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REVIEW

Multi-level learning in climate change adaptation planning: comparing three experiences from Latin America

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Abstract
With the adoption of the Paris Agreement on Climate Change, adaptation has become more visibly important for responding to the climate crisis. Countries are encouraged to put in place policy measures to implement their National Determined Contributions (NDC) including National Adaptation Plans (NAPs) to address the needs of adaptation across sectors and governance levels. Multi-level learning implies learning across international, national, and local levels of governance and is of particular importance to guide countries' adaptation planning efforts and to enable them to benefit from the experience and lessons learned obtained at other levels around the world. The objective of this paper is to assess the contribution of multi-level learning to adaptation planning in Latin America by analyzing and comparing learning across levels in three illustrative cases in Latin America: integration of climate change adaptation in watershed planning in Bolivia, ecosystem-based adaptation in Ecuador, and adaptation planning in small-scale agriculture in Honduras. The three research questions formulated cover the learning needs of adaptation planning, the structure and dynamic of the social network that enables multi-level learning nodes, and the strategies adopted by the stakeholders to learn on adaptation planning. In the three cases, adaptation planning functions can be enhanced through changes in multi-level learning nodes and the governance levels involved and through adjustments in the cognitive, normative, and relational dimensions of multi-level learning and the direction of such learning.

Keywords Adaptation to climate change · Governance of adaptation · Multi-level learning · Adaptation planning · Latin America

Introduction

Since the adoption of the Paris Agreement, adaptation has gained prominence in the global response to climate change. The multilateral process of the UNFCCC and the academic community both increasingly recognize that adaptation is not only a locally circumscribed process of national concern, but a multi-level governance challenge. This implies the need for enhanced coherence across different levels of governance to facilitate planning adaptation and learning (Amundsen et al. 2010; di Gregorio et al. 2019).

Integrating learning into adaptation is essential, as adaptation constitutes a dynamic and iterative process that necessitates continuous refinement, innovation, and flexibility (Adger 2003; High et al., 2005). Learning is acknowledged for its role in deepening the understanding of climate change challenges, enabling the anticipation and adaptation of responses (e.g., Pelling et al. 2008; Tschakert, and Dietrich, 2010); for sharing and scaling up possible responses (Fünfgeld 2015); integrating diverse perspectives, particularly those of vulnerable groups (e.g., Jabeen et al. 2010; Naess 2013); and as a key functionality of governance settings serving the purpose of resilience and adaptive capacity (e.g., Pahl-Wostl 2009; Siebenhüner 2008).

The assumption of this paper is that if learning for the sake of adaptation is taking place across levels of governance (henceforth multi-level learning), it will motivate and support countries to organize their own adaptation policies

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and implementation processes and learn from other country experiences. Multi-level learning is encouraged, for example, through international cooperation networks among different types of stakeholders across levels of governance (di Gregorio et al. 2019); the accumulation of knowledge by international and multilateral organizations about what works in terms of international cooperation and technical assistance (Vinke-de Kruijf, and Pahl-Wostl, 2016); and scaling up tested solutions through mechanisms of peer learning at local, national, and international levels (e.g., Fünfgeld 2015).

Furthermore, adaptation literature underscores that learning enhances the effectiveness of climate change adaptation policies (Huntjens et al. 2012), and enhances the adaptive capacity of governance systems (Diduck 2010), thus also contributing to institutional design and arrangements at different governance levels needed to support adaptation policies (e.g., Crona et al.,2012; Huntjens et al. 2012).

This paper examines how multi-level learning processes among stakeholders across different governance levels enhance capacities for adaptation planning, and what institutional arrangements are required to facilitate this process (Ison et al. 2015). We answer this question empirically by assessing multi-level learning in three selected cases in Latin America: the integration of climate change adaptation in watershed planning in Bolivia, ecosystem-based adaptation in Ecuador, and adaptation planning in small-scale agriculture in Honduras. These cases were chosen because they represent diverse adaptation challenges and governance contexts, allowing for a comparative analysis of multi-level learning dynamics. Moreover, one of the authors has direct working experience in all three cases, providing in-depth knowledge of the institutional settings, stakeholder interactions, and learning processes involved.

The paper is organized as follows. In the "Research questions and analytical framework" section, the theoretical background is described; the "Methods" section presents the methods; the "Results" section presents the results; and the "Integration and discussion of the results" and "Conclusions" sections cover the discussion of the results and conclusions.

Research questions and analytical framework

Multi-level learning is linked to the notion of multi-level governance (Hooghe et al., 2010) and has been defined as the interplay of policy learning (e.g., Sabatier 1988) and social learning (Reed et al. 2010) across levels of governance.

Social learning is frequently defined as a convergent change in stakeholders' perspectives on a particular problem and its possible solutions, in light of both their own and other stakeholders' views, interests, and positions with regard to the problem. Such learning achieves a change in understanding that goes beyond the individual toward collectives and social networks (Ison et al. 2015; Reed et al. 2010). In contrast, policy learning is referred to as a mechanism to address typical questions of public administration, such as facilitating the adoption and transfer of policies (Benz 2012), the adoption of new rules, or maintaining institutional memory (Getimis 2003).

Adaptation literature has also stressed the importance of multi-level learning in adaptation planning settings, and a central question in this research is how multi-level learning supports relevant policy processes that enhance the ability and performance of the governance system to deal with climate change challenges (Termeer et al. 2017). An entry point suggested by environmental governance scholars is to assess a set of institutional functions that together increase the adaptive capacity of a governance system (Gupta et al. 2010).

Drawing on organizational learning, multi-level learning can be evaluated, analyzing the factors that foster learning and the outcomes of such learning (e.g., Armitage et al. 2018; Gerlak, and Heikkila, 2011). The analytical framework utilized for our empirical examination of multi-level learning and adaptation planning is presented in Fig. 1. The framework applied is designed to help understand this relationship by analyzing the roles of a network of multi-level learning nodes in relation to adaptation planning, examining the changes across the cognitive, normative, and relational dimensions of multi-level learning, and how these changes enhance adaptation planning functions.

The objective of this paper is to assess the contribution of multi-level learning to adaptation planning in Latin America by analyzing and comparing learning across levels in three illustrative cases in the region.

The empirical analysis of the selected cases is guided by the following questions:

- What are the essential learning requirements for key adaptation planning functions in the three cases?
- How are multi-level learning nodes structured within the social networks that facilitate adaptation planning in the selected cases?
- What learning strategies are employed in adaptation planning, and how do they vary across the three cases?

