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Institutional dynamics in climate change adaptation – a bibliometric analysis

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Introduction: Climate change poses significant challenges to agricultural and water sectors globally, threatening food security, water availability, and ecosystem services. Understanding institutional dynamics in climate change adaptation is crucial for developing effective governance responses across different administrative levels.

Methods: This systematic literature review followed PRISMA guidelines to analyze institutional challenges and enabling factors in climate adaptation governance. A comprehensive search of Scopus and Web of Science databases identified relevant studies published between 2014–2024. After rigorous quality assessment, 38 papers were selected for analysis. Bibliometric analysis was conducted to identify research patterns and geographical distributions.

Results: The bibliometric analysis revealed research concentration in Western countries and parts of Africa, with significant gaps in South Asian countries. Key institutional barriers identified include governance fragmentation, resource limitations, knowledge gaps, and policy misalignments across sectors and governance levels. Enabling factors that facilitate effective adaptation include boundary organizations, collaborative governance frameworks, and multi-level institutional partnerships. The review identified critical research gaps in understanding informal institutional dynamics, power relations in adaptation governance, and practical implementation pathways for institutional reform.

Discussion: The findings suggest that effective climate adaptation policies in agricultural and water sectors require targeted interventions that balance formal institutional structures with flexible governance approaches. This is particularly important in climate-vulnerable regions where institutional capacity may be limited. The research highlights the need for enhanced understanding of informal governance mechanisms and power dynamics that influence adaptation outcomes, especially in underrepresented regions such as South Asia

KEYWORDS

adaptive governance, environmental policies, institutional barriers, reform in governance, agricultural resilience, water resource management, climate adaptation

Introduction

Climate change poses significant challenges to the agricultural and water sectors globally. It is a deepening concern primarily because it threatens food security, water availability, and ecosystem services. Dealing with these challenges is not just about using the right technology; it more about how things are set up at the institutional level. It takes a lot of coordination across different layers of government to really make it work (Biesbroek et al., 2013; Eisenack et al., 2014). Like North (1990) points out, institutions which are basically built on a mix of official rules and more unwritten norms and habit can either help or get in the way when it comes to adapting to climate change. Over the years, people have started paying more attention to how these systems shape climate responses, and one can see that in the acceleration of research in this area (Lemos and Agrawal, 2006; Van Kerkhoff and Lebel, 2015). This idea is backed up by the Sixth Assessment Report of IPCC's, which clearly states that good adaptation needs inclusive governance that cares about fairness and justice. The report also points out that the right kind of institutional setups are keys to making deep and lasting changes (IPCC, 2022). But even with such strong statements and research backing them, there's still a big knowledge gap when it comes to figuring out exactly how these institutional systems affect the results of adaptation effort, especially in developing countries, which are invariably hit hardest by climate change. Understanding institutional dynamics in climate adaptation requires recognizing that institutions operate differently across urban and rural contexts. Research on megacities has shown that sustainability transitions in urban areas face unique institutional challenges, particularly regarding risk management and adaptation governance in densely populated areas (Ajibade et al., 2016). Similarly, the development of knowledge systems for sustainable development requires institutional arrangements that can effectively bridge scientific research with practical implementation (Cash et al., 2003).

In this study, we have tried to break down and make sense of what is already known about how institutions work when it comes to climate adaptation. We have looked at where the research is concentrated, where the gaps are, and we have also put together some practical suggestions for both policymakers and researchers. What sets our work apart is that we have taken a global view of the topic using a mix of bibliometric and systematic review methods. Most earlier reviews have stuck to certain regions or focused on particular sectors, so they have not covered the full scope. To make sure our review was solid and transparent, we followed the PRISMA guidelines throughout. We pulled in research from 2014 to 2024 to keep things as up-to-date as possible. This period was chosen on purpose because it includes some major turning points in global climate governance that had a strong impact on how institutions responded to the need for adaptation. For instance, The formulation and implementation of the Paris Agreement (2015), which emphasized adaptation alongside mitigation. This required countries to develop critical national adaptation plans. This also triggered new institutional arrangements across governance levels. The publication of major IPCC reports (AR5 in 2014 and AR6 in 2022) which played a role in highlighting institutional dimensions of adaptation. A period of accelerating climate impacts globally, with eight of the hottest years on record occurring during this timeframe (WMO, 2023). This created unprecedented pressure on institutions

to respond to the extremity. The establishment of key adaptation funding mechanisms including the Green Climate Fund that has its operational launch in 2015. This created new institutional frameworks for climate finance distribution.

The COVID-19 pandemic (2020–2022), which tested institutional resilience and adaptive capacity while revealing interconnections between different types of systemic risks. This decade thus represents a crucial period in the evolution of institutional responses to climate change, making it particularly relevant for understanding current dynamics and future directions in adaptation governance.

The review addresses several key questions:

1. How do various institutional arrangements influence climate adaptation outcomes?
2. What institutional barriers impede effective adaptation?
3. What institutional enabling factors facilitate successful adaptation?
4. How can institutional design and reform support enhanced adaptive capacity?

Understanding these dimensions is crucial for developing effective policies and governance frameworks that can enhance climate resilience, particularly in South Asia, where research on institutional adaptation remains limited despite high vulnerability to climate impacts.

Materials and methods

Search strategy and selection criteria

The chronological distribution of the 38 selected articles used in the systematic literature review, with vertical bars representing the number of publications per year is shown in Figure 1. A steady increase in research output is observed over the 10-year period, with a notable peak in 2024, indicating growing scholarly interest in institutional responses to climate adaptation.

Literature was collected from Scopus and Web of Science databases using the following search strings: a) "Climate Change" AND "Institutions" OR "Agriculture" b) "Climate Change" AND "Adaptation". This comprehensive search strategy was designed to capture relevant studies across multiple disciplines including environmental science, social science, policy studies, and agricultural research. The selection process focused on institutional preparedness towards climate change adaptation. Only journal articles with titles and abstracts directly related to this topic were included, with preference given to open-access publications to ensure transparency. Conference papers and review articles were excluded to focus on primary research findings. Only articles published in English were retained, which represents a limitation of this study as relevant research in other languages was not captured.

Data extraction and quality assessment

The initial search retrieved 305 articles from Scopus and 35 articles from Web of Science. After removing duplicates and

conducting a thorough evaluation of abstracts and research objectives, 38 relevant articles from 29 sources were selected for analysis. This selection process involved multiple screening stages by two independent reviewers to minimize selection bias, with any disagreements resolved through discussion with a third reviewer. For each selected article, we extracted data on study location, institutional focus, governance level, methodological approach, key findings related to institutional barriers and enablers, and recommendations for institutional reform. Quality assessment was conducted using a modified version of the Critical Appraisal Skills Programme (CASP) checklist, evaluating methodological rigor, relevance to research questions, and clarity of findings. Studies were scored on a scale of 1-5 for each criterion, with only those scoring above 3.5 included in the final analysis. This rigorous quality assessment ensured that our review synthesized high-quality evidence. Studies were categorized according to geographical context, institutional focus (formal, quasi-formal, or informal), and governance level (local, national, or international).

The PRISMA diagram shown in Figure 2 illustrates the complete article selection process from initial identification (n = 305 from Scopus; n=35 from Web of Science) through screening, eligibility assessment, to final inclusion (n = 38). Records were excluded based on duplicate detection, irrelevance to institutional dynamics in climate adaptation, non-English language, and quality assessment criteria. Statistical significance was determined through rigorous quality assessment following PRISMA guidelines.

