ADAPTIVE GOVERNANCE FOR NATURAL RESOURCES MANAGEMENT: A BIBLIOMETRIC ANALYSIS

Sulie Ak Slat[1*], Muhammad Hafiz Mohd Yatim[2], Pitus @ Vitus Bagu[3]

[1] Faculty of Built Environment and Survey, Universiti Teknologi Malaysia, Malaysia
Email: sulie@graduate.utm.my
[2] Faculty of Built Environment and Survey, Universiti Teknologi Malaysia, Malaysia
Email: muhammadhafiz.my@utm.my
[3] Department of Civil Engineering, Politeknik Kota Kinabalu Sabah, Malaysia
Email: pitus@polikk.edu.my
[*] Corresponding Author

Article Info:

Abstract:

This bibliometric analysis explores the evolving research landscape of "Adaptive Governance for Natural Resources Management," a field that addresses the growing complexity and uncertainty in environmental management. Despite increasing attention, scholarly work on adaptive governance remains fragmented across disciplines, with limited synthesis of its intellectual development and thematic focus. This study aims to fill that gap by identifying key trends, influential contributions, and thematic structures within the literature. A targeted search was conducted using three keywords: "adaptive governance," "adaptive management," and "natural resource" in the Scopus database. After applying the inclusion criteria and performing data cleaning using OpenRefine, a total of 832 relevant documents were selected for analysis. The Scopus Analyzer was used to examine publication trends and citation metrics. At the same time, VOSviewer was used to generate visualizations of keyword co-occurrence, country collaboration, and authorship networks. The results reveal a steady increase in publication output over the last decade, with peaks in 2023 and 2024. Core research clusters focus on themes such as water governance, climate change, adaptive capacity, and sustainability. The United States, Germany, and the United Kingdom emerged as the most productive and influential countries. This study contributes to a clearer understanding of the field's structure, highlights dominant research areas, and identifies opportunities for future interdisciplinary collaboration. The findings provide valuable insights for researchers, policymakers, and practitioners seeking to enhance adaptive approaches to natural resource management.

Introduction

Adaptive governance has emerged as a critical framework for managing natural resources in the face of institutional failures and unforeseen changes in resource dynamics. This approach provides a context for managing both known and unknown consequences of prior management strategies, increasing the legitimacy and flexibility of resource management practices (Gunderson et al., 2016; Heurkens, 2012). Adaptive governance is particularly significant in addressing the complexities and trade-offs among ecosystem goods and services, as demonstrated in various water management systems in the United States (Gunderson et al., 2016). The iterative nature of adaptive governance, which emphasizes learning through management, is crucial for addressing the inherent uncertainties and complexities of natural resource systems (Allen & Garmestani, 2015; McLoughlin & Thoms, 2015; Sandström, 2011). The concept of adaptive management, a cornerstone of adaptive governance, involves a structured decision-making process designed to guide the management of natural resource systems under conditions of uncertainty (Moore et al., 2013; Muller, 2012). Unlike traditional trial-and-error approaches, adaptive management includes explicit goal setting, identification of alternative management objectives, and hypotheses of causation, followed by data collection, evaluation, and reiteration (Allen & Garmestani, 2015). This iterative process reduces uncertainty and builds knowledge and improves management (Allen & Garmestani, 2015; McLoughlin & Thoms, 2015), such as species reintroduction, disease and invasive species control, and habitat restoration (Williams & Brown, 2016). However, its implementation has faced significant challenges, including the need for adequate resources, management tools, collaboration, and learning (Månsson et al., 2023).

Recent developments in the field have highlighted the importance of integrating social and human contexts into adaptive management frameworks. Collaborative governance, which involves the co-production of goals and strategies by stakeholders, has been identified as a mechanism for providing an integrated, ecosystem-based approach to natural resource management (Davies & White, 2012; Okumu et al., 2021; Spooner et al., 2021). This approach emphasizes the need for participatory processes that include diverse stakeholder groups representing multiple communities of interest, place, and identity (Aleu et al., 2022; Deitch et al., 2021). The participatory co-management process, as illustrated by non-regulatory programs modeled after the United States Environmental Protection Agency's National Estuary Program, demonstrates the potential for the successful management of environmental resources through collaborative efforts (Deitch et al., 2021; Musavengane, 2019). Additionally, the concept of adaptive co-management, which combines adaptive management with community-based natural resource management, has shown promise in enhancing the resilience of both human and ecological (Hill et al., 2010; McLoughlin & Thoms, 2015; Tompkins & Adger, 2004). Despite the potential benefits of adaptive governance, its implementation has encountered several obstacles. These include difficulties in achieving an appropriate balance between different modes of learning (single-, double-, and triple-loop learning), building capacity for reflexive learning, and ensuring the flexibility of governance systems (Månsson et al., 2023; McLoughlin & Thoms, 2015; Walch, 2019). Moreover, the

effectiveness of adaptive management over traditional management techniques remains a subject of debate, with studies suggesting that more communication between practitioners and scholars could promote interdisciplinary learning and problem-solving (Dreiss et al., 2017; Wittmayer et al., 2014). The challenges of integrated, adaptive, and ecosystem management have led government agencies to adopt participatory modes of engagement, which, while promising, require careful consideration of role allocation, responsibility sharing, and the establishment of trust within institutional networks (Davies & White, 2012; Schoon et al., 2017).
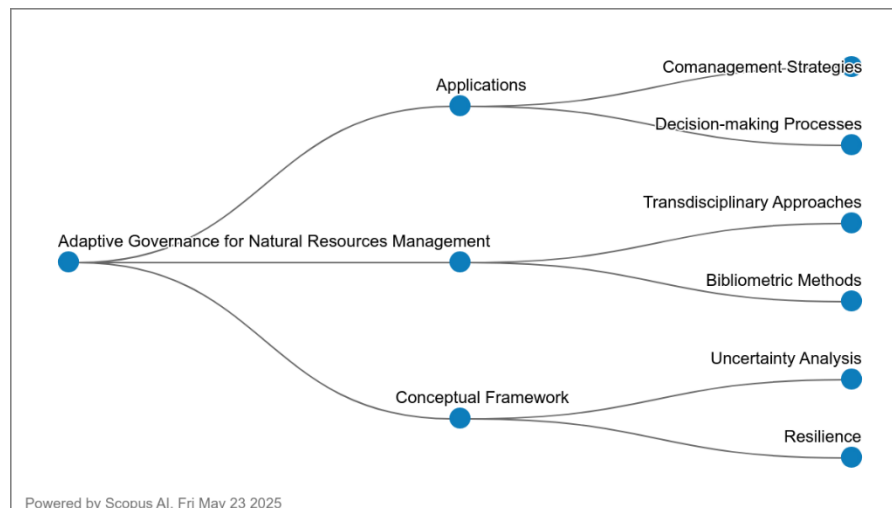
Figure 1: Concept Map of Adaptive Governance for Natural Resources Management

