SRSD
Spatial Review for Sustainable Development
SRSD 3(1): 53–70
ISSN 3062-8229

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

Mapping global research dynamics on climate change and land use land cover change: A bibliometric analysis using R studio

Maisuna Kundariati[1,*], Dea Fajria Tatarizqa Japal[2]
[1] *Department of Biology, Faculty of Mathematics and Sciences, Universitas Negeri Malang, Malang, East Java 65145, Indonesia;*
[2] *Sustainable Finance Program, Faculty of Economics and Business, Universitas Islam International Indonesia, Depok, West Java 16425, Indonesia.*
*Correspondence: maisunakundariati@gmail.com

Received Date: December 20, 2025 Revised Date: February 26, 2026 Accepted Date: February 27, 2026

ABSTRACT

Background: Land use and land cover change (LULC) has emerged as one of the most critical environmental issues influencing global climate change. Rapid urbanization, deforestation, and agricultural expansion have transformed landscapes, altering carbon cycles and ecosystem services. Previous studies have explored the links between LULC and climate change, yet global trends, research patterns, and thematic focuses remain fragmented. This study aims to map and analyze the global research trends on land use change and its relationship with climate change using a bibliometric approach. **Methods:** This study employed bibliometric analysis using data extracted from the Scopus database, focusing on publications related to land use change and climate change. The analysis utilized R Studio and bibliometric mapping techniques to identify key research themes, co-occurrence of keywords, and geographic distribution of publications. Theoretical support was drawn from the concepts of sustainable land management and ecosystem-based adaptation. **Findings:** The results indicate that "land use change," "climate change," "land cover," and "remote sensing" are dominant research themes, reflecting the strong integration between geospatial analysis and environmental assessment. China appears as the most frequently studied region, indicating its central role in global LULC research. Other prominent themes include "ecosystem services," "urbanization," "watersheds," and "sustainable development," suggesting that current research increasingly integrates ecological and socio-economic perspectives. The findings also highlight a growing shift toward interdisciplinary studies combining spatial analysis, environmental modeling, and policy evaluation. **Conclusion:** The study concludes that global research on LULC and climate change is expanding toward integrative, data-driven, and solution-oriented approaches. Strengthening collaboration between countries and linking scientific findings to policy implementation are essential to address climate and land transformation challenges effectively. **Novelty/Originality of this article:** This article provides a comprehensive bibliometric synthesis of global LULC–climate change research, revealing emerging hotspots, dominant themes, and geographical focus areas. The study uniquely integrates spatial and conceptual mapping to highlight research gaps and directions for future interdisciplinary collaboration.

KEYWORDS: bibliometrix; climate change; land use land cover change.

1. Introduction

Climate change has been widely occurring in world regions. It is driven by rising global temperatures resulting from human activities, which have brought the planet to a critical state (Baldwin et al., 2022; Zhu et al., 2023). Climate change can threaten food safety

Cite This Article:
Kundariati, M., & Japal, D. F. T. (2026). Mapping global research dynamics on climate change and land use land cover change: A bibliometric analysis using R studio. *Spatial Review for Sustainable Development*, *3*(1), 53-70. https://doi.org/10.61511/srsd.v3i1.2026.3186

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(Duchenne-Moutien & Neetoo, 2021), impacting on agriculture sector (Dossa et al., 2024), rising poverty rates, social inequality (Dang et al., 2024), and biodiversity loss (Godfrey & Tunhuma, 2020). While Intergovernmental Panel on Climate Change (IPCC) reports predict global food shortages, coastal city flooding, and a refugee crisis unprecedented in history, critics argue that these documents fail to account for the economic costs of extreme weather events, as well as the displacement of people, among other factors that may exacerbate future climate scenarios (García Vinuesa et al., 2022). Human activities such as deforestation and land use change (Evseeva et al., 2021; Hermosilla-Palma et al., 2021), thereby increasing the concentration of CO_2 gas in the atmosphere.