Analytical framework

The analysis was guided by an institutional framework that categorizes institutions into three distinct but interconnected types.

- 1. Formal institutions: These include laws, policies, regulations, and official organizational structures that are codified and

enforced through official channels. Examples include national climate change policies, water management regulations, and agricultural development strategies.

- 2. Quasi-formal institutions: These comprise organized stakeholder platforms, committees, and other semi-structured arrangements that operate with some degree of official recognition but maintain flexibility in their operations. Examples include watershed management committees, farmer cooperatives, and multi-stakeholder climate adaptation platforms.
- 3. Informal institutions: These encompass social norms, customs, traditional practices, and unwritten rules that govern behavior within communities. Examples include traditional water sharing arrangements, communal land management practices, and informal knowledge exchange networks.

This framework enabled identification of key institutional factors affecting climate adaptation across multiple governance levels---local, national, and international---and across various sectors, particularly agriculture and water management. It allowed us to analyze how different types of institutions interact and influence adaptation outcomes in different contexts.

Understanding institutions in different societal contexts

It is important to clarify that the meaning and operation of “institutions” varies considerably across different societal contexts. In Western societies, institutions are often conceptualized as formal organizations with codified rules and clear jurisdictions. However, in many developing countries, particularly in rural settings, informal institutions based on traditional governance systems, kinship networks, and customary law may be equally or more influential in shaping adaptation outcomes.



FIGURE 1
Time span distribution of records identified for institutional dynamics in climate change adaptation (2014–2024).

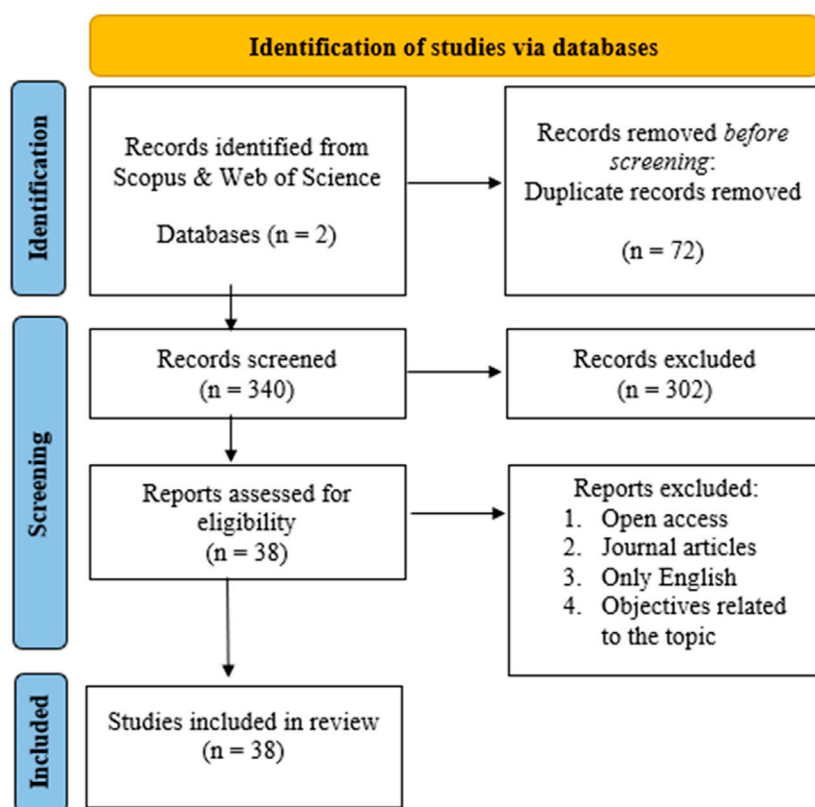


FIGURE 2
PRISMA flow diagram showing the systematic review process for identifying relevant literature on institutional dynamics in climate adaptation.

In South Asian contexts, for instance, traditional village councils (e.g., Panchayats in India) or religious institutions often play significant roles in natural resource management and community adaptation strategies, operating alongside or sometimes in tension with formal government institutions. In African contexts, traditional chieftaincy systems and communal land tenure arrangements frequently influence how adaptation resources are distributed and utilized. Our conceptualization of institutions therefore acknowledges these diverse societal contexts, recognizing that institutional arrangements for climate adaptation must be understood within their specific cultural, historical, and socio-political settings. The adaptation literature has increasingly recognized this contextual diversity, though our bibliometric analysis reveals that research remains disproportionately focused on formal institutions in Western contexts.

Data analysis approach

We employed a mixed-methods approach combining qualitative content analysis with quantitative bibliometric techniques to systematically analyze the selected literature. For the qualitative component, we utilized thematic content analysis following the methodology outlined by Braun and Clarke (2006). This process involved: 1) familiarization with the data through repeated reading of the selected articles; 2) generating initial codes using NVivo 12 software to identify relevant features; 3) searching for themes by

collating codes into potential themes; 4) reviewing themes to ensure coherence and distinctiveness; 5) defining and naming themes; and 6) producing the analysis report with key insights. The coding framework was developed iteratively, with two researchers independently coding a subset of articles to ensure consistency, achieving an inter-coder reliability of 85% (Cohen's kappa = 0.82).

For the quantitative component, we conducted a comprehensive bibliometric analysis using R Studio (version 4.1.0) with the 'bibliometrix' package to assess research trends and identify thematic clusters in the literature. This quantitative analysis provided an objective mapping of research patterns and relationships that complements the qualitative synthesis. The bibliometric analysis included the following analytical techniques.

1. Geographical mapping of study locations: The visualizations were created by showing the global distribution of research on institutional dynamics in climate adaptation by means of geographical coordinates extracted from study metadata and text. Location data was plotted using the 'ggplot2' and 'maps' packages in R.
2. Temporal analysis of publication trends: Publication frequency was tracked over the study period (2014–2024) and statistical analysis was conducted to locate significant trends using linear regression. Time series analysis was performed using the 'stats' package in R.
3. Visualization of author collaborations: Network analysis was used to identify collaboration patterns between authors and

institutions. This was to reveal key research clusters and knowledge exchange pathways. The 'igraph' package was used to calculate network metrics such as degree centrality, betweenness centrality, and clustering coefficients.

4. Word cloud and text mining analysis: Abstracts and keywords include the 'tm' and 'word cloud' packages as text mining techniques. This provided insights into the conceptual focus areas. The most significant terms in the corpus were then identified using term frequency-inverse document frequency (TF-IDF) analysis.
5. Co-occurrence network analysis of key themes: We identified thematic clusters within the literature using the co-occurrence of keywords and terms. Hierarchical clustering and multidimensional scaling techniques were applied to analyze the relationships between concepts.
6. Three-field plot and bibliographic coupling: These techniques mapped connections between authors, their institutional affiliations, and research themes, revealing patterns of specialization and collaboration. Bibliographic coupling analysis identified similar research based on shared references.

Statistical approaches to bibliometric data analysis incorporated frequency analysis, trend analysis via linear regression for temporal publication advance assessment, and network analysis using centrality and density. This was done to ascertain key nodes and clusters within collaboration and thematic networks. For analysis of the distribution of research among geographical spatial regions and thematic areas, chi-square tests were applied. Differences in the volume of publications across disciplines were examined using ANOVA. All designs were done in R Studio with 'ggplot2', 'wordcloud', 'igraph' and custom visualization scripts as add-on tools, which were created specifically for the purpose. A level of significance for all analyses was set at $p < 0.05$. The combination of qualitative and quantitative approaches offered profound understanding on research regarding institutional dynamics in climate change adaptation while systematically charting the literature landscape.