In conclusion, adaptive governance represents a significant advancement in the management of natural resources, as shown in Figure 1, offering a flexible and learning-oriented approach to address the complexities and uncertainties inherent in these systems. The integration of social and human contexts, along with collaborative governance mechanisms, enhances the potential for successful and sustainable resource management. However, implementing adaptive governance requires overcoming substantial challenges, including capacity building, stakeholder engagement, and developing effective communication channels between practitioners and scholars. As the field continues to evolve, further research and practical applications will be essential in refining adaptive governance frameworks and ensuring their effectiveness in diverse environmental contexts.

Research Questions
To guide this bibliometric analysis, the following research questions were formulated to explore key aspects of the publication landscape:

RQ1: What is adaptive governance according to the year of publication?
RQ2: What are the most cited articles?
RQ3: Where are the top 10 countries based on the number of publications?
RQ4: What are the popular keywords related to the study
RQ5: What is the co-authorship by countries' collaboration?

Methodology

Bibliometrics involves gathering, organizing, and analyzing bibliographic data from scientific publications (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). Beyond basic statistics, such as identifying publishing journals, publication years, and leading authors (Wu & Wu, 2017), bibliometrics encompasses more sophisticated techniques, including document co-citation analysis. Conducting a successful literature review requires a careful, iterative process to select suitable keywords, search the literature, and perform an in-depth analysis. This approach facilitates the compilation of a comprehensive bibliography and yields reliable results (Fahimnia et al., 2015). With this in mind, the study focused on high-impact publications, as they provide meaningful insights into the theoretical frameworks that shape the research field. To ensure data accuracy, Scopus served as the primary source for data collection (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). Additionally, to maintain quality, the study only considered articles published in peer-reviewed academic journals and conference papers, deliberately excluding books and lecture notes (Gu et al., 2019). Using Elsevier's Scopus, known for its broad coverage, publications were collected from 2000 through December 2024 for further analysis.

Data Search Strategy

The study employed a screening sequence to determine the search terms for article retrieval. The study was initiated by querying the Scopus database, as shown in Table 1, with the selection criterion outlined in Table 2. This process yielded 1,056 results, which were further scrutinized to include only research articles and conference papers written in English. The final search string refinement included 832 articles, which were used for bibliometric analysis. As of May 2025, all articles from the Scopus database relating to adaptive governance and focusing on natural resources were incorporated into the study.

Table 1: The Search String

Scopus	TITLE (adaptive AND (governance OR management) AND (natural OR nature OR resources OR fish OR water OR river OR marine)) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2000) OR LIMIT-TO (PUBYEAR , 2001) OR LIMIT-TO (PUBYEAR , 2002) OR LIMIT-TO (PUBYEAR , 2003) OR LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2005) OR LIMIT-TO (PUBYEAR , 2006) OR LIMIT-TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-

TO (PUBYEAR , 2017) OR LIMIT-
TO (PUBYEAR , 2018) OR LIMIT-
TO (PUBYEAR , 2019) OR LIMIT-
TO (PUBYEAR , 2020) OR LIMIT-
TO (PUBYEAR , 2021) OR LIMIT-
TO (PUBYEAR , 2022) OR LIMIT-
TO (PUBYEAR , 2023) OR LIMIT-
TO (PUBYEAR , 2024)) AND (LIMIT-
TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp"))

Table 2: The Selection Criterion in Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Year	2000-2024	> 2000
Literature Type	Journal (Article) and Conference Paper	Book, Review
Publication Stage	Final	In Press

VOSviewer is a user-friendly bibliometric tool developed by Nees Jan van Eck and Ludo Waltman of Leiden University in the Netherlands (van Eck & Waltman, 2010, 2017). VOSviewer is a popular tool for visualizing and exploring scientific literature. It helps researchers make sense of complex data by creating clear network maps, grouping related topics, and showing how ideas are connected through density maps. Whether looking at co-authorship, co-citation, or keyword patterns, VOSviewer gives a deeper understanding of how research fields are shaped. Its user-friendly design and regular updates make it easy to work with large datasets. Additionally, with features that enable it to calculate key metrics, adjust visual settings, and work with various data sources, it is a valuable resource for anyone studying trends and connections in academic research.

One of VOSviewer's greatest strengths is its ability to transform complex bibliometric data into clear, easy-to-understand maps and charts. Designed with a focus on network visualization, it helps users identify patterns by clustering related items, analyzing how keywords co-occur, and creating detailed density maps. The software's intuitive interface makes it accessible to both beginners and experienced researchers, allowing them to explore research landscapes with ease. Thanks to ongoing updates and improvements, VOSviewer remains current and continues to offer powerful tools for analyzing metrics and customizing visualizations. Its flexibility in handling different types of data—such as co-authorship links and citation networks—makes it a go-to choice for scholars aiming to uncover deeper insights and understand trends in their fields.

