inefficiencies in its institutional arrangements [52,98,156], and the potential for outcomes that may be undesirable, including the neglect of power relations and social inequities [20,118,151]. Given the inherently political and wicked nature of transformation processes [95,157,158], adaptive governance may have limited transformational ability where some of these challenges are not identified and addressed [38]. Similarly, the ecosystem-based adaptation approach may not be a panacea to all climate change impacts, and in some instances, structural or engineering options may be necessary alternative or complementary solutions [39]. The utility of ecosystem-based adaptation may also be limited in scenarios of severe global warming that lead to irreversible changes in ecosystem structures and functions, hence, the need for comprehensive climate policies that combine adaptation with mitigation options, as well as broader conservation, development, and governance issues [4,39,40]. In spite of these inherent limitations, policies on ecosystem-based adaptation that are informed by an adaptive governance approach hold promise in advancing efforts towards climate-resilient development. However, more work is needed to address the conceptual and implementation shortfalls associated with these and other emerging concepts to overcome hard and soft adaptation limits. To conclude, the findings from this review suggest a number of practical policy recommendations that are essential

for navigating the transition towards ecosystem-based adaptation. First, policies should aim to create enabling conditions for the integration of diverse forms of knowledge, the development of appropriate indicators for understanding the impacts of climate change on ecosystems and human societies, as well as testing of options for mitigation and adaptation through adaptive management. Second, policies should provide diverse forms of incentives, including economic and non-economic incentives, to motivate collective societal responses across multiple scales. Third, policies should seek to facilitate capacity-building through the provision of relevant forms of support, ranging from funding and information to technical skill training. Finally, policies aiming to enhance the transition towards ecosystem-based adaptation should provide the institutional avenues for the meaningful involvement of diverse actors across multiple scales in various stages of decision-making and the implementation of ecosystem-based adaptation processes.

Funding: This research was funded by the USDA National Institute of Food and Agriculture McIntire Stennis Project, grant number 1020037. The APC was funded by the same agency.

Data Availability Statement: No data is available for sharing, as the manuscript was based on a review of the literature.

Acknowledgments: I would like to thank my Research Assistants for their contributions to the research project upon which this paper is based. I am also indebted to the anonymous reviewers for the helpful feedback they provided on the manuscript.

Conflicts of Interest: The author declares no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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