Results and trends in adaptation research

Geographical distribution of climate adaptation research

When we looked deeply at the extant literature, it was clear that a lot of work has been done on how institutions deal with climate adaptation—but mostly in developed regions like North America, Europe, and some parts of Africa. There is barely any research coming out of South Asian countries like India, Pakistan, and Sri Lanka, even though these places are some of the most at risk when it comes to climate change. The numbers backed this up too; our statistical analysis showed big differences in how research is spread across the world ($\chi^2 = 42.7$, $p < 0.001$), pointing to a clear imbalance. This is especially worrying since the Global Climate Risk Index highlights that South Asia is one among the most climate-vulnerable regions (Eckstein et al., 2021).

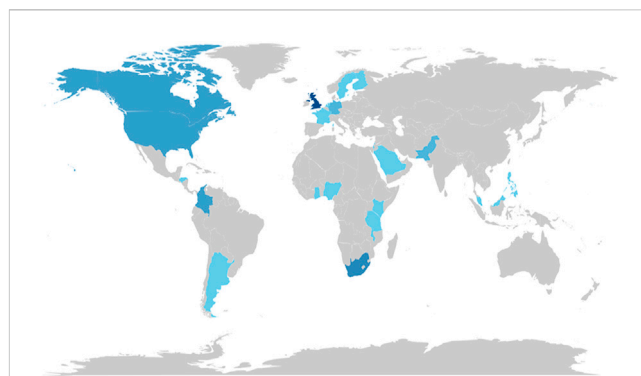
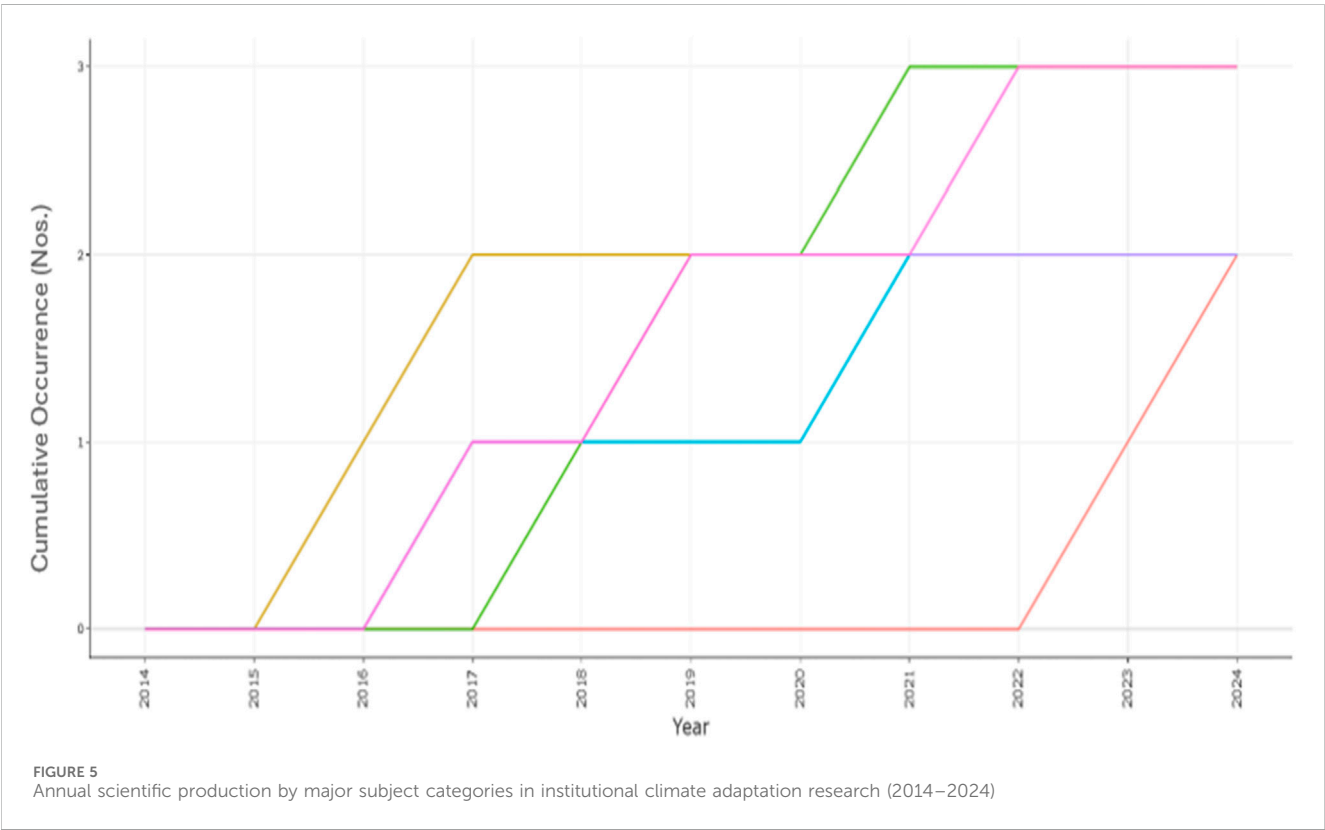
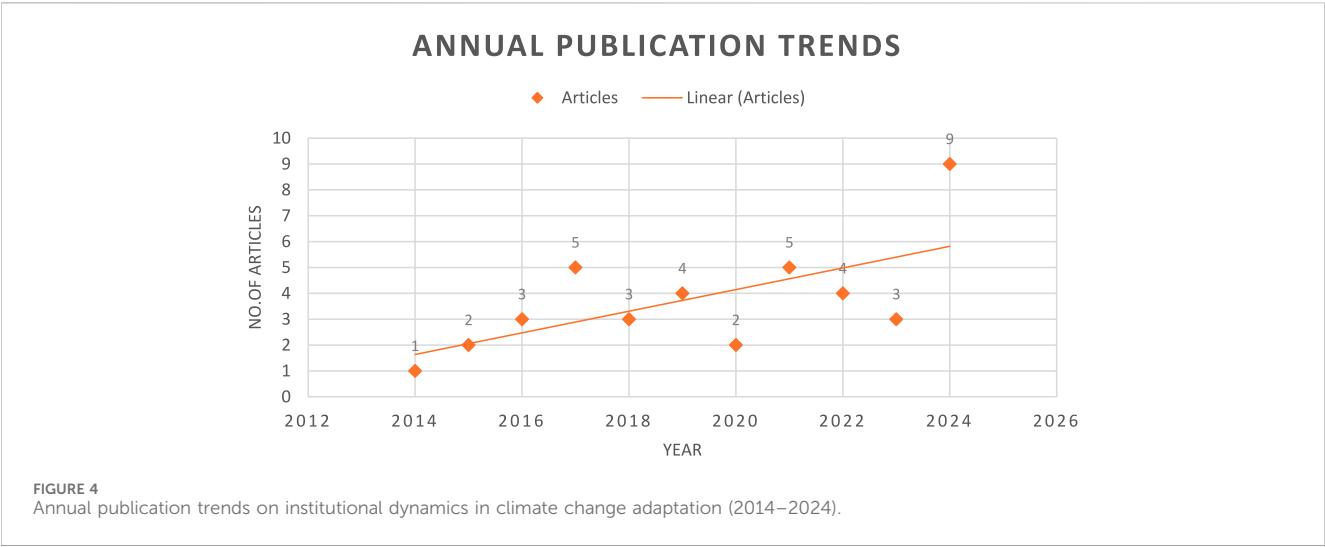


FIGURE 3
Global distribution map showing geographical concentration of institutional climate adaptation research (2014–2024).