The dataset, which included details such as publication year, title, author names, journal, citation count, and keywords in PlainText format, was retrieved from the Scopus database covering the period from 2004 to December 2024. This data was then processed using VOSviewer version 1.6.19. By applying VOS clustering and mapping techniques, the software enabled the visualization and analysis of the data through intuitive maps. Unlike traditional Multidimensional Scaling (MDS), VOSviewer places items in a low-dimensional space in a way that reflects the distance between any two items as their degree of similarity or connection (van Eck & Waltman, 2010). In this respect, VOSviewer shares a similarity with the MDS

approach (Appio et al., 2014). Unlike MDS, which typically relies on similarity measures such as cosine or Jaccard indices, VOS employs a more suitable approach for normalizing co-occurrence frequencies, such as the Association Strength (AS_{ij}), and it is calculated (van Eck & Waltman, 2007):

$$AS_{ij} = \frac{c_{ij}}{w_i w_j},$$

which is "proportional to the ratio between, on the one hand, the observed number of co-occurrences of i and j and, on the other hand, the expected number of co-occurrences of i and j under the assumption that co-occurrences of i and j are statistically independent" (van Eck & Waltman, 2007).

Findings

The findings of this study provide a detailed overview of the research landscape on adaptive governance for natural resources management. Based on the analysis of 832 publications retrieved from the Scopus database, the results highlight publication trends, citation patterns, prominent keywords, key contributing countries, and patterns of international collaboration. These findings offer valuable insights into the development, focus areas, and global distribution of research within this field.

RQ1: What are the Adaptive Governance Studies According to the Year of Publication?

Based on Figure 2 and Table 3, the publication trend from 2015 to 2024 indicates a growing scholarly interest in adaptive governance for natural resource management. Beginning with 44 publications in 2015 (5.29%), the field has maintained a steady presence in the academic landscape, with a generally upward trajectory over the decade. The number of publications peaked in 2023 at 58 (6.97%), marking the highest output, followed closely by 2024 with 52 publications (6.25%). This suggests a sustained and possibly intensifying focus on adaptive governance as a critical framework for managing complex environmental challenges in recent years.

Between 2016 and 2021, the data reveals some fluctuation in output. The lowest number of publications occurred in 2021, with 28 publications (3.37%), potentially reflecting the lingering impact of the COVID-19 pandemic on academic productivity and fieldwork-based research. However, this dip was followed by a significant recovery in 2022, which recorded 47 publications (5.65%). This rebound underscores the resilience of the research community and the renewed urgency of adaptive governance in the context of post-pandemic recovery and accelerating climate change impacts.

Scopus
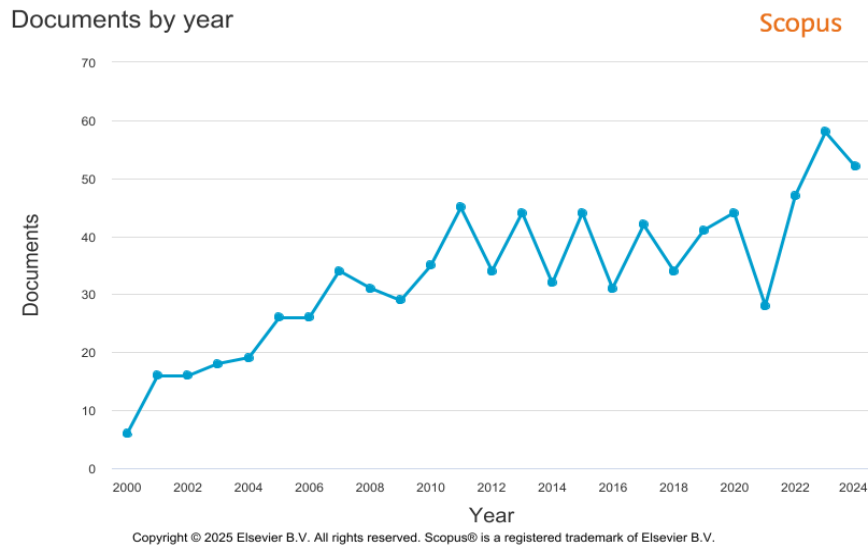
Figure 2: Trend of Research in Adaptive Governance by Years

Table 3: Percentages of Publication in Adaptive Governance by Years

Year	Number of Publication	Percentages (%)
2024	52	6.25
2023	58	6.97
2022	47	5.65
2021	28	3.37
2020	44	5.29
2019	41	4.93
2018	34	4.09
2017	42	5.05
2016	31	3.73
2015	44	5.29

The earlier years of the dataset, particularly from 2015 to 2018, show a moderate but consistent level of publication activity, averaging around four to five percent. These years likely represent a foundational phase in which core concepts, frameworks, and empirical case studies were established. As awareness of environmental uncertainties and the need for flexible, participatory governance models has increased, so too has academic output. Overall, the data reflect a maturing and dynamically evolving field, with adaptive governance increasingly recognized as a vital approach to addressing socio-ecological complexity and promoting sustainable resource management.

RQ2: What are the Most Cited Articles?
Table 4 shows the most cited articles in adaptive governance for natural resource management. The citation analysis reveals Claudia Pahl-Wostl as the most prolific and influential scholar in adaptive governance for natural resource management, with five of the ten most cited publications bearing her name. Her seminal 2009 article in Global Environmental Change, with 1,574 citations, presents a conceptual framework for adaptive capacity and multi-level learning, establishing a foundational theory widely adopted in the field of environmental studies. Her consistent focus on water governance, institutional learning, and systemic change

through social learning processes places her at the intellectual core of adaptive governance scholarship.