Multi-level learning nodes, defined as institutionalized arrangements of social and policy learning practices and routines across governance levels (Gonzales-Iwanciw et al. 2021), offer a valuable perspective on the structural factors that enable multi-level learning, including the role of networks in multi-level governance (di Gregorio et al. 2019; Ziervogel et al. 2017). Understanding these structural

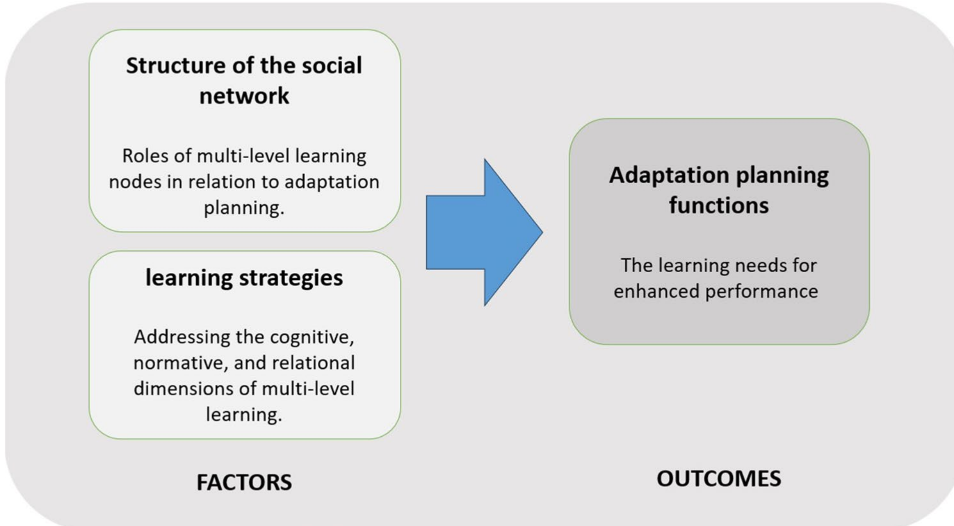

Fig. 1 Multi-level learning and adaptation planning functions: Multi-level learning shapes adaptation planning functions through a network of learning nodes that perform specific roles, alongside the learning strategies employed by actors

factors provides a foundation for analyzing the relationships between social units and organizations within the broader social network, particularly the interactions among diverse stakeholders and their influence on learning dynamics.

Multi-level learning is also assessed through changes in its *cognitive*, *normative*, or *relational* dimensions (Baird et al. 2014; Haug et al. 2011) influencing over time learning strategies applied for adaptation planning. Scholars highlight differences between cognitive, normative, and relational. There is a fundamental difference between cognitive learning, such as the acquisition of knowledge, and the normative dimension of ethical values, i.e., how individuals and organizations make judgments about right and wrong learning (Baird et al. 2014; Huitema et al. 2010; Munaretto et al., 2012). A typology of policy learning suggested by Huitema et al. (2010) outlines cognitive learning, linked to the factual learning without changing underlying norms, values, and belief systems; normative learning encompasses a change in norms, values, and belief systems; and relational learning results from enhanced trust and improved understanding of the mindsets of others.

Methods

The study relies on a comparison of three selected cases of adaptation planning in Latin America. Data collection, case selection, and a description of methods used for analyzing empirical data are described below.

Data collection

Document analysis and expert opinions obtained through semi-structured interviews serve as the primary data sources for this study. The document review (see Table S1 in the supplemental materials) includes a curated sample of 49 policy documents, identified through systematic web searches and iterative selection, allowing for new directions to emerge during the review (Bowen 2009; Kemper et al. 2003).

To complement the findings from the document analysis, 20 face-to-face semi-structured interviews were conducted between 2018 and 2022 with key stakeholders selected through purposive sampling (Robinson 2013). Given the limited number of interviews, they were strategically designed to provide targeted insights and triangulate key information. Interviewees represent a diverse set of actors across governance levels, including government officials, international and multilateral cooperation agencies, climate finance institutions, and civil society groups (see Table S2 in the supplemental materials). Additionally, representatives from international cooperation and climate finance institutions provided regional-level perspectives relevant to one or more of the cases.

The cases

The selection of three different cases across Latin America reflects diverse sectoral entry points in National Adaptation Plans (NAPs), enabling a comparative analysis of multi-level learning in adaptation governance. A key criterion for selection was the visibility of policy implementation, ensuring that adaptation measures are not only planned but actively executed, thus providing a concrete basis for analyzing learning dynamics. Furthermore, the three cases involve middle-income countries with similar institutional capacities and constraints in the Latin America context and offer valuable insights into how contextual factors influence adaptation processes and learning (Table 1).

Table 1 Summary of the selected cases

Country	Sector	Main approach
Bolivia	Integration of climate change adaptation in watershed planning	Cross-level climate integration in water governance
Ecuador	Ecosystem-based adaptation	Nexus of adaptation and the socio-ecological settings
Honduras	Adaptation planning in small-scale agriculture	Climate resilience in rural livelihoods and value chains

Integration of climate change adaptation in watershed planning in Bolivia

Water is a priority for Bolivia's adaptation planning efforts as is highlighted in different official documents (e.g., PNC 2017, NDC Bolivia 2022). Various internationally funded projects, including a basket fund of budgetary support and climate change funding, have accompanied adaptation planning efforts in the water sector (GEF 2007; SPCR Bolivia). International support and technical assistance have included capacity building processes for better planning of adaptation in priority watersheds (e.g., PDC Rocha) and the implementation of climate change adaptation projects in different subsectors, including drinking water, irrigation, and watershed protection. Climate change adaptation has been integrated across levels of governance, including in the preparation of guidelines and tools for watershed plans and project design, the integration of climate change considerations in water governance (GAD CBBA 2015, AFD Bolivia), and strengthening hydrological measurements and modelling (BH Bolivia 2016). The resulting experience, mainstreaming climate change adaptation at the level of watershed planning, is relevant for reducing climate-related risk in the sector and for policy learning to extrapolate this experience to other subsectors and climate change adaptation policy in general (Lima-Quispe et al. 2021).

Ecosystem-based adaptation in Ecuador

The experience of Ecuador in integrating adaptation together with other relevant processes of land use change and biodiversity conservation at different scales and territorial entities, including cities, key ecosystems, and indigenous territories, is noteworthy (Dupuits et al. 2022). Ecuador started the formulation of its NAP in 2015 with international support (e.g., NAP-GSP Ecuador). The country is implementing Ecosystem-based Adaptation (EbA) in collaboration with different stakeholders and international technical assistance in different types of ecosystems, including mountain, coastal, and urban regions (e.g., CIIFEN 2019; PBA 2017). The country has integrated EbA with its NAP that was conducted as a multi-stakeholder process addressing different sectors (MAE, UICN, and GIZ 2019). This approach addresses the protection of key environmental functions, including water sources, biodiversity hotspots, forests, and carbon sinks, and enhancing socio-ecological resilience (e.g., Baum et al. 2021). As it will be presented below, one of the challenges is to give EbA an institutional basis within adaptation planning in Ecuador. Multi-level learning in the governance of adaptation can support the policy processes needed for such integration.

Adaptation planning in small-scale agriculture in Honduras

Reducing the vulnerability of small-scale agriculture is central in Honduras's adaptation planning efforts (e.g., SAG 2015; Alianza Corredor Seco 2017). Climate change poses additional threats to already vulnerable rural livelihoods in key ecosystems in Honduras like the dry Corridor (Alianza Corredor Seco 2017, CABEI 2021). It is expected that climate change will affect rural livelihoods and agricultural value chains, including of food security crops like maize and beans, and export-oriented crops like coffee and cacao (Bouroncle et al. 2017; Donatti et al. 2019).