The lack of research in South Asian countries is particularly concerning given recent evidence that shows how critical institutional determinants are for climate-smart agriculture adoption among smallholder farmers in these regions (Waaswa et al., 2024). Similarly, research on agricultural practices and their effects on farm income and food security demonstrates the importance of institutional support for sustainable practices, particularly in vulnerable regions like northern Ghana (Setsoafia et al., 2022).

The spatial distribution of research on institutional responses to climate change adaptation (The color intensity represents research concentration) is illustrated in the map shown in Figure 3. Significant research clusters are observed in North America, Europe, and parts of Africa, and research gaps are evidently seen in South Asian countries, namely, India, Pakistan, and Sri Lanka. This geographical imbalance highlights the need for more research in climate-vulnerable developing regions. The geographical concentration of research in certain regions indicates the relationship between patterns of climate vulnerability and existing institutional capacities. Research clusters in show that these countries have substantial research funding, established academic networks, and robust institutional frameworks for climate governance. The highlighted areas in Africa likely indicate the intersection of high climate vulnerability with significant international adaptation funding and research partnerships.

The lack of research in South Asian countries is alarming because these regions are already the worst affected by climate threats. As noted in the 'Global Climate Risk Index' (Eckstein et al., 2021), India, Pakistan, Bangladesh, and Sri Lanka are in the top tier of countries vulnerable to climate impacts. These countries have faced devastating climate extremes during the period under study, which include unprecedented heatwaves in India and Pakistan (2015, 2022), severe flooding in Kerala, India (2018, 2019), and decade-long cyclone sprees in coastal regions. Even with the accelerating climate pressures creating pressing institutional challenges, research to these contexts on institutional adaptation responses is scant. Adaptation gaps and challenges research with local contexts suggests a concerning geographical imbalance in research focus. Ignoring South Asian contexts limits understanding of how institutional frameworks endure climate challenges in some of the most vulnerable and densely populated



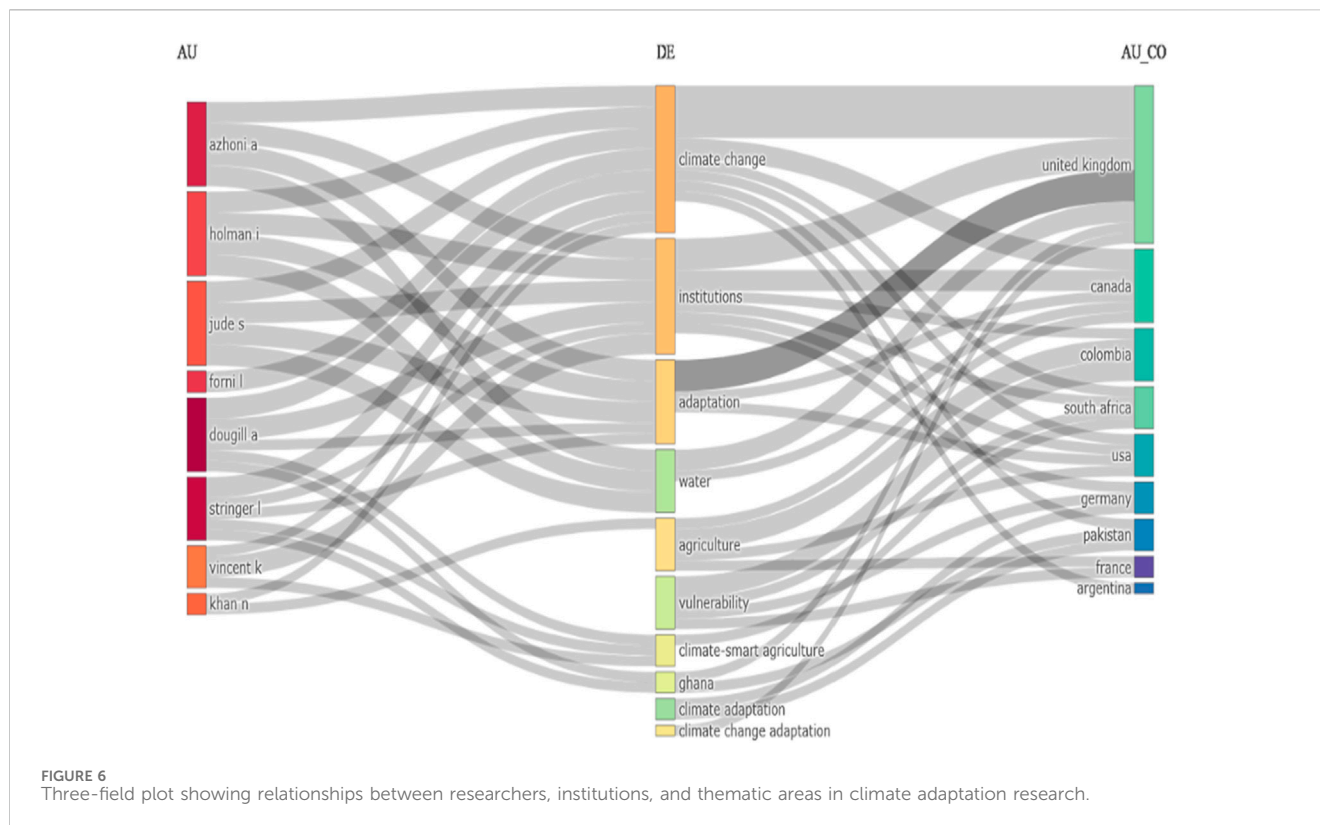
regions of the world. Because these contexts are missing, this gap is likely to have troubling consequences for intervention policy and strategy. A lack of evidence from these critical contexts can lead to poorly designed adaptation policies and practices.

Temporal trends in adaptation research

The Analysis of publication trends as shown in the [Figure 4](#) demonstrates overall progress in research on institutional dynamics

in climate adaptation over the past decade, with the highest number of publications recorded in 2024 and a notable dip in 2020. Linear regression analysis confirmed a statistically significant increasing trend ($R^2 = 0.78$, $p < 0.05$), with publication volume growing at an average rate of 1.2 papers per year over the study period.

While the analysis confirms a statistically significant increasing trend in publication volume ($R^2 = 0.78$, $p < 0.05$), the data exhibits notable non-linear characteristics. The linear trend was applied as the primary analysis to demonstrate the overall growth trajectory. But, the scattered plot of publications *versus* time reveals a more



complex pattern that suggests additional underlying factors. For improved clarity and analytical accuracy, displaying both the linear trend line with its corresponding equation ($y = 1.2x + 0.8$) and a polynomial curve that better captures the temporal fluctuations observed in the data. This would provide a more nuanced visualization of research growth patterns, particularly regarding the 2020 decline likely associated with the COVID-19 pandemic and the subsequent acceleration in 2024. Due to fluctuating behavior of trend in the publication, the linear metrics was taken into consideration while calculating the growth rates in this evolving field. The acceleration in publication rate following the pandemic period possibly reflects increased attention to climate adaptation following major policy developments such as the Paris Agreement implementation guidelines, COP26 outcomes, and growing recognition of institutional dimensions in the IPCC Sixth Assessment Report.