Table 4: Top 10 Most Cited Authors

Authors	Title	Year	Source Title	Cited by
Pahl-Wost C. (Pahl-Wostl, 2009)	A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes	2009	Global Environmental Change	1574
Pahl-Wostl C. (Pahl-Wostl, 2007)	Transitions towards adaptive management of water facing climate and global change	2007	Water Resources Management	912
Huitema D.; Mostert E.; Egas W.; Moellenkamp S.; Pahl-Wostl C.; Yalcin R. (Huitema et al., 2009)	Adaptive water governance: Assessing the institutional prescriptions of adaptive (co-)management from a governance perspective and defining a research agenda	2009	Ecology and Society	673
Williams B.K. (Williams, 2011)	Adaptive management of natural resources-framework and issues	2011	Journal of Environmental Management	540
Pahl-Wostl C.; Sendzimir J.; Jeffrey P.; Aerts J.; Berkamp G.; Cross K. (Pahl-Wostl et al., 2007)	Managing change toward adaptive water management through social learning	2007	Ecology and Society	431
Pahl-Wostl C.; Lebel L.; Knieper C.; Nikitina E. (Pahl-Wostl et al., 2012)	From applying panaceas to mastering complexity: Toward adaptive water governance in river basins	2012	Environmental Science and Policy	333
Shojafar M.; Cordeschi N.; Baccarelli E. (Shojafar et al., 2019)	Energy-Efficient Adaptive Resource Management for Real-Time Vehicular Cloud Services	2019	IEEE Transactions on Cloud Computing	313
Engle N.L.; Lemos M.C. (Engle & Lemos, 2010)	Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil	2010	Global Environmental Change	312
Crona B.I.; Parker J.N.	Learning in support of governance: Theories, methods, and a framework to assess how	2012	Ecology and Society	300

(Crona & Parker, 2012)	bridging organizations contribute to adaptive resource governance			
Lempert R.J.; Groves D.G. (Lempert & Groves, 2010)	Identifying and evaluating robust adaptive policy responses to climate change for water management agencies in the American west	2010	Technological Forecasting and Social Change	285

Collaboration emerges as a key characteristic of high-impact work, with many top-cited articles co-authored by interdisciplinary teams. For example, the 2009 Ecology and Society article (673 citations), co-authored by Huitema, Mostert, Moellenkamp, and Pahl-Wostl, among others, addresses governance prescriptions and sets a research agenda, reflecting a convergence of policy analysis and institutional theory. Similarly, the involvement of other prominent scholars, such as Williams (2011) and Engle & Lemos (2010), demonstrates the diversity of perspectives from ecological management frameworks to climate change adaptation in river basins, contributing to the field's robust theoretical and applied base.

Interestingly, newer domains are also making an impact. The 2019 article by Shojafar et al., which focused on adaptive resource management in vehicular cloud services, shows that adaptive governance principles are extending beyond traditional natural resource domains into high-tech and urban systems. This suggests the adaptability of the governance framework to new contexts and emerging technologies, pointing to future directions where digital transformation and smart systems intersect with adaptive management strategies. Overall, the citation data underscores both the foundational contributions that continue to shape the field and the evolving, interdisciplinary applications of adaptive governance.

RQ3: Where is the Top 10 Country Based on the Number of Publications?
The data on the top ten most publishing countries in adaptive governance for natural resource management (refer to Figures 3 and 4) reveals a significant lead by the United States, with 262 publications, more than double that of the second-ranking country, China (101). This dominance reflects the strong research infrastructure, funding availability, and interdisciplinary interest in environmental governance across American institutions. The United States also likely benefits from a diverse ecological landscape and well-established policy networks that foster extensive case studies and theoretical development in adaptive governance.

Documents by country or territory

Compare the document counts for up to 15 countries/territories.
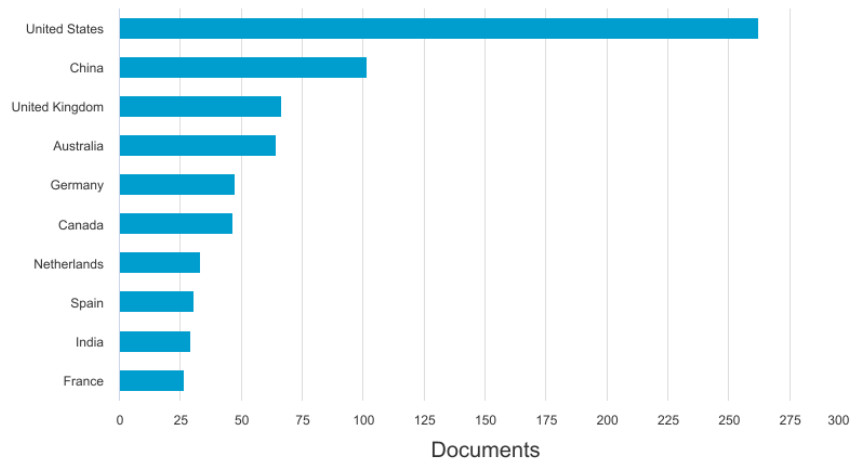
**Figure 3: Top 10 Countries Based on the Documents**

China, the United Kingdom, Australia, and Germany follow as key contributors, each demonstrating distinct regional priorities and environmental challenges that shape their research outputs. China's growing contribution is notable and likely driven by national policy shifts toward sustainability and ecological modernization. The United Kingdom and Australia, with 66 and 64 publications, respectively, reflect their long-standing academic focus on environmental management and participatory governance models, often influenced by their colonial histories of resource use and contemporary debates surrounding decentralization and community rights.