Adaptation efforts have been integrated within Honduras NAP endorsed by the Secretary of Environment in 2018 (SERNA 2018) and received international climate funding to address the priorities linked to food security and value chain development (e.g., SPCR Honduras; NAP-GSP Honduras; CIF 2020). These projects consider issues such as better access of the farmers to technical and financial services, including the diversification of crops and rural livelihoods, water usage, and a series of adjustments along different activities of value chains and markets to ensure resilience of the system in the long run (Bouroncle et al. 2017; Donatti et al. 2019). Agriculture policies require sophisticated forms of public–private coordination to manage climate risk and encourage technical assistance and innovation for small-scale agriculture, thus also requiring the participation and learning of multiple stakeholders across levels of governance.

Research operationalization and data analysis

The analysis of the documents and interviews combines content and thematic analysis (Fereday, and Muir-Cochrane, 2006) with a mixed deductive and inductive coding of the data, and its organization into major themes and categories; see the analytical framework in Fig. 1 and the coding structure in Table S3 in the supplementary material 1.

The study initiates understanding the learning requirements of adaptation planning functions, recognizing that adaptation is not solely a technical process but a governance challenge that demands continuous learning and institutional adaptation.

Adaptation planning functions are categorized based on similar research (Dixit et al. 2012; Füssel 2007) and UNFCCC guidance (LDC Expert Group (LEG) 2012) in six categories: coordination, knowledge base and prioritization, policy integration, funding, implementation, monitoring and evaluation.

Social network analysis (SNA) (e.g., Serrat 2017) was applied to examine and compare multi-level learning nodes across cases, analyzing their roles and positions within the social network. The examination identified different types of multi-level nodes: Policy nodes (P) are multi-stakeholder spaces oriented to define and put in place adaptation policies; knowledge nodes (K) are platforms or collaboration spaces oriented to enhance the science needed in the specific sector addressed; and implementation or innovation nodes (I) are multi-stakeholder spaces oriented to solve concrete aspects of implementation.

Using SNA tools such as Gephi, various network metrics (e.g., network diameter, degree centrality of nodes) were calculated, and different distribution algorithms were applied to enhance network visualization (see Fig. S1 in Supplemental Material 2). The coding process identified the participation of different governance levels within these nodes and captured the direction of learning interactions.

Furthermore, the analysis focused on three key dimensions of multi-level learning: cognitive, normative, and relational as defined above (see Table S3 in the supplemental materials 1). The coding also incorporated the learning categories from the DIKW model (data, information, knowledge, and wisdom) to guide the analysis (Rowley 2007).

Furthermore, we have adopted the following categorization of governance levels for the analysis: global, including, for example, UNFCCC and the Adaptation Committee facilitated activities; international, including activities and partnerships of bilateral and international agencies; regional, including regional programs and agencies; national, activities carried out by national agencies and with a national scope; and local, activities happening at different subnational levels, including subnational regions, municipalities, and communities.

Results

This section presents the results in response to the research questions. The "Multi-level learning in adaptation planning" section analyzes the learning requirements of adaptation planning in the selected cases. The "Multi-level learning nodes" section examines the configuration of multi-level learning nodes within the social network and their role in addressing adaptation planning functions. The "Multi-level learning strategies" section explores learning strategies employed by actors to enhance adaptation planning. The results are compared across the cases, focusing on the specific findings for each of the cases but also analyzing common trends and patterns about the contribution of multi-level learning to adaptation planning.

Multi-level learning in adaptation planning

This study begins by examining the learning requirements of six adaptation planning functions, acknowledging that adaptation extends beyond technical solutions to encompass a governance challenge that necessitates ongoing learning and institutional evolution.

Coordination

In all cases, learning is closely tied to cross-sectoral and cross-level coordination efforts. Cross-sectoral coordination requires enhanced institutional capabilities, including relational learning, to address overlaps and identify synergies between different government departments for effective performance. In Ecuador and Honduras, NAP serves as the primary platform for cross-sectoral coordination, with relational learning playing a key role in strengthening coordination (interviews CS4 and IC6). In Bolivia, within the context of watershed planning, learning is essential to facilitate vertical integration across institutional functions and ensure budgetary alignment (interviews IC1 and FI1).

Knowledge base and prioritization

The three cases highlight distinct entry points for addressing the multi-level learning needs related to knowledge base and prioritization. In Bolivia, there is a need to integrate climate change scenarios into hydrological balances to inform decision-making around watershed planning (BH Bolivia 2016). In Honduras, both national and local levels must learn how to enhance farmers' coping capacity and adaptability to new challenges (CGIAR 2014; INNOVA; interview IC7). In Ecuador, knowledge needs center around characterizing ecosystem functions to support decision-making (MAE, UICN, and GIZ 2019; ProCambio II; interview IC6). In all cases, gaps exist in the science–decision-making interface (interviews SC2, FI1, and IC3).

Policy integration

The three cases highlight the need to share information and knowledge about methods and tools for integrating decision-making across different sectors and levels of governance (interviews G1, G2, and IC6). In all the cases, policy integration involves cross-sectoral efforts to educate the stakeholders, including decision-makers at the national and local levels, about the implications of climate change adaptation and possible solutions.

In the case of Bolivia, there is a need to learn about the application of adaptation tools at the national and local levels, like the integration of climate change adaptation in watershed planning instruments (e.g., SPCR Bolivia).

In the case of Ecuador, multi-level learning is needed across EbA stakeholders to enhance the capacities of municipal governments and territorial entities to better plan for the conservation and restoration of key ecosystem functions (e.g., UICN and GIZ 2019; CONDESAN 2021). The interviews in Ecuador highlight this need: "We have two separate processes that need to be streamlined, one to apply EbA with municipalities and a second one at the level of municipalities institutions to integrate climate change considerations at the level of territorial planning" (IC6).

In the Honduras case, multi-level learning is needed to strengthen the capacities of public agencies to integrate climate change adaptation in agricultural extension services to the farmers (SAG 2915; AECID 2018; CGIAR 2014; INNOVA). Relational forms of learning are needed among the stakeholders, including private sector agents present in value chains to facilitate the adoption of adaptation measures (IFPRI 2019; IFAD 2020).

Funding

In relation to funding in all the cases, multi-level learning is needed to enhance the capacities of national and local stakeholders to better access international climate funding. The conditions and rules that countries need to put in place to facilitate access to climate funding are evolving rapidly (interview FI4). Training programs prepared for that purpose attempt to, for example, enhance the capacities of financial institutions at the national and local levels to apply financial products in resonance with adaptation priorities (PNUD Guia Financiamiento Climático, PFA 2013).

In Bolivia and Ecuador, the experience around "water fonds" is generating opportunities for multi-level learning across regional, national, and local platforms. In Ecuador, international funding supported well-designed business models oriented to pay for water conservation and other ecosystem services like biodiversity and ecotourism (ProCambio II, interview IC6). The involvement of public stakeholders in these institutional arrangements is attracting the interest of Bolivian agencies (interviews IC1 and FI1).

Implementation

In the three cases, the experience obtained from intervention models at the local level is relevant for analyzing the success factors and obtaining lessons learned for scaling up the intervention. In the three cases, multi-level learning is needed to refine successful intervention models and replicate those experiences in similar or different contexts.