The Annual Scientific Production by major subject displayed in Figure 5 shows growth in interdisciplinary perspectives on climate adaptation research. Disciplines such as environmental science, agricultural science, and governance studies are worth mentioning under this category. Analysis of variance (ANOVA) testing showed significant differences in publication rates across disciplines ($F = 8.76$, $p < 0.01$), with environmental science showing the highest growth rate.

This multi-line graph displays publication trends across different disciplinary categories. The distinct colors represent various subject areas. The green line represents environmental science, the blue line represents agricultural science, the orange line represents governance studies, the purple line represents water resource management, and the red line represents policy research.

The visualization demonstrates the increasing interdisciplinary nature of climate adaptation research, with environmental science, agricultural science, and governance studies showing particularly strong growth. Statistical analysis indicates significant differences in publication rates across disciplines ($p < 0.01$).

Thematic patterns and research networks

The Three-Field Plot in Figure 6 mapped relationships between key researchers, their institutional affiliations, and research themes, revealing interconnections and collaborative patterns in the field. This analysis highlighted the multidisciplinary nature of institutional climate adaptation research and identified key nodes in the research network with high betweenness centrality, indicating their role as bridges between different research communities.

The visualization maps connections between authors (left), their institutional affiliations (center), and research themes (right), with line thickness representing strength of association. This network analysis reveals key research clusters and collaborative patterns in the field, highlighting the multidisciplinary nature of institutional climate adaptation research. Centrality measures indicate the most influential nodes in the research network. The distinction between the interdisciplinary nature shown in Figure 5 and the multidisciplinary character depicted in Figure 6 is important to clarify. Figure 5 demonstrates interdisciplinarity by showing how different disciplinary approaches (environmental science, agricultural science, governance studies) have converged and integrated over time to address climate adaptation challenges, with parallel growth across fields indicating shared research



FIGURE 9

Hierarchical tree map of keyword distribution in institutional climate adaptation literature. The visualization represents the proportional representation of keywords in the dataset, with rectangle size indicating relative frequency. "Climate change" dominates (14% of articles), followed by institutional frameworks, agriculture, and adaptive management (each ~5%). The hierarchical clustering reveals thematic patterns in the literature thereby highlighting primary research focus areas and potential knowledge gaps. Statistical analysis indicates significant differences in keyword distribution across the corpus ($\chi^2 = 42.7$, $p < 0.001$).

by institutional frameworks, agriculture, and adaptive management (each ~5%). This visualization revealed thematic patterns in the literature and highlighted primary research focus areas. Statistical analysis of keyword distribution across the corpus was performed using chi-square tests, which confirmed significant differences in the representation of different themes ($\chi^2 = 42.7$, $p < 0.001$).

Key findings on institutional dynamics

Multi-level governance and coordination

The literature revealed that climate adaptation involves institutional arrangements that works across multiple governance levels. Successful adaptation requires coordination across these levels where formal, quasi-formal, and informal institutions collaboratively facilitated the adoption of climate adaptation technologies as demonstrated in coastal Bangladesh (Haque et al., 2024). Similarly, local institutions in Cameroon serve as crucial bridges between national policies and community-level adaptation

practices (Brown and Sonwa, 2015). Similarly, climate services have proven effective in supporting agricultural productivity when institutional frameworks facilitate knowledge transfer between farmers and climate information providers (Naab et al., 2019).

Many studies highlight the misalignments between governance levels as seen in the case of Honduras where only 9% of climate adaptation interventions targeted highly vulnerable regions. This indicates indicated poor coordination between institutional networks and territorial needs (González-Rodríguez et al., 2024). Similarly, a disconnect between central and regional water management institutions in India impedes effective climate adaptation (Azhoni et al., 2017).

Works have underscored the need of collaboration at all levels of governance. Haque et al. (2024) reported that at coastal Bangladesh, institutional collaborations across different levels facilitated the creation and implementation of adaptation technologies. Ghimire et al. (2022) showed that in Nepal, the Climate-Smart Village approach blended indigenous knowledge and scientific insights through multi-level institutional frameworks within a single innovative architecture. Bhattacharya et al. (2023) demonstrated

in their research about collaborations between formal institutions and informal community networks that effectively managing local water resources significantly improved climate resilience in extreme environments. Noor et al. (2023) conducted additional research consolidating these findings by noting how multi-level governance structures in the coastal regions of Indonesia increased adaptive capacity. This was done by linking local innovation to national policies and funding systems. Also, Patra et al. (2023) reported that there is enhanced agricultural adaptation in eastern India because of multi-level partnerships of institutions. This improved the agriculture knowledge system and resource management across the different levels of governance.

These findings align with recent research by Schipper et al. (2023), who has found that effective adaptation requires “nested” institutional arrangements where local responses are supported by enabling national frameworks. Cradock-Henry et al. (2022) similarly has emphasized that institutional fragmentation across governance levels remains a persistent challenge in adaptation governance.

Sectoral integration and policy mainstreaming

From the extant literature we can understand that there are significant variations in how climate adaptation is seen across different sectors. Nkiaka and Lovett (2018) found substantial progress in mainstreaming climate adaptation into forestry and energy sectors in Cameroon which was facilitated by national policies. The integration of climate adaptation into educational curricula represents another important sectoral approach, as demonstrated by efforts to mainstream climate change adaptation in agricultural education programs (Coronacion, 2016). This educational mainstreaming helps ensure that future practitioners understand institutional frameworks for climate adaptation.

Similarly, Antwi-Agyei et al. (2017) identified limited coherence between sector policies in Ghana with inadequate work on climate adaptation in agricultural policies. Nightingale et al. (2023) identified sectoral siloing as a key barrier to transformative adaptation. Thomas et al. (2022) found that sectoral policy integration remains challenged due to competing priorities and institutional mandates. Brockhaus et al. (2023) demonstrated that cross-sectoral coordinating bodies can efficiently overcome fragmentation when given appropriate authority and resources.

Formal and informal institutional interactions

Several studies emphasized the complementary roles of formal and informal institutions in adaptation processes. Brown and Sonwa (2015) demonstrated how informal savings groups and agricultural cooperatives in Cameroon created community resilience to climate impacts despite limited formal institutional support. Porras et al. (2019) argued that informal networks in Mexico's Rio del Carmen watershed compensated for formal governance failures in water management. The effectiveness of payments for environmental services represents an important intersection between formal policy mechanisms and informal community arrangements,

demonstrating how institutional design can bridge formal and informal systems (Börner et al., 2017). Similarly, hybrid governance approaches that combine formal regulations with flexible community-based arrangements show promise for environmental management (Ghosh, 2021). Nchu et al. (2019) argued that informal institutions can also impact adaptation, particularly when traditional cultural practices discriminate against women's land access thereby limiting their adaptive capacity to climate change.

Recent research by Nyantakyi-Frimpong (2023) shows how informal kinship networks in Ghana has facilitated adaptation through knowledge sharing and resource pooling especially when formal extension services have been inadequate. Vij et al. (2023) has demonstrated that informal institutions often fill critical gaps left by formal arrangements. This should be seen particularly in resource-constrained contexts. However, Mngumi (2021) cautioned that over-reliance on informal institutions can cause inequality when they replicate existing power structures.