The presence of countries such as Canada, the Netherlands, Spain, India, and France in the top ten illustrates the global breadth of interest in adaptive governance. These nations, although smaller in output compared to the United States, represent diverse biogeographic and socio-political contexts, contributing valuable, localized insights and methodologies. Particularly, India's inclusion suggests a rising engagement from the Global South, aligning with growing concerns about climate vulnerability, water security, and equitable governance. Collectively, the data highlight the internationalization of adaptive governance research and the increasing recognition of its relevance in both developed and developing country contexts.
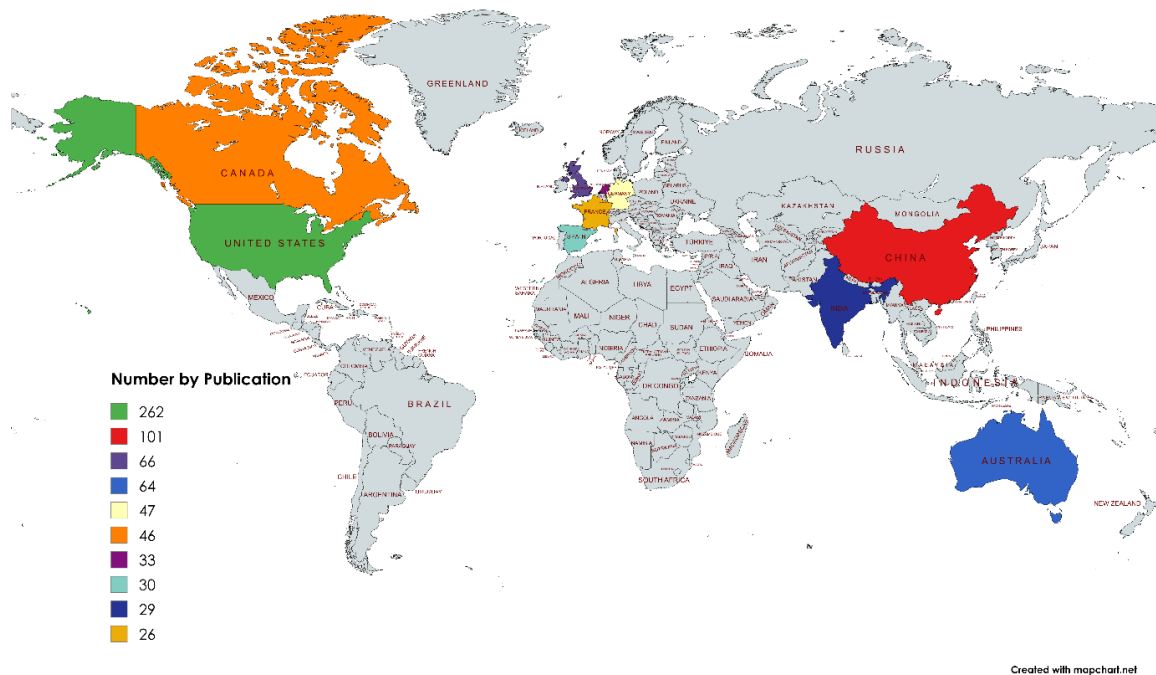
Figure 4: Top 10 Most Publishing Countries

RQ4: What are the Popular Keywords Related to the Study?

The keyword analysis from VOSviewer reveals the dominant themes and conceptual structure within the field of adaptive governance for natural resources management (Figure 5 and Table 5). The most frequently occurring keywords include "adaptive management" (111 occurrences, with a total link strength of 192), "resource management" (77 occurrences, 118 links), "adaptive capacity" (61 occurrences, 126 links), and "climate change" (59 occurrences, 123 links). These high-frequency and high-link-strength keywords indicate a strong emphasis on flexible, learning-based approaches to managing environmental uncertainty, particularly in the context of climate change impacts and sustainable resource use. The presence of "adaptive governance" (50 occurrences, 90 links) also confirms the centrality of the study's core concept within the academic discourse.
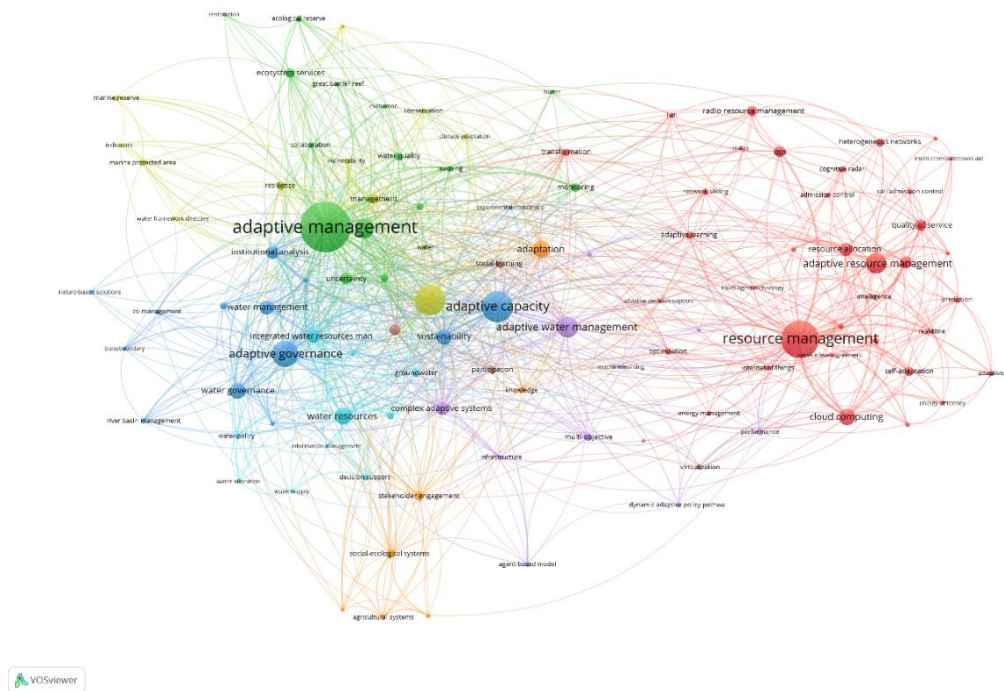
Figure 5: Network Visualization Map of Keywords' Co-occurrence

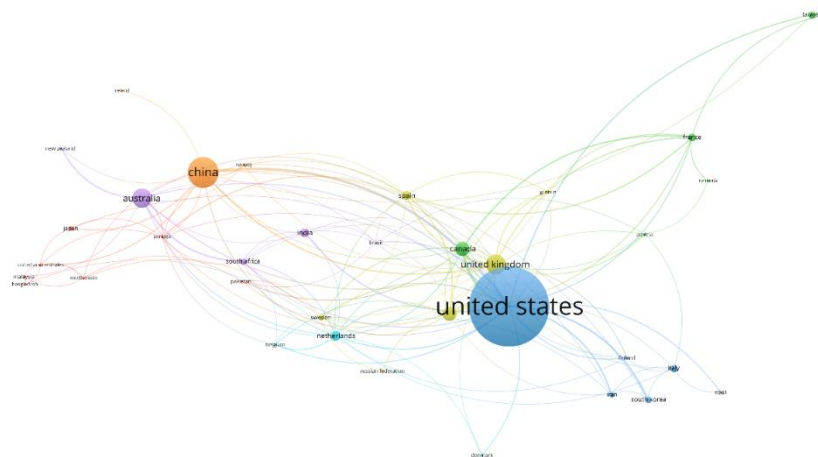**Table 5: Total Link Strength Keywords' Co-occurrence**