In the case of Bolivia, for example, it is vital to make sure that the projects in the water sector are climate proof (PNC Evaluation 2013, 2017). Multi-level learning can contribute to share this experience with other priority sectors (interview IC4).

In the case of Ecuador, multi-level learning is needed to showcase EbA as a possible planning approach to different stakeholders, including municipal bodies and national ministries (interview IC6).

In the case of Honduras, multi-level learning is needed for the adoption of an intervention model for agricultural resilience. Climate-smart agriculture (CSA) still needs to be tested as an implementation model (interview IC7). CSA combines agricultural extension service with new financial and non-financial services to encourage CSA by connecting farmers to agricultural value chains (SAG CGIAR, SAG 2015).

Monitoring and evaluation

In relation to monitoring and evaluation, the three cases implement M&E tools and guidelines with different grades of success. Multi-level learning can contribute to the effective application of M&E guidelines and tools. One of the challenges highlighted by different interviewees is the lack of a unified framework and indicators for tracking adaptation (e.g., interviews G3, G5, and IC4). In all the cases, M&E of adaptation demands enhanced capacities to translate climate change–specific knowledge and terminology to the specific needs of the sectors involved, linked to normative and relational forms of multi-level learning.

Multi-level learning nodes

Between four and six learning nodes were identified for each case (see Table 2 and Fig. S1 in Supplemental Materials 2), divided into three types: policy oriented (P1, P2, P3, P4, and P5), knowledge oriented (K1, K2, and K3), and implementation oriented (I1, I2, I3, and I4) which are described further below.

The structure of the social networks (see Fig. S1 in the supplemental materials 2) provides complementary

Table 2 Multi-level learning nodes identified in the case studies

Integration of climate change adaptation in watershed planning in Bolivia	
P1	National Watershed Plan coordination platform (*PNC*) that involves different stakeholders linked to a central water sector policy implemented since 2007 and supported by international cooperation organizations
K1	Glacier melting and hydrological research activities have brought together different research institutes and international cooperation programs
I1	Expert group of irrigation projects and climate change risks has brought together different experts in the field with the aim to integrate climate change adaptation considerations at the level of project guidelines
I2	Collaboration group on business models for the protection of water sources
Ecosystem-based adaptation in Ecuador	
P2	*EBA Regional Program* conducted initially in Colombia and Ecuador is putting in place the methodological framework for the implementation of Ecosystem base adaptation in Ecuador
P3	NAP Platform (*PLANACC*) is receiving international support funded by the Green Climate Fund
P4	Implementation group of climate change provincial strategies
K2	Biodiversity and climate change research activities has brought different research institutes and international cooperation programs
I3	Climate funding capacity building facilities
Adaptation planning in small-scale agriculture in Honduras	
P5	Interinstitutional efforts of adaptation in the dry corridor
P6	National Adaptation Plan platform
K3	Collaborative efforts about climate risk in the agriculture sector
I4	Agriculture innovation hub

information about those multi-level learning nodes and multi-level learning processes taking place, inferring the potential for close collaboration or similar interest among different stakeholders in relation to climate change adaptation, but also potential gaps or areas of lack of communication. The same Fig. S1 provides relevant information about which stakeholders play a more prominent role in adaptation planning and have the potential to highlight learning needs related to the identified planning functions.

Policy nodes build around a given policy or national plans fulfilling coordination and policy integration functions. In the case of Bolivia, the National Watershed Plan Coordination Platform (P1) has served as a sector-wide umbrella to promote dialogue and multi-level learning among the stakeholders, including international cooperation and technical assistance (interviews G1 and IC4).

In the case of Ecuador, the NAP platform (PLANACC) (P3) fulfills cross-sectoral coordination functions and is central to fostering the adaptation agenda at national and local levels (interviews G2 and IC6). Two other policy nodes—the EBA Regional Program involving regional activities in Colombia and Ecuador (P3) (e.g., MAE, UICN, and GIZ 2019) and a strategy to integrate climate change adaptation at the level of provincial strategies (P4)—build the landscape of policy nodes supporting EBA in Ecuador (interview IC6). In the case of Honduras, two collaboration platforms build the structure for policy development and multi-level learning: Interinstitutional efforts on adaptation in the dry corridor (P5) and the National Adaptation Plan platform (P6) (interview IC5 and CS4).

In Honduras, the interviews IC5 and CS4 recognize both the leadership of the Secretary of Agriculture in the coordination of different programs and the limitation of governmental actors to address all the needs and demands of agriculture and the farmers, due to the size and complexity of the agriculture sector (interview CS4).

For instance, in Bolivia, the PNC Coordination Platform (P1) plays a central role in shaping the adaptation agenda, driving multi-level learning in the water sector (interviews G1 and IC1). In contrast, Honduras features a more complex network, where the NAP Platform (P6), alongside the Secretariats of Environment (SERNA) and Agriculture (SAG), and multilateral bank-funded activities, serves as the focal point for guiding the adaptation agenda and fostering multi-level learning (e.g., SPCR Honduras).

While Bolivia and Ecuador exhibit a more normative policy formulation process, with a stronger influence from public organizations in shaping the agenda, Honduras stands out for its more cohesive multi-level learning network. In Honduras, all four identified nodes are interconnected, promoting a more inclusive and dynamic learning environment (interviews G4 and G5). Notably, the participation of diverse organizations in the Honduran case fosters more integrative solutions, where cognitive, normative, and relational learning are more effectively combined and applied.

Knowledge nodes have very similar settings in the cases analyzed, expanding the knowledge base for decision-making. In Bolivia, a group of research institutions and projects with permanent support from international research programs, like tropical glaciers (Francou et al. 2003) has been expanding the cognitive base for decision-making (K1). Similarly, in Ecuador, biodiversity and climate change (K2) have motivated research institutions to produce and share relevant information about ecosystems, biodiversity, and climate change. In Honduras, concerns about climate risks in the agriculture sector (K3) have brought together a number of research activities (e.g., Bouroncle et al. 2017).

For example, in Bolivia, the research group focused on glacier melting and hydrology (K1) is highly specialized, with only a few bridging connections. Furthermore, there are limited links between this group and those working on business models for water source protection (I2) (interview IC4), highlighting areas where integration is needed. In Ecuador, similar structural gaps emerge, where groups operating in different geographic regions (e.g., Andes and Amazon) and thematic areas (e.g., municipal development and biodiversity conservation) lack formal connections. Interview IC6 confirms that while provincial strategies and municipal plans should integrate EbA, the framework has not yet been formally adopted by the government for territorial planning at the municipal level (interview IC6).

Implementation nodes gather practitioners from different organizations to share information and experiences, fulfilling implementation functions. In Bolivia, we identified two nodes: an ad hoc expert group with the mandate to include climate change adaptation considerations at the level of irrigation projects guidelines (I1) and a group of organizations exchanging experiences about intervention models and funding schemes for water protection (I2) (interview IC4). In Ecuador, a group of organizations is collaborating around a school to develop capacities for funding climate change projects (I3) and in Honduras, an innovation platform for climate-smart agriculture is developing intervention models to support adaptation efforts at the level of small farmers and value chains (I4) (interviews IC and CS4).