Land use and land cover change (LULC) has intensified rapidly over recent decades, especially in tropical regions (Velastegui-Montoya et al., 2022), This accelerating transformation poses serious environmental risks, including biodiversity loss, ecosystem degradation, and increased carbon emissions (Gitima et al., 2025). However, beyond its environmental impact, LULC reflects complex economic and policy-driven intentions (Yang et al., 2023), ranging from industrial expansion to energy production (Yadem Lamien & Farzaneh, 2025) and urban development (Karimi & Sultana, 2024). Understanding current research trends and the underlying motives behind LULC is therefore urgent to ensure that land conversion aligns with sustainable development goals. By integrating spatial data analysis with socioeconomic perspectives, researchers can uncover not only where LULC occurs but also why it happens, providing essential insight for climate action and land management strategies.

Climate change has become one of the most extensively researched global issues of the 21st century (IPCC, 2023). Scholars from environmental science, economics, sociology, and education increasingly recognize climate change not only as an environmental phenomenon but also as a multidimensional challenge that affects human well-being, resource distribution, and sustainable development (Adger et al., 2022). This rapid growth in research reflects the global urgency to understand and address the causes, consequences (Hassan, 2024), and potential solutions to a problem that transcends national and disciplinary boundaries (Feigin et al., 2023). Research on climate change encompasses a wide range of topics, from atmospheric (Dib, 2011) and oceanic processes (Qiao et al., 2025) to human-induced factors such as fossil fuel combustion, industrial activities, and land use transformation (Trenberth, 2018). Scientists investigate how greenhouse gas emissions contribute to global warming (Bhatti et al., 2024), while social researchers explore adaptation, policy responses, and public awareness (Calculli et al., 2021). The complexity of climate change demands interdisciplinary collaboration to integrate physical, biological, and social dimensions (Qiu et al., 2024). Such diversity in research perspectives allows for a more holistic understanding of the issue, enabling the development of comprehensive mitigation and adaptation strategies that are both scientifically sound and socially equitable.

Given the vast and growing body of literature on climate change, it is increasingly important to map the evolution of research trends, themes, and collaborations within this field. Bibliometric approaches provide valuable tools to analyze the dynamics of scientific production, identify influential works and emerging topics, and reveal how global attention shifts in response to policy changes or environmental crises (Yumnam et al., 2024). Understanding these patterns helps researchers and policymakers to recognize knowledge gaps, prioritize funding, and strengthen international cooperation. Ultimately, tracing the trajectory of climate change research contributes to more informed decision-making and the advancement of sustainable solutions for a rapidly changing planet.

Land Use and Land Cover Change (LULC) is widely recognized as one of the major drivers of climate change (Tilahun et al., 2025), mainly because it affects the global carbon cycle and alters the energy and water balances within terrestrial ecosystems. Land cover changes, such as deforestation, agricultural expansion, urbanization, and infrastructure development contribute substantially to the release of greenhouse gases, particularly carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), into the atmosphere (Srivastava, 2025). These emissions result from both direct processes, such as biomass

burning and soil disturbance, and indirect mechanisms, including reduced carbon sequestration capacity due to vegetation loss (Alang & Aggarwal, 2024). This is particularly concerning because forests play a crucial role in storing large amounts of carbon, acting as significant natural sinks that help regulate the global carbon balance (Kundariati et al., 2024).

In tropical regions, large-scale conversion of forests into agricultural or plantation areas has become one of the most critical contributors to global carbon emissions (Sugiarto et al., 2024). For instance, tropical deforestation in countries like Indonesia and Brazil accounts for a substantial share of anthropogenic CO_2 emissions. Beyond the carbon dimension, LULC also modifies the Earth's albedo, evapotranspiration rates, and surface temperature, further intensifying regional and global climate feedbacks (Patle & Ghuge, 2025). Moreover, LULC interacts with socio-economic systems, driven by population growth, market demand, and policy interventions, creating complex feedback loops between human activities and environmental change. As such, understanding LULC dynamics is essential not only for quantifying its contribution to climate change but also for designing effective mitigation and adaptation strategies. Accurate mapping, long-term monitoring, and spatial modeling of LULC trends are thus critical to support evidence-based policymaking and sustainable land management in the face of accelerating climate challenges.