No.	Keyword	Occurrences	Total Link Strength
1.	adaptive management	111	192
2.	adaptive capacity	61	126
3.	climate change	59	123
4.	resource management	77	118
5.	adaptive governance	50	90
6.	environmental flows	33	72
7.	adaptive water management	37	67
8.	water governance	26	66
9.	sustainability	25	63
10.	complex adaptive systems	21	59

Several keywords indicate a rich network of related but distinct thematic areas. Terms like "resilience" (12 occurrences, 40 links), "sustainability" (25 occurrences, 63 links), "institutional analysis" (20 occurrences, 58 links), and "social-ecological systems" (13 occurrences, 30 links) reflect interdisciplinary linkages between ecological science, governance theory, and systems thinking. The inclusion of governance-specific terms such as "polycentric governance", "multi-level governance", and "public participation" further illustrates how adaptive governance is often situated within complex institutional arrangements requiring collaboration and integration across multiple scales. These linkages show that the research field is not only concerned with management strategies but also with the governance architectures and processes that enable adaptivity.

Moreover, the emergence of technical and systems-oriented keywords, such as "cloud computing", "machine learning", "cyber-physical systems", and "Internet of things", indicates a growing intersection between digital innovation and adaptive governance frameworks. These terms suggest a trend toward smart, data-driven approaches to environmental management and real-time decision-making, particularly in urban or technologically advanced contexts. Meanwhile, keywords such as "water governance", "ecosystem services", and "river basin management" underscore the continued relevance of water systems as a focal point in adaptive governance research. Collectively, the keyword landscape reflects a diverse, evolving, and increasingly interconnected body of knowledge that spans ecological, technological, institutional, and participatory dimensions.

RQ5: What are the Co-authorship by Countries' Collaboration?

The bibliometric data from VOSviewer highlights the global distribution of scholarly contributions to adaptive governance for natural resources management (refer to Figure 6 and Table 6). The United States leads significantly with 261 documents, 6,373 citations, and a total link strength of 76, underlining its dominant influence in shaping the field. This is followed by Germany, with 47 documents and an impressive 4,962 citations, indicating that German publications are highly cited and influential despite having a smaller document count. The United Kingdom also ranks highly with 66 documents and 2,186 citations, backed by a strong link strength of 43, reflecting active collaboration and integration in the international research network.

Figure 6: Network Visualization Map of Keywords' Citation by Country

Table 6: Total Link Strength Keywords' Citation by Country

No.	Country	Documents	Citations	Total Link Strength
1.	United States	261	6373	76
2.	China	101	1212	30
3.	United Kingdom	66	2186	43
4.	Australia	64	1948	24
5.	Germany	47	4962	35
6.	Canada	46	1228	30
7.	Netherlands	33	1895	29
8.	Spain	30	701	23
9.	India	29	180	9
10.	France	26	179	20

China stands out with the second-highest number of documents (101) but a comparatively modest citation count (1,212), indicating a substantial research output that is still gaining global influence. Countries such as Australia (64 documents, 1,948 citations), Canada (46 documents, 1,228 citations), and the Netherlands (33 documents, 1,895 citations) also emerge as key contributors, with high citation impact and strong link strengths, indicating their prominent role in advancing and disseminating adaptive governance research. Meanwhile, Sweden and South Africa, despite having fewer documents, display strong citation performance and link strength, suggesting focused yet impactful contributions.

Several developing or smaller research economies, such as India, Indonesia, Malaysia, and Bangladesh, exhibit growing participation, albeit with lower citation counts and less network integration. Their involvement signals an expanding interest in adaptive governance across diverse environmental and socio-political contexts, particularly in the Global South. However, their lower link strength suggests opportunities for increased international collaboration to amplify their contributions and visibility. Overall, the data reflect a globally diverse yet asymmetrical research landscape, with a core group of Western countries driving much of the discourse. At the same time, emerging contributors gradually increase their influence in this important area.

Conclusion

The purpose of this bibliometric study was to analyze the research landscape of adaptive governance for natural resource management, focusing on publication trends, influential works, dominant themes, and the geographic distribution of scholarly contributions. The analysis was driven by the need to clarify the conceptual structure and intellectual progress within a rapidly evolving and interdisciplinary field. Using a dataset of 832 documents retrieved from the Scopus database, the study employed Scopus Analyzer, OpenRefine, and VOSviewer tools to examine bibliometric indicators and generate visual representations of research networks and thematic clusters.

The results highlight several important patterns. A steady increase in publication output was observed from 2015 to 2024, peaking in 2023, reflecting the rising academic interest in adaptive governance as a response to complex environmental challenges. The most cited publications identified foundational work on adaptive capacity and institutional learning, underscoring the theoretical significance of the field. Key themes included adaptive

management, climate change, water governance, and institutional resilience. Countries such as the United States, Germany, and the United Kingdom emerged as leading contributors, with strong citation performance and network connectivity, indicating their central roles in advancing the discourse.

This study contributes to the understanding of adaptive governance by mapping its bibliometric profile and highlighting areas of concentrated research activity. It provides a structured overview that can guide scholars in identifying influential research, potential collaborators, and emerging areas of interest. The findings also have practical relevance for policymakers and practitioners seeking to design flexible, inclusive, and evidence-based governance strategies. However, limitations exist, including language restrictions and the exclusive use of Scopus as a data source. Future research could expand the scope by incorporating additional databases, exploring grey literature, and analyzing longitudinal shifts in policy implementation. Overall, this bibliometric analysis highlights the importance of adaptive governance and provides a foundational reference for further exploration in this critical domain.