Looking at the roles of multilateral and international actors in multi-level learning, we observe very similar settings in all three cases. For example, the GEF NAP Global Support Program (NAP-GSP) supported the formulation and implementation of the NAP in Ecuador and Honduras with important implications in the way the NAP process is implemented, lessons extracted, and reported in both cases (NAP-GSP Ecuador, NAP-GSP Honduras). The same is true for activities of the Climate Investment Fund (CIF) – Pilot Project for Climate Resilience (PPCR) in Bolivia and Honduras (SPCR Bolivia and SPCR Honduras) funding important sector-wide interventions and lessons learned (interview FI2). In the case of PPCR, learning is encouraged across levels of governance, including at the level of local communities, addressing gender gaps and the needs of the most vulnerable in project design and evaluations, but also bringing together practitioners across levels of governance to evaluate the outcomes and impact of interventions and learning (interview FI2).

Other national and local actors, including research and civil society groups, also play a significant role in multi-level learning as knowledge nodes or bridging organizations, addressing new or less recognized themes and involving less represented groups (e.g., interviews CS1 and CS4).

Multi-level learning strategies

Regarding learning strategies, the data reveal three key groups: (1) strategies focused on the *collection and dissemination of data and information*, (2) strategies centered on *acquiring and exchanging knowledge and experiences*, and (3) strategies related to *evaluation and reflection* on progress achieved. Key results have been integrated in Table 3 at the end of the section.

The collection and dissemination of key data and information on climate change trends and their potential impacts on various sectors and social groups is a fundamental strategy for enhancing understanding of climate risks across the cases. This cognitive strategy is typically bidirectional between international/national and national/local levels, expanding the information and knowledge base necessary for developing and implementing adaptation policies and measures (e.g., BH Bolivia 2016; CATIE 2017).

Beyond data sharing, this strategy often includes identifying information gaps and launching targeted projects to address them, making the learning process increasingly unidirectional from the national to the local level (e.g., BUR1 Honduras). A critical component of this approach is the standardization of methods and data requirements, aligning scientific outputs with decision-making needs. However, significant gaps persist at the interface between climate science and policymaking, particularly in ensuring that climate model results are comparable across scales and timeframes to effectively support decision-making across governance levels (e.g., interviews G1 and CS4).

Acquiring and sharing knowledge through "learning by doing" is a frequently mentioned strategy among stakeholders, allowing them to gain practical experience and test intervention models (e.g., MMAyA 2013; PBA 2017; PROAMAZONIA). Multi-level learning is often promoted in a top-down, unidirectional manner from international and national levels, primarily as normative learning, involving the standardization, validation, and dissemination of methods, approaches, and tools. This process includes training

Table 3 Adaptation planning functions

Watershed planning in Bolivia		Ecosystem-based adaptation in Ecuador		Small-scale agriculture in Honduras	
Coordination					
(N↔L) Define roles and competencies (I↔N↔L) Organize cross-sectoral coordination for water and sanitation and irrigation projects (N↔L) Involve different types of stakeholders, e.g., farmer associations, communities and water operators	(N, R) Stakeholder dialogue encouraged by the need to take action	(N↔L) Organize vertical integration with subnational governments (N↔L) Involve different types of stakeholders, e.g., municipal entities, water funds and protected areas	(N, R) Participation in different dialogue spaces in the NAP platform	(N↔L) Integrate extension services across levels (N↔L) Coordinate with the farmers (I-N-L) Coordinate along priority value chains	(R) Promoting knowledge dialogues between local observers and meteorological services
Knowledge and prioritization					
(I↔N) Expand the knowledge base about glacier melting, hydrological balances and climate change scenarios (I↔N) Standardize methods and data requirements for modelling (N↔L) Knowledge dialogues between local practices of water governance (use and customs) and national water use regulations	(C) Conducting measurements and data collection, e.g., glacier melting (N) Enhancing the coverage of key data and information for decision-making, e.g., hydrological balances in key watersheds	(I↔N↔L) Expand the knowledge base about ecosystem services (I↔N) Characterize ecosystems functions and services (I↔N) Test EbA and other tools for territorial planning at the local level	(C) Understanding key ecosystem functions and the application of EBA models including the social acceptance (C) Analyzing information and knowledge gaps and needs in the NAP process	(R↔N↔L) Understand the impacts on food systems and small farmers (N↔L) Identify coping strategies (I↔N) Define data requirements for agricultural insurance (N↔L) Conduct knowledge dialogues between local practices of the farmers and agronomic science	(C) Enhancing the collection of agrometeorological data and forecasting
Policy integration					
(I↔N) How to better integrate climate change into watershed planning (I↔N) Apply tools for watershed planning (N↔L) Knowledge dialogues between local practices of water governance (use and customs) and national water use regulations	(N) Integrating climate change adaptation and disaster risk reduction in watershed planning (C, N) Applying tools and methods for integrating climate change adaptation in watershed planning instruments (C, N) Extracting lessons learned at the level of the program	(I↔N↔L) Apply the EbA approach	(C) Conducting case studies for the integration of EBA with other existing frameworks, e.g., water fond and territorial planning entities (R) Promoting dialogues with key stakeholders to come up with institutional arrangements and implementation	(I↔N↔L) Apply the climate-smart agriculture (CSA) approach (I↔N↔L) Apply the climate-smart agriculture (CSA) approach (N↔L) Conduct knowledge dialogue between extension services and the farmers	(C, N, R) Developing and scale up of application models, e.g., resilient agriculture of climate-smart agriculture (C) Extracting lessons learned by implementation of the program

practitioners and expanding communities of practice at national and local levels to implement adaptation measures, evaluate their impact, and generate further learning (e.g., MAE, UICN, and GIZ 2019; CABEI 2021).

In all three cases, integrating climate change adaptation into sectoral planning requires the application of common approaches within national planning processes (e.g., LEG 2012). For instance, in Bolivia, watershed plans serve as

Table 3 (continued)