Tackling climate change is a key global challenge, and arguably, knowledge the causes and consequences of climate change, as well as the possible solutions, needs to be included in formal education. As climate change has come to the forefront of public attention, educational efforts have also intensified, meaning that tracking the development of international publication and providing an overview of trends in climate change research can be highly informative. RQ1. How has the annual growth of publications on climate change and land-use/land-cover (LULC) research progressed over the past two decades? RQ2. Which countries contribute most to climate change–LULC research, and how has their publication productivity changed over time? RQ3. What major research themes characterize climate change–LULC studies, and how have these themes evolved across different time periods?

2. Methods

To identify relevant studies, we developed a comprehensive search string that included terms referring to climate change and land use or land cover change. The search strategy was guided by previous bibliometric analyses and systematic reviews focusing on global environmental change research (e.g., Aria et al., 2020; Mongeon & Paul-Hus, 2016). Accordingly, we used the following search string: ALL(("climate change" AND ("land use/land cover change" OR "LULC" OR "LUCC"))) AND (LIMIT-TO (SUBJAREA,"ENVI")) AND (LIMIT-TO (DOCTYPE,"ar")) AND (LIMIT-TO (PUBSTAGE,"final")) AND (LIMIT-TO (EXACTKEYWORD,"Climate Change") OR LIMIT-TO (EXACTKEYWORD,"Land Use") OR LIMIT-TO (EXACTKEYWORD,"Land Use Change")) AND (LIMIT-TO (SRCTYPE,"j")) AND (LIMIT-TO (LANGUAGE,"English")) AND (LIMIT-TO (OA,"all")) AND PUBYEAR > 2015 AND PUBYEAR < 2026. This search string was applied to the *titles*, *abstracts*, and *keywords* of publications indexed in the Web of Science Core Collection, which is widely recognized as one of the most reliable databases for high-quality scientific literature (Aria & Cuccurullo, 2017).

The search was conducted on October 13th 2025 and initially yielded 15.335 records. We included only English-language scientific articles published from 2015 to 2025, representing the post–Paris Agreement period when global research on climate change and land-use dynamics significantly accelerated in response to international climate policy commitments. Non-scientific items such as editorials, conference abstracts, letters, or news articles were excluded. Furthermore, we filtered out records unrelated to environmental or sustainability research areas. After applying these exclusion criteria, a total of 4017 records were retained for inclusion in the bibliometric analysis.

2.1 Bibliometric method as analytical tools

Bibliometric studies enable the exploration of a research field from a quantitative perspective, taking into account key themes, influential publications, authors, institutions, and contributing countries. The systematic examination of scientific literature in a particular research domain has gained significant importance with the advancement of research databases and the development of quantitative methods that allow automatic analysis of large bodies of literature (Kraus et al., 2022). Bibliometric analysis has become a common approach to investigating the evolution and structure of scientific knowledge within a specific discipline, revealing connections between research clusters, identifying influential scholars, and tracing the intellectual and conceptual development of a field (Martinez-Garcia et al., 2023). Moreover, it helps identify emerging research trends and innovative approaches that are shaping the future direction of a discipline (Benomar et al., 2022).

Given that journal articles serve as a major formal channel of communication among scientists, bibliometric analysis provides valuable insights into the historical development, collaboration patterns, and state-of-the-art progress within a research domain (Lim et al., 2024). While previous bibliometric studies have analyzed climate change-related themes such as adaptation, mitigation, and ecosystem impacts (Li et al., 2024; Setiawan et al., 2023; Westphal et al., 2025), or the bibliometric research focuses only on LULC (Afuye et al., 2024). Despite, few have specifically focused on the intersection between climate change and land use/land cover change (LULC), two interlinked processes that critically influence global environmental dynamics (Barati et al., 2023; Tilahun et al., 2025). Therefore, the present study employs bibliometric methods using R software to map global research trends, thematic evolution, and collaboration networks related to climate change and LULC from 2000 to 2025. The goal is to provide a comprehensive understanding of existing research patterns, highlight major thematic areas, and identify emerging knowledge gaps that warrant future investigation.