Acknowledgements

References

Al-Khoury, A., Hussein, S. A., Abdulwhab, M., Aljuboori, Z. M., Haddad, H., Ali, M. A., Abed, I. A., & Flayyih, H. H. (2022). Intellectual Capital History and Trends: A Bibliometric Analysis Using Scopus Database. *Sustainability (Switzerland)*, *14*(18). https://doi.org/10.3390/su141811615

Aleu, R. B., Larsen, R. K., & Methner, N. (2022). Participation and marginalization in water governance: probing the agency of powerholders. *Ecology and Society*. https://doi.org/10.5751/es-13680-270433

Allen, C. R., & Garmestani, A. S. (2015). Adaptive management. In *Adaptive Management of Social-Ecological Systems* (pp. 1–10). Springer Netherlands. https://doi.org/10.1007/978-94-017-9682-8_1

Alves, J. L., Borges, I. B., & De Nadae, J. (2021). Sustainability in complex projects of civil construction: Bibliometric and bibliographic review. *Gestao e Producao*, *28*(4). https://doi.org/10.1590/1806-9649-2020v28e5389

Appio, F. P., Cesaroni, F., & Di Minin, A. (2014). Visualizing the structure and bridges of the intellectual property management and strategy literature: a document co-citation analysis. *Scientometrics*, *101*(1), 623–661. https://doi.org/10.1007/s11192-014-1329-0

Assyakur, D. S., & Rosa, E. M. (2022). Spiritual Leadership in Healthcare: A Bibliometric Analysis. *Jurnal Aisyah : Jurnal Ilmu Kesehatan*. https://doi.org/10.30604/jika.v7i2.914

Crona, B. I., & Parker, J. N. (2012). Learning in support of governance: Theories, methods, and a framework to assess how bridging organizations contribute to adaptive resource governance. *Ecology and Society*, *17*(1). https://doi.org/10.5751/ES-04534-170132

Davies, A. L., & White, R. M. (2012). Collaboration in natural resource governance: Reconciling stakeholder expectations in deer management in Scotland. *Journal of*

Environmental Management, *112*, 160–169. https://doi.org/10.1016/j.jenvman.2012.07.032

Deitch, M. J., Gancel, H. N., Croteau, A. C., Caffrey, J. M., Scheffel, W., Underwood, B., Muller, J. W., Boudreau, D., Cantrell, C. G., Posner, M. J., Bibza, J., McDowell, A., & Albrecht, B. (2021). Adaptive management as a foundational framework for developing collaborative estuary management programs. *Journal of Environmental Management*, *295*. https://doi.org/10.1016/j.jenvman.2021.113107

di Stefano, G., Peteraf, M., & Veronay, G. (2010). Dynamic capabilities deconstructed: A bibliographic investigation into the origins, development, and future directions of the research domain. *Industrial and Corporate Change*, *19*(4), 1187–1204. https://doi.org/10.1093/icc/dtq027

Dreiss, L. M., Hessenauer, J.-M., Nathan, L. R., O'Connor, K. M., Liberati, M. R., Kloster, D. P., Barclay, J. R., Vokoun, J. C., & Morzillo, A. T. (2017). Adaptive Management as an Effective Strategy: Interdisciplinary Perceptions for Natural Resources Management. *Environmental Management*, *59*(2), 218–229. https://doi.org/10.1007/s00267-016-0785-0

Engle, N. L., & Lemos, M. C. (2010). Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil. *Global Environmental Change*, *20*(1), 4–13. https://doi.org/10.1016/j.gloenvcha.2009.07.001

Fahimnia, B., Sarkis, J., & Davarzani, H. (2015). Green supply chain management: A review and bibliometric analysis. In *International Journal of Production Economics* (Vol. 162, pp. 101–114). https://doi.org/10.1016/j.ijpe.2015.01.003

Gu, D., Li, T., Wang, X., Yang, X., & Yu, Z. (2019). Visualizing the intellectual structure and evolution of electronic health and telemedicine research. *International Journal of Medical Informatics*, *130*. https://doi.org/10.1016/j.ijmedinf.2019.08.007

Gunderson, L. H., Cosens, B., & Garmestani, A. S. (2016). Adaptive governance of riverine and wetland ecosystem goods and services. *Journal of Environmental Management*, *183*, 353–360. https://doi.org/10.1016/j.jenvman.2016.05.024

Heurkens, E. (2012). Private Sector-led Urban Development Projects. Management, Partnerships and Effects in the Netherlands and the UK. *Architecture and the Built Environment*. https://doi.org/10.59490/abe.2012.4.820

Hill, R., Williams, K. J., Pert, P. L., Robinson, C. J., Dale, A. P., Westcott, D. A., Grace, R. A., & O'Malley, T. (2010). Adaptive community-based biodiversity conservation in Australia's tropical rainforests. *Environmental Conservation*, *37*(1), 73–82. https://doi.org/10.1017/S0376892910000330

Huitema, D., Mostert, E., Egas, W., Moellenkamp, S., Pahl-Wostl, C., & Yalcin, R. (2009). Adaptive water governance: Assessing the institutional prescriptions of adaptive (co-)management from a governance perspective and defining a research agenda. *Ecology and Society*, *14*(1). https://doi.org/10.5751/ES-02827-140126

Khiste, G. P., & Paithankar, R. R. (2017). Analysis of Bibliometric term in Scopus. *International Research Journal*, *01*(32), 78–83.

Lempert, R. J., & Groves, D. G. (2010). Identifying and evaluating robust adaptive policy responses to climate change for water management agencies in the American west. *Technological Forecasting and Social Change*, *77*(6), 960–974. https://doi.org/10.1016/j.techfore.2010.04.007

Månsson, J., Eriksson, L., Hodgson, I., Elmberg, J., Bunnefeld, N., Hessel, R., Johansson, M., Liljebäck, N., Nilsson, L., Olsson, C., Pärt, T., Sandström, C., Tombre, I., & Redpath, S. M. (2023). Understanding and overcoming obstacles in adaptive management.