Barriers to effective institutional adaptation

Knowledge constraints and capacity limitations

There are several studies that have identified limited institutional knowledge and capacity which act as significant barriers to adaptation. Azhoni et al. (2016) pointed out that water management bodies in Himachal Pradesh, India, did not really have the technical know-how or a proper understanding of how to deal with climate adaptation. Dougill et al. (2016) found something similar in Malawi. Agriculture institutions there had some serious knowledge gaps when it came to Conservation Agriculture practices. Research has shown that institutional capacity is particularly important for managing complex environmental challenges, such as managed aquifer recharge systems that require coordination between multiple stakeholders and technical expertise (Reznik et al., 2022). Additionally, institutional arrangements that address aquifer management and climate adaptation require careful attention to incentives, information systems, and governance structures (Asprilla-Echeverría, 2023).

Other studies have shown that just being aware of climate risks does not automatically mean people or institutions will take real action to adapt (Khan et al., 2020). This ties in with more recent research by Monstadt et al. (2022), who also found that water management institutions across South Asia still struggle because they do not have enough technical expertise. In the same vein, Bedmar Villanueva et al. (2023) pointed out that a lack of capacity is one of the biggest roadblocks to rolling out climate-smart agriculture in East Africa. For instance, the local extension services did not have enough technical skills or resources to actually help farmers in a meaningful way.

Structural and governance barriers

A bunch of studies have shown that disorganized institutions become major roadblocks. Haque et al. (2024) saw similar situation

in Bangladesh, where even though there were efforts to build partnerships, institutional fragmentation hindered smooth and sustainable running of climate adaptation programs. Understanding governance challenges requires attention to how different forms of institutional change occur, particularly in contexts where power relations shape adaptation outcomes (Benjaminsen et al., 2022). Research has shown that institutional barriers often extend beyond technical limitations to encompass deeper structural issues related to path dependency and the speed of institutional change (Barnett et al., 2015).

On a global level, Nightingale et al. (2023) noted that these fragmented systems keep slowing things down. When institutions operate in silos, they miss the chance to respond in a more joined-up way especially as climate issues keep getting more complex. Eriksen et al. (2023) also pointed out that when governance is fragmented in this manner, it often leads to maladaptation, because different institutions are chasing different goals without bothering to coordinate.

A lot of studies have pointed out that not having enough resources is a big hurdle when it comes to institutions trying to adapt. For instance, Khan et al. (2020) found that agricultural institutions in Pakistan focused on immediate climate responses rather than long-term capacity building. Similarly, Azhoni et al. (2017) found that Indian water institutions struggled to balance day-to-day management with long-term climate adaptation planning. Patra and Babu (2022) showed that in Nagaland, India, the lack of proper funding for climate-focused research and programs was a major reason why institutions were not really ready to take on climate-smart agriculture. Similarly, Savo et al.'s (2023) study on resource constraints which have limited institutional adaptive capacity in low-income countries because of adaptation funding falling short of need. Similarly, Berrang-Ford et al. (2021) also identified resource limitations as an ongoing constraint to adaptation initiation and in the Global South.

Other research has noted political dimensions and governance difficulties as prominent hindrances. Patterson (2021) suggests that political factors, rather than a logical evaluation of climate risks, drove institutional change in 96 major cities. Sullivan et al. (2018) pointed out that rule and norm interpretation conflict at the basin's Colorado River stakeholder level was a problem for cooperative drought planning. In other contexts, corruption came out as a particular governance issue and a notable hindrance to adaptive water governance in Mexico (Porrás et al., 2019). Similarly, Nalau and Verrall (2021) showed that adaptation planning and execution is still highly governed by political issues, bypassing technical aspects of adaptation planning. Recently, Leiter and Pringle (2023) also observed that the quality of governance has critical importance to adaptation results, noting that corruption and insufficient accountability severely damage even well-funded programs.

Enabling factors for institutional adaptation

Knowledge integration and boundary organizations

A bunch of studies have stressed how important boundary organizations are when it comes to linking science and policy to

make climate adaptation actually work. These are special kinds of institutions that help different groups talk to each other, understand each other, and work together. Basically, they sit right in the middle, turning complex scientific data into something policymakers can actually use, and making sure research is tackling questions that matter on the ground. One solid example is the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which managed to boost how useful, reliable, and trustworthy climate knowledge became by doing some solid boundary work (Dinesh et al., 2021). Similarly, differences in how science-policy connections work in soil and land governance show how boundary organizations create chances for real interaction between the science world and the policy world (De Donà, 2021). What makes these boundary organizations click? Things like strong accountability, smart use of tools that both sides understand (boundary objects), good leadership, coordination, clear communication, and the right kind of motivation or incentives (Dinesh et al., 2021).

Collaborative governance and institutional partnerships

Lots of studies talk about how adaptive governance systems can really help make climate adaptation more effective. For example, Sullivan et al. (2018) looked at how collaborative drought planning was done in the Colorado River basin. They showed that bringing different stakeholders into the process helped handle power struggles and disagreements over how rules were interpreted. Similarly, Ziervogel et al. (2017) used nodal governance and network analysis to study ecosystem-based adaptation in South Africa. They found that there were real chances to strengthen the way institutions worked together in that context. In Ojwang et al. (2017) looked at how watersheds were being managed and found that the governance was not only more fair but also more effective due to including different types of knowledge and directly addressing the power imbalances that often come with mixing governance styles. Clark et al. (2023) also showed that adaptive capacity was enhanced with collaborative governance as there was trust and learning across institutional networks. Jiang et al. (2023) provided compelling evidence from China's southeast coast demonstrating how adaptive policy adjustments can deliver significant ecosystem-agriculture-economy co-benefits in land degradation neutrality efforts when institutional frameworks properly coordinate across sectors.

Works have underscored the need of collaboration at all levels of governance. Haque et al. (2024) reported that at coastal Bangladesh, institutional collaborations across different levels facilitated the creation and implementation of adaptation technologies. Ghimire et al. (2022) showed that in Nepal, the Climate-Smart Village approach blended indigenous knowledge and scientific insights through multi-level institutional frameworks within a single innovative architecture. Noor et al. (2023) conducted additional research consolidating these findings by noting how multi-level governance structures in the coastal regions of Indonesia increased adaptive capacity. This was done by linking local innovation to national policies and funding systems. Also, Patra et al. (2023) reported that there is enhanced

agricultural adaptation in eastern India because of multi-level partnerships of institutions. This improved the agriculture knowledge system and resource management across the different levels of governance.

Policy integration and adaptive governance approaches

Integration and mainstreaming policies have been identified as important enablers. As Nkiaka and Lovett (2018) observed, national frameworks and policies enhanced the integration of adaptation strategies into sectoral policies in Cameroon. In the Philippines, Coronacion (2016) showed how climate adaptation was being integrated into the development of agricultural teaching programs, thereby ensuring the dissemination of knowledge to future practitioners of agriculture. Brockhaus et al. (2023) has argued that integration of policies is important for effective adaptation. These specific policies enable a country's coherence in cross-sector coordination. The existence of sub-national adaptation plans which detail sectoral integration are of greater value for intersectoral coordination than those without. Some literature has proposed different strategies to increase flexibility within an institution. These are termed adaptive governance. As the adaptive governance approach suggests, iterative learning, adaptive management, and fostering collaboration with responsive institutions to shifting environments and emerging expertise are essential. These approaches incorporate the unknowns of future climate impacts and focus on strategies that encourage regular review and update of policies.

Porrás et al. (2019) argued that transitioning to adaptive water governance in Mexico requires building informal networks and eventually formalizing stakeholder engagement. Similarly, Forni et al. (2018) found that robust decision support frameworks could help water resource managers in Argentina to address climate uncertainty through adaptive management. Recent research by Wuijts et al. (2018) supports these findings by showing that adaptive governance approaches in European river basins enhances response to extreme events through iterative learning and flexible management structures. Similarly, Villamayor-Tomas et al. (2023) found that adaptive governance arrangements in irrigation systems improved resilience to climate variability by enabling rapid response to changing conditions.