3. Results and Discussion

3.1 Annual growth of publications on climate change and LULC

The figure 1 illustrates the trend of published scientific articles between 2015 to 2025. Overall, the graph shows a steady increase in research productivity over the years, indicating a growing interest and engagement in the field. Between 2015 and 2019, the increase in publications was gradual, suggesting that research in this area was still developing or gaining momentum. A sharp rise occurred from 2020 to 2024, reflecting a period of significant expansion in scientific output, possibly driven by increased global attention, research funding, or collaborative initiatives. However, in 2025, the number of publications declined compared to the previous year, which may indicate a temporary slowdown, a shift in research focus, or delays in publication processes. Despite this recent drop, the overall pattern demonstrates a strong upward trajectory in scientific production over the decade, highlighting the field's growing relevance and impact.

This result shows a markedly increasing trajectory, underscoring the rising importance of this research field over the past decade. The gradual growth observed between 2015 and 2019 suggests that the field was in an early developmental phase, slowly attracting scholarly attention and building foundational research. The sharp increase from 2020 onward likely reflects a convergence of factors, including heightened global awareness of environmental issues, improved access to geospatial technologies, and increased funding for climate- and land-related studies. This surge may also be associated with the expansion of interdisciplinary collaborations, which have broadened the scope and scale of research outputs. Although the decline in publications in 2025 indicates a temporary fluctuation, potentially due to delays in the publication cycle, shifting research agendas, or incomplete indexing, it does not diminish the overall upward momentum. Taken together, the decade-

long pattern demonstrates a strong and steady advancement of scientific interest, signaling that this research area has become increasingly relevant for informing policy, guiding land management, and addressing broader sustainability challenges.

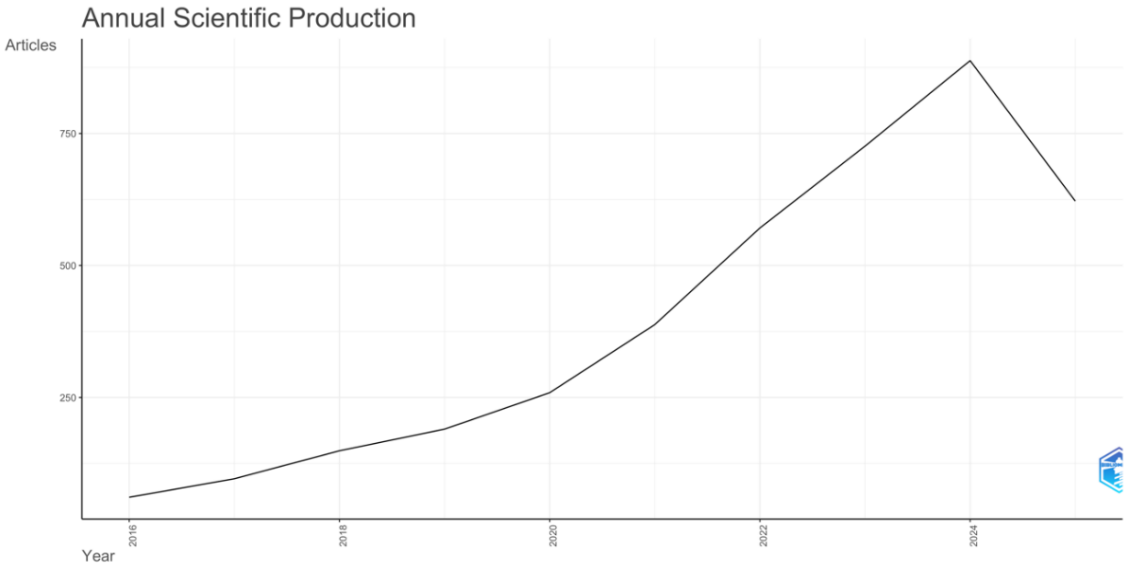


Fig. 1. Publication trend annually

3.2 Country scientific production

The country scientific production map reveals a clear geographical disparity in climate change–LULC research output. China leads global scientific production, followed by the United States, India, Brazil, and several European nations, reflecting strong research capacity and investment in environmental studies. Moderate contributions are observed in Southeast Asia and parts of Africa, indicating growing but uneven engagement in this field. The dominance of Asian and Western countries suggests that much of the current knowledge is generated in regions with advanced remote-sensing infrastructure and climate research funding, highlighting the need for broader international collaboration and data sharing to address region-specific land-use and climate challenges.