Watershed planning in Bolivia		Ecosystem-based adaptation in Ecuador		Small-scale agriculture in Honduras	
Funding					
(N↔L) Define concurrent funding (N↔L) Define the institutional arrangements, e.g., the protection of water sources	(C, N) Learn from sector-wide funding to mainstream adaptation in the sector	(R↔N↔L) Prepare projects oriented to climate funds (N↔L) Define concurrent funding (R↔N↔L) Identify and apply business models, e.g., water funds	(C, N) Train stakeholder for funding proposals	(N↔L) Identify microfinance services for the farmers	(C, N; R) Develop financial products that integrate climate change adaptation
Implementation					
(N↔L) Extract lessons from the experience in priority watersheds (N↔L) Dialogue among different groups, e.g., municipalities, local communities, irrigation associations, water utilities	(C, N) Training of operators, e.g., watershed planning consultants (C, N, R) Promoting knowledge dialogues, e.g., drought forecasting involving local and indigenous knowledge	(N↔L) Extract lessons from the experience in priority sites (N↔L) Dialogue with different groups, e.g., municipalities, protected areas administration, water fonds, indigenous groups	(C, N, R) Making guidance available for the application of EBA models	(N↔L) Extract lessons from the experience in priority crops and value chains (N↔L) Dialogue among different groups, e.g., the private sector, small-scale farmers, agricultural extension services to apply measures	(C, N) Enhancing farmers access to key information, e.g., climate information and early warning systems to cope with climate risks (C, R) Compiling of best practices (C, N) Training of trainers, e.g., the agriculture extension services
Monitoring and evaluation					
(I↔N↔L) Define a set of adaptation indicators (I↔N) Apply UNFCCC reporting guidelines and indicators (N↔L) Translate climate change terminology with the sectors involved	(C, N) Development of indicators in line with SDG	(I↔N↔L) Define a set of adaptation indicators (N↔L) Define a set of EbA indicators (I↔N) Apply UNFCCC reporting guidelines and indicators (N↔L) Translate climate change terminology with the sectors involved	(C) Collecting data about key ecosystem features like biodiversity, carbon storage and water, e.g., endangered species (IUCN)	(I↔N↔L) Define a set of adaptation indicators (I↔N) Apply UNFCCC reporting guidelines and indicators (N↔L) Translate climate change terminology with the sectors involved	(C, N, R) Multi-stakeholder evaluation of the impact of interventions and lessons learnt at the level of programs

Multi-level learning levels: international (I), regional (R), national (N), local (L).

Types of learning: cognitive (C), normative (N), relational (R).

↔, ←, →, the main direction of multi-level learning.

the primary policy instrument for adaptation planning (e.g., PDC Rocha 2015), while in Ecuador, the Ecosystem-based Adaptation (EbA) framework fulfills a similar role (interview IC6, Programa ABE Manual de Líderes). The NAP process, adopted by all three countries, facilitates cross-country comparisons and iterative learning, particularly at international and global levels. However, this learning is less prominent at the national and local levels, where practical implementation takes place.

Efforts to enhance relational learning—which fosters knowledge exchange and mutual understanding—are evident in all cases. This includes incorporating local knowledge into regional and national planning processes, increasing opportunities for multi-level learning between local stakeholders and decision-makers. In Honduras, for example, agroclimatic platforms integrate small farmers' climate observations with meteorological service data, strengthening the link between scientific and experiential knowledge (e.g., SAG CGIAR, interviews G5 and CS4). Similarly, co-creation and dialogue-based learning approaches are used to combine traditional/local knowledge with scientific and academic perspectives (AECID 2018, pp. 44). However, interviews suggest that specific skills are essential for successful relational learning, particularly the ability to recognize and value local knowledge as a legitimate and valuable source of insight (interviews CS1, FI1, and FI2).

Regarding the *evaluation and reflective learning strategy*, assessing information and knowledge gaps is a common learning approach encouraged by the UNFCCC process and reflected in official documents (e.g., ENT Honduras, BUR1 Honduras). This strategy is forward-looking, aiming to identify and address gaps in data, information, and knowledge to strengthen adaptation planning.

Additionally, evaluators have the opportunity to reflect on policy processes, assess what works and what does not, and share findings with stakeholders and decision-makers. However, a key challenge is that not all stakeholders fully participate in or are aware of these reflections and lessons learned (interview FI2), making this form of learning predominantly unidirectional, flowing from the local to the national level rather than fostering broader engagement.

There is limited evidence across the three cases that evaluative or reflective processes are systematically embedded and sustained over time among key stakeholders. Encouraging a more participatory reflective process could be facilitated through multi-stakeholder planning platforms, such as EbA platforms (interviews IC6 and CS4). However, these efforts are often hindered by fragmented collaboration, institutional competition for climate funds, and the absence of coordinated governance, clear stewardship, and well-defined governmental policies (interviews IC1 and CS4).

Integration and discussion of the results

Multi-level learning is integral to adaptation planning, as climate adaptation requires coordinated action across different governance levels, sectors, and stakeholder groups. Effective adaptation planning depends on the ability of institutions and actors to continuously acquire, share, and integrate knowledge across scales, from local communities to national and international decision-making bodies evolution (Newig, and Fritsch, 2009).

Multi-level learning facilitates the alignment of policies, the integration of scientific and local knowledge, and the development of adaptive capacities, ensuring that adaptation strategies are contextually relevant, evidence-based, and responsive to emerging challenges. Without robust multi-level learning mechanisms, adaptation efforts risk fragmentation, inefficiency, and limited effectiveness in addressing complex climate risks (Gonzales-Iwanciw et al. 2023; Pahl-Wostl 2009).

The examined cases illustrate how a network of multi-level learning nodes, shaped around adaptation agendas, addresses the diverse learning needs and strategies in adaptation planning. Overall, the cases provide valuable insights into the cognitive, normative, and relational dimensions of multi-level learning (Baird et al. 2014; Huitema et al. 2010). The analysis highlights the challenges and opportunities for enhancing learning across different governance levels and underscores the need for improved coordination and collaboration to foster effective adaptation planning, which is not always the case due to competence and niche contributions in adaptation agendas, power asymmetries, and different opportunities to participate in expertise building projects and networks (di Gregorio et al. 2019; Zelli 2011).

The structure of the social networks—specifically, the degree of interconnectedness and the centrality of key stakeholders—has a significant influence on stakeholder participation and learning opportunities (di Gregorio et al. 2019). The level of collaboration, such as involving relevant actors in defining policy priorities, directly impacts the effectiveness of learning across levels as underpinned by the literature (Bachofen et al. 2014). However, the analysis reveals structural gaps, such as the limited involvement of local actors, which hinder opportunities for multi-level learning (Fünfgeld 2015; Naess 2013).

The analysis of these networks reveals that the predominance of international technical assistance, which applies uniform methods and tools across the cases, shapes the involvement of different levels of governance and defines priority setting. However, challenges persist in coordinating and collaborating between various cooperation programs.

The cases reveal both commonalities and differences regarding the cognitive, normative, and relational dimensions of multi-level learning in adaptation planning as presented in academic literature (Haug et al. 2011; Munaretto et al., 2012). Cognitive learning dimensions are primarily advanced by the need to expand the information and knowledge base for informed decision-making. Normative learning is largely driven by the adoption of internationally defined adaptation frameworks, such as the technical guidelines for NAP (LEG 2012), as well as the evaluation of outcomes based on predefined criteria set by technical assistance agencies and funders. Relational learning is linked to the interaction between different actors with different backgrounds and experiences.

The findings also indicate that multi-level learning is not always reciprocal or bidirectional. In the case of normative learning, reflection on assumptions and imperatives typically occurs at the level of the agencies leading the processes, rather than across all stakeholders involved. This creates a significant gap, hindering deeper learning among national and local actors and limiting their capacity for agency, more autonomous actions, and transformations in adaptation planning.

The cases point to limited participation in more relational forms of multi-level learning, such as reflective spaces and evaluations. Evaluations are often conducted by "experts" without actively engaging stakeholders in the reflective process or allowing them to draw their own lessons learned. This gap has notable implications for the ownership, leadership, and agency of local and national actors, further impeding meaningful learning and change.