Some studies have pointed out how important it is to have the right incentives along with institutional changes. For example, Echeverría (2022) argued that to really change how ecosystems are managed, we need to bring in some innovative incentives. Banna et al. (2016) looked at what drives farmers in Malaysia to pay for climate adaptation programs and found that socio-economic and motivational factors played a big role. The need to untangle incentives is still key to successful adaptation, as shown by Lipper et al. (2023), who found that payment-for-ecosystem-services programs only really worked if they were tied to both private and public benefits. Transformative adaptation, on the other hand, is all about shifting institutional frameworks and elements that go beyond just making small, step-by-step changes (Schipper et al., 2023).

Discussion

Context dependency of institutional arrangements

Our findings really stress that the effectiveness of institutional arrangements for climate adaptation depends a lot on the context. Azhoni et al. (2016) made this point clear by showing how important it is to consider socio-economic and cultural factors when looking at barriers to adaptation. Patterson (2021) also pointed out that we need to take local factors into account when comparing how different cities are adapting. This focus on context lines up with more recent ideas about adaptation governance. Nalau and Verrall (2021) argue that adaptation has to be grounded in specific places, meaning institutions should be tailored to local conditions instead of taking a one-size-fits-all approach. Likewise, Sherman et al. (2023) show that for adaptation institutions to work, they need to be integrated into the local governance systems. If they ignore the local political and economic realities, even the best technical solutions can fail. So, the fact that most of the research focuses on Western contexts, as shown by our bibliometric analysis, is pretty important. Wuijts et al. (2018) note that institutional models developed in high-income contexts often prove ineffective when transferred to developing countries without appropriate modification. Likewise, Boda et al. (2022) caution against uncritical policy transfer in adaptation governance, arguing that institutional arrangements must be co-developed with local stakeholders to ensure relevance and legitimacy.

Knowledge integration and power dynamics

Our research highlights the need for integrating different knowledge (scientific, traditional, and local) for effective adaptation purposes. Ghimire et al. (2022) showed the effectiveness of the Climate-Smart Village approach which integrated traditional knowledge and science. In the same way, Brown and Sonwa (2015) said that the incorporation of formal scientific knowledge with local knowledge systems could enhance adaptation. These align with the recent literature on co-production of knowledge within adaptation governance. Monstadt et al. (2022) argue that effective adaptation requires 'democracy of expertise'—meaning different types of knowledge are appreciated and combined to inform action. Nobre et al., 2023 argue that boundary organizations are most useful when they support genuine knowledge co-production in contrast to a unidirectional knowledge transfer. Moreover, Waseem et al. (2023) have demonstrated through their advanced bibliometric analytical framework that adaptation planning requires integration of diverse knowledge types and governance approaches to be effective in different geographical and socio-political contexts. During our bibliometric analysis, we found an absence of collaboration between the computational research clusters and the welfare/management clusters. This indicates a gap between the technical and social approaches to adaptation within the literature. That supports Nightingale et al. (2023) study that highlights that social and technical aspects of adaptation are often treated separately, responding less effectively to coordinated climate challenges.

The different types of negotiations and relations of power are considered primary factors that influence the pace of changes in the institution. Women's adaptability as noted from Nchu et al.'s (2019) research was diminished as a result of gender biases regarding land access. Power which helps in creating a social order also was emphasized by Ziervogel et al. (2017) who argued that the same affected the adaptive capacity in South Africa. Eriksen et al. (2023) claim that for the most part attempts to improve conditions in society reinforce outcomes and power relations which are already there unless there is special attention to inequality reduction strategies. The case is similar with Few et al. (2023) showing that power gaps decide whose knowledge is of value and whose concerns are looked after in adaptation planning thus leading to increase vulnerability among marginalized groups. As revealed from our bibliometric analysis, there is little literature which has focused on the issue if governance structures power relations suggesting that this is a gap is increasingly becoming overlooked. In other words, this is precisely what Schipper et al. (2023) were saying, observing that research in adaptation tends to focus on control mechanisms and technical measures without considering the power relations concerned.

Tensions and contradictions in institutional approaches

With respect to earlier concepts, we highlight key associated discrepancies within the approaches taken by the institutions toward adaptation. Drawing from the work of scholars such as Nkiaka and Lovett (2018) and Brown and Sonwa (2015), it appears that policies at the national level tend to offer frameworks that are useful for guidance, while local institutions facilitate the relevant contextual adaptations on the ground. This integration of locally led adaptation tends to clash with automated systems as described by Boda et al. (2022) and Clark et al. (2023). This results in an overarching conflict between top-down *versus* bottom-up policies.

Another discrepancy is the tension of having rigid controls and flexible adaptive governance strategies. For instance, policies Shiferaw et al. (2014) provided, ensures responsibility and provides structure, which is a prerequisite form for any governance, but is devoid of agility in responding to changing climate situations. The opposite, informal and adaptive approaches lack the enforcement backbone (Porrás et al., 2019). Villamayor-Tomas et al. (2023) has addressed this lack in balance by depicting case studies from Spain under extreme climatic conditions illustrating that efficient governance of water resources required a blend of formal and adaptive methods. Wuijts et al. (2018) also found that the governing structure of 'ready to adapt' approaches used in the case of the European river basins was dependent on formal participatory guidelines paired with informal networks that enabled flexible responses to emerging challenges.

Many studies highlight tensions between addressing immediate climate impacts and building long-term institutional capacity. Khan et al. (2020) found that agricultural institutions in Pakistan focused on immediate climate responses rather than long-term capacity building. Similarly, Azhoni et al. (2017) found that Indian water institutions struggled to balance day-to-day management with long-term climate adaptation planning. Leiter and Pringle (2023) validate

the growing consensus that adaptation governance often prioritizes short-term responses to climate hazards over transformative institutional changes that are needed for long-term resilience. Nightingale et al. (2023) argue that effective adaptation requires addressing both immediate vulnerabilities and underlying structural causes, though institutions often struggle to bridge these timeframes. Similarly, Nightingale et al. (2023) argue that effective adaptation requires addressing both immediate vulnerabilities and underlying structural causes, though institutions often struggle to bridge these timeframes.

Research gaps and future directions

The integrated analysis exposed some significant gaps that need more attention in the future. Informal institutions are increasingly recognized within existing research; however, very few explain how these institutions operate and change in adaptation processes. There is a gap in understanding how informal norms, customs, and practices shape climate change adaptation, especially when formal institutions are weak or ineffective. One such effort is Nyantakyi-Frimpong's (2023) study, which investigates how informal kinship networks in Ghana support climate adaptation through knowledge sharing and resource pooling, but this evidence is not systematic across other contexts. Some studies briefly touch upon the idea of power relations, but there is little detailed exploration of how power relations influence the processes and outcomes of institutional adaptation. More attention is needed to the dimensions of power, equity, and injustice within climate adaptation institutional frameworks. This complements earlier calls by Schipper et al. (2023) for climate change adaptation research that has clear power dynamics focus in the adaptation outcomes. Few et al. (2023) study can also be useful to demonstrate that power-sensitive analysis of adaptation governance can reveal how institutional arrangements may reinforce existing inequalities. All this point to the need for more systematic approaches to studying power in adaptation contexts.