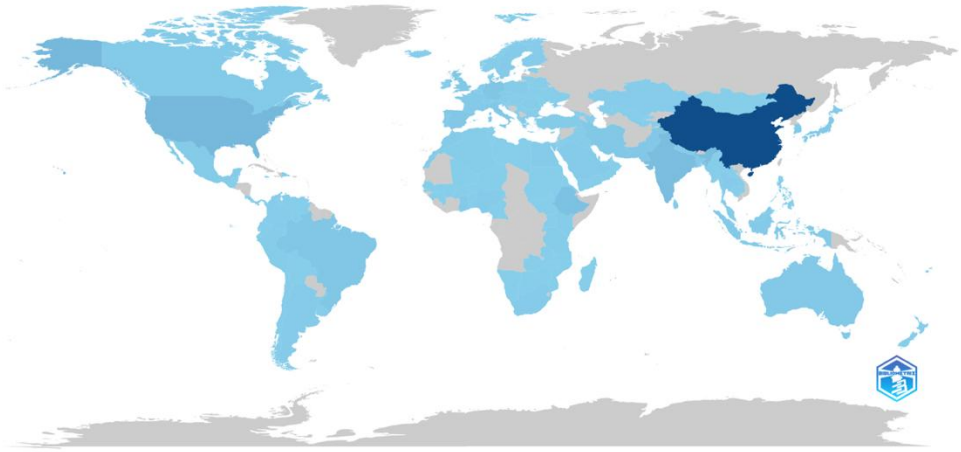


Fig. 2. Publication trend based on country scientific production

This result highlights significant geographical disparities in climate change–LULC research output. China emerges as the leading contributor, followed by the United States, India, Brazil, and several European countries, reflecting strong research capacity, technological infrastructure, and sustained investment in environmental science. In

contrast, Southeast Asia and parts of Africa show moderate but uneven contributions, indicating increasing interest yet limited resources or access to advanced geospatial tools. The concentration of scientific output in Asian and Western nations suggests that much of the existing knowledge is shaped by regions with robust research funding and remote-sensing capabilities. This imbalance underscores the need for more inclusive international collaboration, capacity-building efforts, and data-sharing initiatives to ensure that diverse regional land-use and climate challenges are adequately represented and addressed in the global research landscape.