Conclusions

This research builds upon theories of multi-level governance and adaptive capacity, which emphasize the importance of governance structures and learning processes in effective adaptation planning (Crona et al., 2012; Huntjens et al. 2012). By focusing on the network and structure of multi-level learning nodes, as well as the cognitive, normative, and relational dimensions of learning, this study contributes to understanding how learning processes can be more effectively integrated into adaptation planning frameworks.

As outlined in the "Methods" section, we chose to narrow our focus to specific sections of adaptation planning processes rather than encompass the entire NAP in each case. While this decision may have restricted our capacity to fully capture all potentially significant aspects, it allowed for a more in-depth examination within a clearly defined scope.

The configuration of multi-level learning nodes and the governance levels engaged in these nodes offers valuable insights into how various planning functions within the governance system are carried out. This finding aligns with theories of multi-level governance (Hooghe et al., 2010; Newig et al., 2009), which stress the significance of intergovernmental networks and the capacity of local actors to influence broader policy agendas. Our analysis shows that the structure and relationships among actors in these networks reveal not only the practical dynamics of adaptation planning but also confirm the relevance of governance as a complex, dynamic system of interconnected actors.

The learning strategies adopted by stakeholders across the cases demonstrate both common approaches and significant gaps in the engagement of national and local governance levels, as well as the direction of multi-level learning. These findings resonate with the concept of "vertical fragmentation" in policy networks, where decision-making is often centralized, limiting the participation and influence of local actors (Zelli 2011). Addressing these gaps provides an opportunity to enhance multi-level learning in adaptation planning by reassessing how contributions at various levels are perceived and their implications for fostering ownership, agency, and deeper learning.

Our results further emphasize the need to evolve from a predominant focus on cognitive aspects of learning toward a greater emphasis on the normative and relational dimensions. This evolution is supported by social learning and policy learning theory (Diduck 2010; Huitema et al. 2010; Huntjens et al. 2012), which posits that adaptation requires not only expanding knowledge but also altering norms and relationships among actors (Baird et al. 2014; Haug et al. 2011; Huitema et al. 2010). The findings and also the literature coincide that while cognitive learning has been prioritized in many adaptation processes, addressing the normative and relational dimensions is crucial for fostering deeper, more sustainable learning outcomes across different levels of governance.

To deepen our understanding of how multi-level learning impacts the effectiveness of adaptation planning, further empirical research integrated with real-world adaptation planning processes is essential. This research should address theoretical gaps in the literature on governance and institutional change (Connor et al., 2004; Matthews 2013) to better understand how multi-level learning processes evolve, particularly in terms of power dynamics and the role of local actors in shaping adaptation strategies.

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Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Competing interest The authors declare that they have no competing interests.

References

Adger WN (2003) Social aspects of adaptive capacity. In: Climate change, adaptive capacity and development, pp 29–49. https://doi.org/10.1142/9781860945816_0003

Amundsen H, Berglund F, Westskog H (2010) Overcoming barriers to climate change adaptation - a question of multilevel governance?

Environ Plann C: Politics Space 28(2):276–289. https://doi.org/10.1068/c0941
Armitage D, Dzyundzyak A, Baird J, Bodin Ö, Plummer R, Schultz L (2018) An approach to assess learning conditions, effects and outcomes in environmental. Governance 28(1):3–14. https://doi.org/10.1002/eet.1781
Bachofen C, Sundstrom R, Iqbal FY, Suarez P (2015) Participation, learning and innovation in adaptation to climate change: development & climate days 2013. Clim Dev 7(2):192–195. https://doi.org/10.1080/17565529.2014.951020
Baird J, Plummer R, Haug C, Huitema D (2014) Learning effects of interactive decision-making processes for climate change adaptation. Glob Environ Change 27(1):51–63. https://doi.org/10.1016/j.gloenvcha.2014.04.019
Baum D, Yagüe-Blanco JL, Escobar J (2021) Capacity development strategy empowering the decentralized governments of Ecuador towards local climate action. J Clean Prod 285. https://doi.org/10.1016/j.jclepro.2020.125320
Benz A (2012) Yardstick competition and policy learning in multi-level systems. Reg Fed Stud 22(3):251–267. https://doi.org/10.1080/13597566.2012.688270
Bouroncle C, Imbach P, Rodríguez-Sánchez B, Medellín C, Martinez-Valle A, Läderach P (2017) Mapping climate change adaptive capacity and vulnerability of smallholder agricultural livelihoods in Central America: ranking and descriptive approaches to support adaptation strategies. Clim Change 141:123–137. https://doi.org/10.1007/s10584-016-1792-0
Bowen GA (2009) Document analysis as a qualitative research method. Qual Res J 9(2):27–40. https://doi.org/10.3316/QRJ0902027
Connor R, Dovers S (2004) Institutional change for sustainable development. In: Institutional change for sustainable development. Edward Edgar Publishing. https://doi.org/10.4337/9781843769675
Crona BI, Parker JN (2012) Learning in support of governance: theories, methods, and a framework to assess how bridging organizations contribute to adaptive resource governance. Ecol Soc 17(1). https://doi.org/10.5751/ES-04534-170132
di Gregorio M, Fatorelli L, Paavola J, Locatelli B, Pramova E, Nurrochmat DR, May PH, Brockhaus M, Sari IM, Kusumadewi SD (2019) Multi-level governance and power in climate change policy networks. Glob Environ Change 54:64–77. https://doi.org/10.1016/j.gloenvcha.2018.10.003
Diduck A (2010) The learning dimension of adaptive capacity: untangling the multi-level connections. In: Adaptive capacity and environmental governance, pp 199–221. https://doi.org/10.1007/978-3-642-12194-4_10
Dixit A, Mcgray H, Gonzales Iwanciw J, Desmond M (2012) Ready or not: assessing national institutional capacity for climate change adaptation. World Resources Institute, pp 1–56. http://pdf.wri.org/working_papers/ready_or_not.pdf
Donatti CI, Harvey CA, Martinez-Rodriguez MR, Vignola R, Rodriguez CM (2019) Vulnerability of smallholder farmers to climate change in Central America and Mexico: current knowledge and research gaps. Clim Dev 11(3):264–286. https://doi.org/10.1080/17565529.2018.1442796
Dupuits E, Llambí LD, Peralvo M (2022) Implementing climate change adaptation policies across scales: challenges for knowledge coproduction in Andean mountain socio-ecosystems. Mt Res Dev 42(2):A1–A11. https://doi.org/10.1659/MRD-JOURNAL-D-21-00040.1
Fereday J, Muir-Cochrane E (2006) Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. Int J Qual Meth 80–92. https://doi.org/10.1177/160940690600500107
Francou B, Vuille M, Wagnon P, Mendoza J, Sicart JE (2003) Tropical climate change recorded by a glacier in the central Andes during the last decades of the twentieth century: Chacaltaya, Bolivia, 16°S. J Geophys Res : Atmos 108(D5). https://doi.org/10.1029/2002JD002959
Fünfgeld H (2015) Facilitating local climate change adaptation through transnational municipal networks. Curr Opin Environ Sustain 12:67–73. https://doi.org/10.1016/j.cosust.2014.10.011
Füssel HM (2007) Adaptation planning for climate change: concepts, assessment approaches, and key lessons. Sustain Sci 2:265–275. https://doi.org/10.1007/S11625-007-0032-Y
Gerlak AK, Heikkila T (2011) Building a theory of learning in collaboratives: evidence from the everglades restoration program. J Public Adm Res Theory 21(4):619–644. https://doi.org/10.1093/jopart/muq089
Getimis P (2003) Improving European union regional policy by learning from the past in view of enlargement. Eur Plan Stud 11(1):77–88. https://doi.org/10.1080/09654310303662
Gonzales-Iwanciw J, Karlsson-Vinkhuyzen S, Dewulf A (2021) Multilevel learning in the governance of adaptation to climate change - the case of Bolivia´s water sector. Clim Dev 13(5):399–413. https://doi.org/10.1080/17565529.2020.1785830
Gonzales-Iwanciw J, Karlsson-Vinkhuyzen S, Dewulf A (2023) How does the UNFCCC enable multi-level learning for the governance of adaptation? Int Environ Agreem : Polit Law Econom 23:1–25. https://doi.org/10.1007/s10784-023-09591-0
Gupta J, Termeer C, Klostermann J, Meijerink S, van den Brink M, Jong P, Nooteboom S, Bergsma E (2010) The adaptive capacity wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. Env Sci Policy 13(6):459–471. https://doi.org/10.1016/j.envsci.2010.05.006
Haug C, Huitema D, Wenzler I (2011) Learning through games? Evaluating the learning effect of a policy exercise on European climate policy. Technol Forecast Soc Change 78(6):968–981. https://doi.org/10.1016/j.techfore.2010.12.001
High C, Pelling M (2005) Social learning and adaptation to climate change. In: Benfield Hazard Research Centre, disaster studies working paper, vol 11, pp 1–19. Retrieved from https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=1b4acdbfe8d29a65c80bc82f82d62786ed175063
Hooghe L, Marks GN (2001) Types of multi-level governance. European Integration online Papers (EIoP) 5(11):1–32. https://doi.org/10.2139/ssrn.302786
Huitema DA, Cornelisse C, Ottow B (2010) Is the jury still out? Toward greater insight in policy learning in participatory decision processes - the case of Dutch citizens' juries on water management in the Rhine Basin. Ecol Soc 15(1):16. http://www.ecologyandsociety.org/vol15/iss1/art16/
Huntjens P, Lebel L, Pahl-Wostl C, Camkin J, Schulze R, Kranz N (2012) Institutional design propositions for the governance of adaptation to climate change in the water sector. Glob Environ Change 22(1):67–81. https://doi.org/10.1016/j.gloenvcha.2011.09.015
Ison RL, Collins KB, Wallis PJ (2015) Institutionalising social learning: towards systemic and adaptive governance. Environ Sci Policy 53(B):105–117. https://doi.org/10.1016/j.envsci.2014.11.002
Jabeen H, Johnson C, Allen A (2010) Built-in resilience: learning from grassroots coping strategies for climate variability. Environ Urban 22(2):415–431. https://doi.org/10.1177/0956247810379937
Kemper EA, Stringfield S, Teddlie C (2003) Mixed methods sampling strategies in social science research. In: Handbook of mixed methods in social and behavioral research, vol 10. Chap, pp 273–296
LDC Expert Group (LEG) (2012) National adaptation plans: technical guidelines for national adaptation plan process. United Nations Framework Convention on Climate Change. https://unfccc.int/sites/default/files/resource/NAP_technical_guidelines_EN.pdf
Lima-Quispe N, Coleoni C, Rincón W, Gutierrez Z, Zubieta F, Nuñez S, Iriarte J, Saldías C, Purkey D, Escobar M, Angarita H (2021)