Trends in Ecology and Evolution, *38*(1), 55–71.
https://doi.org/10.1016/j.tree.2022.08.009

McLoughlin, C. A., & Thoms, M. C. (2015). Integrative learning for practicing adaptive resource management. *Ecology and Society*, *20*(1). https://doi.org/10.5751/ES-07303-200134

Moore, C. T., Shaffer, T. L., & Gannon, J. J. (2013). Spatial education: Improving conservation delivery through space-structured decision making. *Journal of Fish and Wildlife Management*, *4*(1), 199–210. https://doi.org/10.3996/082012-JFWM-069

Muller, M. (2012). Water management institutions for more resilient societies. *Proceedings of the Institution of Civil Engineers: Civil Engineering*. https://doi.org/10.1680/cien.11.00067

Musavengane, R. (2019). Using the systemic-resilience thinking approach to enhance participatory collaborative management of natural resources in tribal communities: Toward inclusive land reform-led outdoor tourism. *Journal of Outdoor Recreation and Tourism*. https://doi.org/10.1016/j.jort.2018.12.002

Okumu, B., Kehbila, A. G., & Osano, P. (2021). A review of water-forest-energy-food security nexus data and assessment of studies in East Africa. *Current Research in Environmental Sustainability*. https://doi.org/10.1016/j.crsust.2021.100045

Pahl-Wostl, C. (2007). Transitions towards adaptive management of water facing climate and global change. *Water Resources Management*, *21*(1), 49–62. https://doi.org/10.1007/s11269-006-9040-4

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

Pahl-Wostl, C., Lebel, L., Knieper, C., & Nikitina, E. (2012). From applying panaceas to mastering complexity: Toward adaptive water governance in river basins. *Environmental Science and Policy*, *23*, 24–34. https://doi.org/10.1016/j.envsci.2012.07.014

Pahl-Wostl, C., Sendzimir, J., Jeffrey, P., Aerts, J., Berkamp, G., & Cross, K. (2007). Managing change toward adaptive water management through social learning. *Ecology and Society*, *12*(2). https://doi.org/10.5751/ES-02147-120230

Sandström, A. (2011). Social networks, joint image building, and adaptability: The case of local fishery management. In *Social Networks and Natural Resource Management: Uncovering the Social Fabric of Environmental Governance*. https://doi.org/10.1017/CBO9780511894985.013

Schoon, M., York, A., Sullivan, A., & Baggio, J. (2017). The emergence of an environmental governance network: the case of the Arizona borderlands. *Regional Environmental Change*. https://doi.org/10.1007/s10113-016-1060-x

Shojafar, M., Cordeschi, N., & Baccarelli, E. (2019). Energy-Efficient Adaptive Resource Management for Real-Time Vehicular Cloud Services. *IEEE Transactions on Cloud Computing*, *7*(1), 196–209. https://doi.org/10.1109/TCC.2016.2551747

Spooner, E., Karnauskas, M., Harvey, C. J., Kelble, C., Rosellon-Druker, J., Kasperski, S., Lucey, S. M., Andrews, K. S., Gittings, S. R., Moss, J. H., Gove, J. M., Samhouri, J. F., Allee, R. J., Bograd, S. J., Monaco, M. E., Clay, P. M., Rogers, L. A., Marshak, A., Wongbusarakum, S., … Lynch, P. D. (2021). Using Integrated Ecosystem Assessments to Build Resilient Ecosystems, Communities, and Economies. *Coastal Management*. https://doi.org/10.1080/08920753.2021.1846152

Tompkins, E. L., & Adger, W. N. (2004). Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society*, *9*(2). https://doi.org/10.5751/ES-00667-090210

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*. https://doi.org/10.1007/s11192-009-0146-3

van Eck, N. J., & Waltman, L. (2017). Citation-based clustering of publications using CitNetExplorer and VOSviewer. *Scientometrics*. https://doi.org/10.1007/s11192-017-2300-7

Van Eck, N. J., & Waltman, L. (2007). Bibliometric mapping of the computational intelligence field. *International Journal of Uncertainty, Fuzziness and Knowldege-Based Systems*, *15*(5), 625–645. https://doi.org/10.1142/S0218488507004911

Verbeek, A., Debackere, K., Luwel, M., & Zimmermann, E. (2002). Measuring progress and evolution in science and technology - I: The multiple uses of bibliometric indicators. *International Journal of Management Reviews*, *4*(2), 179–211. https://doi.org/10.1111/1468-2370.00083

Walch, C. (2019). Adaptive governance in the developing world: disaster risk reduction in the State of Odisha, India. *Climate and Development*. https://doi.org/10.1080/17565529.2018.1442794

Williams, B. K. (2011). Adaptive management of natural resources-framework and issues. *Journal of Environmental Management*, *92*(5), 1346–1353. https://doi.org/10.1016/j.jenvman.2010.10.041

Williams, B. K., & Brown, E. D. (2016). Technical challenges in the application of adaptive management. *Biological Conservation*, *195*, 255–263. https://doi.org/10.1016/j.biocon.2016.01.012

Wittmayer, J. M., Schäpke, N., Wiek, A., Ness, B., Schweizer-Ries, P., Brand, F. S., Farioli, F., Van Kerkhoff, L. E., Lebel, L., Tschakert, P., Tuana, N., Westskog, H., Koelle, B., Afrika, A., Spangenberg, J. H., Seidl, R., Brand, F. S., Stauffacher, M., Krütli, P., … Walmsley, D. (2014). Structuring sustainability science. *Sustainability Science*.

Wu, Y. C. J., & Wu, T. (2017). A decade of entrepreneurship education in the Asia Pacific for future directions in theory and practice. In *Management Decision* (Vol. 55, Issue 7, pp. 1333–1350). https://doi.org/10.1108/MD-05-2017-0518