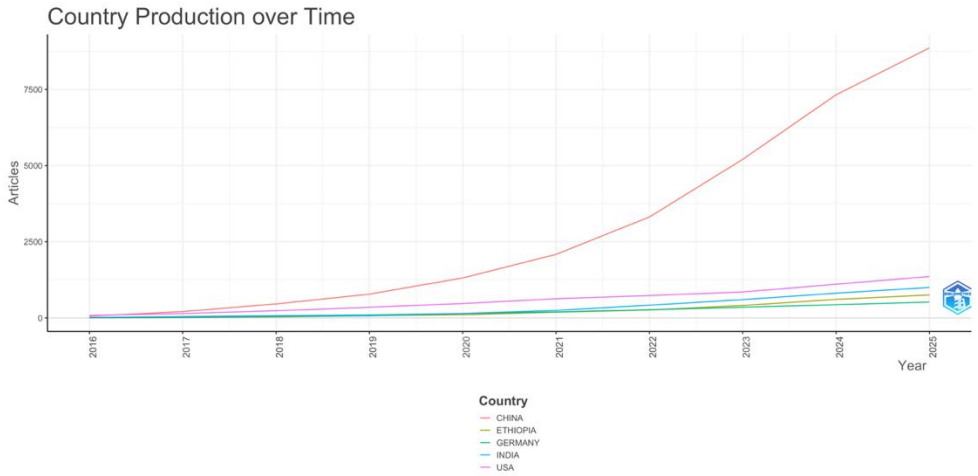


Fig. 3. Publication trend by country production over time

The temporal distribution of publications shows a substantial rise in global scientific output on climate change–LULC topics from 2016 to 2025. China exhibits the most rapid growth, surpassing all other countries since 2020, reflecting major national investments in climate and land-use research. The United States, India, and Germany maintain steady contributions, while Ethiopia's recent increase highlights growing research participation from developing regions. The overall upward trajectory across countries indicates heightened awareness of LULC's role in climate processes and the integration of remote sensing, modeling, and sustainability perspectives into global climate research agendas.

This result reveals a strong and accelerating global engagement with climate change–LULC research between 2016 and 2025. China shows the most pronounced growth, surpassing all other countries after 2020—an outcome that aligns with its substantial national investments in environmental monitoring, climate policy, and land-use planning. The steady contributions from the United States, India, and Germany demonstrate sustained research capacity in long-established scientific hubs, while the emerging rise of Ethiopia signals increasing participation from developing regions. Collectively, these trends reflect heightened global recognition of LULC's critical role in climate dynamics and the expanding use of remote sensing, spatial modeling, and sustainability frameworks within climate-related research. The upward trajectory across countries underscores a broadening international commitment to understanding and addressing land-use and climate interactions.

3.3 Research topic and themes: Thematic map and keywords growth

Keyword analysis shows that land use, land use change, climate change, and land cover are the most dominant terms, highlighting the central focus on land transformation processes and their environmental consequences. The frequent appearance of remote sensing and spatiotemporal analysis indicates the growing role of geospatial technology and data-driven modeling in assessing LULC dynamics. Keywords such as ecosystem services, watersheds, and urbanization further suggest interdisciplinary linkages among ecology, hydrology, and urban planning. Overall, the prominence of these keywords reflects an

integrated research trend that combines land-based analysis with climate change mitigation and adaptation perspectives.