Many studies identify what should be done to enhance institutional capacity for adaptation, but fewer provide detailed guidance on how to implement these changes. Research on practical implementation pathways and transition strategies for institutional reform would be valuable. Sherman et al. (2023) has begun to address this gap by examining local institutional capacity for climate adaptation across communities in Ethiopia, Peru, and Uganda, identifying context-specific pathways for institutional strengthening. Similarly, Brockhaus et al. (2023) offer insights into the politics of institutional change for climate action, highlighting the importance of understanding reform processes rather than just desired end states.

There is limited research on how to measure and evaluate the effectiveness of institutional arrangements for climate adaptation. Developing robust metrics and evaluation frameworks would help identify successful approaches and guide policy development. Recent work by Nobre et al. (2023) on evaluating agricultural climate services provides a potential model, offering a framework that captures user experiences, development outcomes, and enabling environments. Similar approaches could be developed specifically for evaluating institutional dimensions of adaptation.

While individual case studies provide valuable insights, more comparative analysis across different geographical, political, and cultural contexts would enhance understanding of which institutional approaches work best under different conditions. Recent work by [Berrang-Ford et al. \(2021\)](#) demonstrates the value of systematic global assessment of adaptation progress, though institutional dimensions remain underdeveloped in their analysis. Similarly, [Thomas et al. \(2022\)](#) offer a comparative analysis of constraints and limits to adaptation across regions, providing a foundation for more targeted institutional comparisons.

Implications for policy and practice

The conclusions reached from this review are critical for policymakers and practitioners trying to improve institutional capacity to respond to climate change. Policies and programs which aim to respond to climate change must improve communication across various governance levels and sectors to circumvent duplication of effort. As [Haque et al. \(2024\)](#) and [Noor et al. \(2023\)](#) demonstrate, adaptation efforts are best achieved through multi-level institutional linkage at which local provisions are integrated into wider structures enabling access to more powerful resources and funds. In cases where there is a high level of awareness about climate-related risks but very low implementation capability, one structured training, knowledge transfer, and technical assistance towards building institutional knowledge and capacity is imperative. [Savo et al. \(2023\)](#) highlight the persistent funding gap for climate adaptation, particularly in protected areas and marginalized communities, emphasizing the need for more equitable resource distribution. Support for boundary organizations that bridge science, policy, and practice is critical for facilitating knowledge exchange and enhancing the credibility, salience, and legitimacy of adaptation knowledge. [Koubi et al. \(2022\)](#) demonstrate that effective boundary organizations can transform climate information into actionable knowledge for adaptation decision-making.

Inclusive and collaborative governance approaches, where diverse groups (especially marginalized ones) are involved, are crucial to making sure that climate adaptation responses also tackle equity concerns. This helps prevent existing vulnerabilities from getting worse. [Ojwang et al. \(2017\)](#) found that when governance is collaborative, it boosts both the legitimacy and the effectiveness of adaptation efforts. For adaptation governance to work well, there needs to be a balance between formal policy frameworks and adaptive approaches. This way, there is clear direction but also room to adjust to changing situations. [Villamayor-Tomas et al. \(2023\)](#) showed that good climate adaptation governance needs both clear rules and the flexibility to adapt when needed.

The fact that adaptation challenges are so context-specific must be acknowledged, meaning that solutions need to fit local conditions rather than being copied from elsewhere without modification. [Sherman et al. \(2023\)](#) stressed how important it is to tailor institutional strengthening strategies to the local political and governance realities. Finally, integrating different types of knowledge—scientific, traditional, and local—into adaptation planning and action is key to making it all work. [Vij et al. \(2023\)](#)

argued that using a power-sensitive approach when bringing in this knowledge can improve both the quality and credibility of adaptation solutions.

It is really important to address power imbalances that could limit the ability of certain groups, (women, minorities, and resource-poor communities) to adapt to climate change. [Eriksen et al. \(2023\)](#) show that if power dynamics are not dealt with in adaptation governance, it can lead to results that just make existing inequalities worse. Creating the right incentives is also key, as it motivates people to take action and support institutional changes. [Lipper et al. \(2023\)](#) found that incentives for sustainable land management work best when they connect private benefits to public adaptation goals.

Conclusion

The systematic review and bibliometric analysis conducted in this study provide valuable insights into the institutional dimensions of climate change adaptation. Our findings demonstrate the complex interplay between formal policies, organizational structures, and informal norms in shaping adaptation responses across different contexts and governance levels. It shows that effective adaptation requires coordinated institutional arrangements across governance levels and sectors. Yet this critical action faces significant barriers including knowledge and capacity gaps, institutional fragmentation, resource constraints, and governance challenges. Enabling factors identified include boundary organizations that bridge science and policy, collaborative governance frameworks that engage diverse stakeholders, multi-level partnerships that connect local to national efforts, and integrative approaches that mainstream adaptation into sectoral policies. Our bibliometric analysis highlights geographical imbalances in adaptation research, with limited studies from highly vulnerable regions in the Global South, particularly South Asia, pointing to critical gaps in context-specific institutional knowledge.

These findings have important implications for policy, practice, and research. For policymakers, our review suggests the need for institutional designs that balance formal frameworks with flexible implementation, promote cross-sectoral coordination, and address power imbalances that constrain adaptive capacity. For practitioners, the findings highlight the importance of context-specific approaches that integrate diverse knowledge types and strengthen connections across governance levels. For researchers, our analysis identifies critical knowledge gaps regarding informal institutional dynamics, power relations in adaptation governance, implementation pathways, evaluation metrics, and comparative institutional analysis, suggesting fruitful directions for future research. The integrated bibliometric approach represents a methodological contribution that enhances understanding of research trends and thematic clusters in institutional adaptation literature, providing a foundation for more targeted studies.

This study has several limitations that should be acknowledged. First, our focus on English-language publications may have excluded valuable insights from non-English literature, particularly from regions underrepresented in international scientific journals. Second, the reliance on Scopus and Web of Science databases

may have limited the inclusion of gray literature and publications in journals not indexed in these databases. Third, the 10-year timeframe, while ensuring contemporary relevance, may miss longer-term institutional evolution documented in earlier studies. Future research should address these limitations through multilingual reviews, expanded database searches including regional journals and gray literature, and longer-term historical analyses of institutional change. Additionally, more empirical research is needed on the causal mechanisms linking institutional arrangements to adaptation outcomes, particularly regarding how power dynamics shape adaptation processes and how institutional learning occurs across different contexts.

Although some studies mention power dynamics, there is limited in-depth analysis of how power relations shape institutional adaptation processes and outcomes. Future research should more explicitly address questions of power, equity, and justice in institutional arrangements for climate adaptation. This aligns with recent calls by Schipper et al. (2023) for more equity-focused climate scholarship that explicitly examines how power asymmetries shape adaptation outcomes. Similarly, Few et al. (2023) demonstrate that power-sensitive analysis of adaptation governance can reveal how institutional arrangements may reinforce existing inequalities, pointing to the need for more systematic approaches to studying power in adaptation contexts. Recent work by Jiang et al. (2023) illustrates how adaptive policy frameworks can generate multiple co-benefits across ecological, agricultural, and economic domains, providing an exemplary model for integrating institutional adaptation mechanisms into land management practices.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

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PJ: Conceptualization, Supervision, Writing – review and editing, Writing – original draft. RN: Formal Analysis, Writing – review and editing. SJ: Software, Methodology, Writing – review and editing. MS: Writing – original draft, Validation, Methodology. IP: Data curation, Writing – review and editing. PR: Writing – original draft, Visualization, Project administration.

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