Delving into the divisive waters of river basin planning in Bolivia: a case study in the Cochabamba Valley. Water 13(2):26. https://doi.org/10.3390/W13020190

Matthews T (2013) Institutional perspectives on operationalising climate adaptation through planning. Plan Theory Pract 14(2):19. https://doi.org/10.1080/14649357.2013.781208

Munaretto S, Huitema D (2012) Adaptive co-management in the Venice Lagoon? An analysis of current water and environmental management practices and prospects for change. Ecol Soc 17(2). https://doi.org/10.5751/ES-04772-170219

Naess LO (2013) The role of local knowledge in adaptation to climate change. Wiley Interdiscip Rev : Clim Change 4(2):99–106. https://doi.org/10.1002/wcc.204

Newig J, Fritsch O (2009) Environmental governance: participatory, multi-level – and effective? Environ Policy Gov 19(3):197–214. https://doi.org/10.1002/EET.509

Pahl-Wostl C (2009) A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Glob Environ Change 19(3):354–365. https://doi.org/10.1016/j.gloenvcha.2009.06.001

Pelling M, High C, Dearing J, Smith D (2008) Shadow spaces for social learning: a relational understanding of adaptive capacity to climate change within organisations. Environ Plan A 40(4):867–884. https://doi.org/10.1068/a39148

Reed MMS, Evely AC, Cundill G, Fazey I, Glass J, Laing A, Newig J, Parrish B, Prell C, Raymond C, Stringer LC (2010) What is social learning? Ecol Soc 15(4):r1. https://www.jstor.org/stable/26268235

Robinson OC (2013) Sampling in interview-based qualitative research: a theoretical and practical guide. Qual Re Psychol 11(1):24–41. https://doi.org/10.1080/14780887.2013.801543

Rowley J (2007) The wisdom hierarchy: representations of the DIKW hierarchy. J Inf Sci 33(2):163–180. https://doi.org/10.1177/0165551506070706

Sabatier PA (1988) An advocacy coalition framework of policy change and the role of policy-oriented learning therein. Policy Sci 21(2–3):129–168. https://doi.org/10.1007/bf00136406

Serrat O (2017) Social network analysis. In: Knowledge solutions, pp 39–43. https://doi.org/10.1007/978-981-10-0983-9_9

Siebenhüner B (2008) Learning in international organizations in global environmental governance. Glob Environ Politics 8(4):92–116. https://doi.org/10.1162/glep.2008.8.4.92

Termeer CJAM, Dewulf A, Biesbroek GR (2017) Transformational change: governance interventions for climate change adaptation from a continuous change perspective. Journal of Environmental Planning and Management (JEPM) 60(4):558–576. https://doi.org/10.1080/09640568.2016.1168288

Tschakert P, Dietrich KA (2010) Anticipatory learning for climate change adaptation and resilience. Ecol Soc 15(2):art11. https://doi.org/10.5751/ES-03335-150211

Vinke-de Kruijf J, Pahl-Wostl C (2016) A multi-level perspective on learning about climate change adaptation through international cooperation. Environ Sci Policy 66:242–249. https://doi.org/10.1016/j.envsci.2016.07.004

Zelli F (2011) The fragmentation of the global climate governance architecture. Wiley Interdiscip Rev : Clim Change 2(2):255–270. https://doi.org/10.1002/WCC.104

Ziervogel G, Pasquini L, Haiden S (2017) Nodes and networks in the governance of ecosystem-based adaptation: the case of the Bergrivier municipality, South Africa. Clim Change 144(2):271–285. https://doi.org/10.1007/s10584-017-2008-y