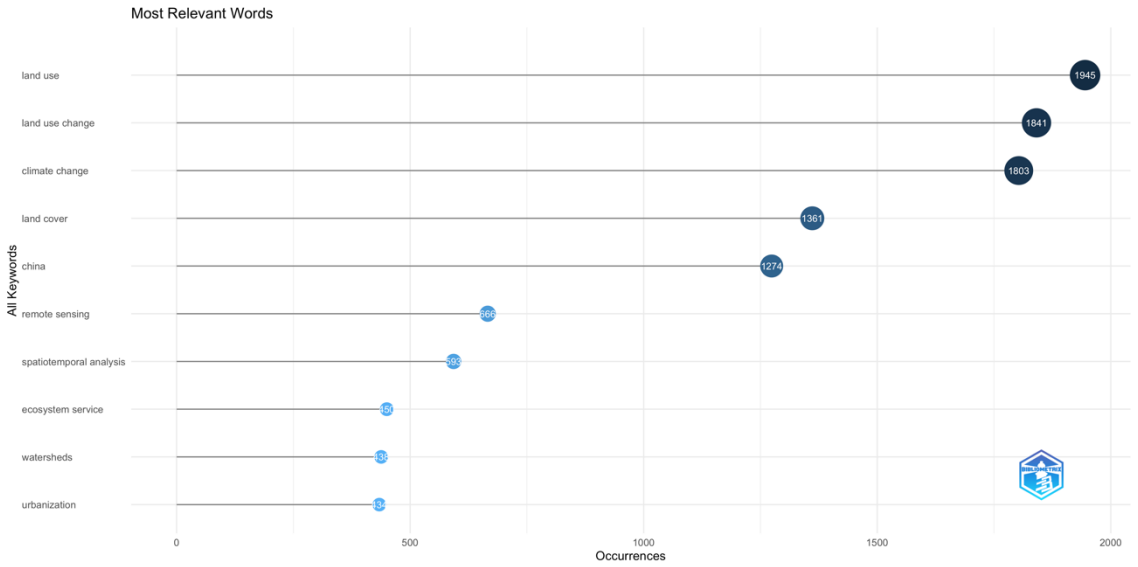


Fig. 4. Publication trend by most relevant words

The result highlights land use, land use change, climate change, and land cover as the most dominant terms, underscoring the strong research emphasis on understanding land transformation and its environmental implications. The prominence of remote sensing and spatiotemporal analysis reflects the increasing reliance on geospatial technologies and data-driven models to monitor and evaluate LULC patterns. Meanwhile, keywords such as ecosystem services, watersheds, and urbanization reveal the interdisciplinary nature of current research, linking ecological processes, hydrological systems, and urban development. Overall, the distribution of keywords indicates a growing integration of land-based assessments with climate change mitigation and adaptation frameworks, demonstrating a shift toward more holistic and cross-sectoral approaches in LULC research.



Fig. 5. Research trend based on the cloud there

The word-cloud analysis shows that land use change and climate change dominate current scholarly discussions, reflecting a strong integration of these two fields. Researchers increasingly recognize that landscape transformations, whether through urban expansion, deforestation, or agricultural intensification, play a significant role in shaping global climate processes. The frequent appearance of land cover and land use reinforces this

connection, highlighting continued efforts to understand how physical shifts in the environment interact with human decisions and policy interventions. Together, these keywords emphasize the need for integrated frameworks that evaluate land dynamics as both drivers and consequences of climate variability (Zhu et al., 2022).

A notable result is the prominence of China as a major geographic focus, indicating the country's central role in shaping global research trends. China's rapid urbanization, extensive land reforms, and large-scale restoration programs provide a unique setting for studying human–environment interactions at multiple scales. Its strong publication output further reinforces its influence on the field. As such, many contemporary insights into land-system change and climate impacts emerge from Chinese case studies, making the region a pivotal reference point for comparative and global analyses. The strong presence of technological terms such as remote sensing and spatiotemporal analysis demonstrates how the field has become increasingly data-driven and methodologically sophisticated. These tools enable precise monitoring of landscape changes, improved modeling of long-term trends, and deeper exploration of climate–land relationships across local, regional, and global scales. Alongside these methods, keywords such as ecosystem service, urbanization, and sustainable development show that the field is broadening beyond biophysical assessments toward interdisciplinary perspectives. This shift reflects growing interest in linking environmental change to societal outcomes, including urban resilience, resource management, and policy planning aligned with sustainability frameworks.

Finally, the appearance of more specialized terms including watershed, runoff, agricultural land, biodiversity, and environmental protection, signals expanding attention to hydrological processes, agricultural sustainability, and conservation challenges. These keywords suggest that researchers are increasingly focused on understanding not only how landscapes change but also how these changes affect water systems, food production, and ecological resilience. Together, these patterns indicate that the research landscape is moving toward more integrated, multi-scalar, and solution-oriented approaches that bridge environmental monitoring with practical strategies for sustainable land management and climate adaptation (Wu et al., 2025).



Fig. 6. Research trend based on treemap

The tree map visualization highlights the main research themes and emerging trends related to land use and climate change studies. The largest areas i.e., land use, land use change, climate change, and land cover which represent the dominant topics, emphasizing that global research is heavily centered on understanding how changes in land utilization

and cover contribute to or are influenced by climate change dynamics. The prominence of China indicates that the country is a major geographical focus, likely due to its rapid urbanization, agricultural transitions, and large-scale land management policies. Supporting themes such as remote sensing, spatiotemporal analysis, and GIS demonstrate that technological approaches and geospatial data are essential tools for monitoring and analyzing land-use and climate interactions. Meanwhile, ecosystem service, urbanization, runoff, watershed, and agricultural land reflect growing interest in the environmental and hydrological impacts of human activity and land transformation. Other keywords such as biodiversity, sustainability, deforestation, risk assessment, and decision making, indicate a broader movement toward integrating ecological, socio-economic, and policy perspectives. The inclusion of ecosystem services, sustainable development, and environmental protection further suggests that recent research is not only diagnostic but also solution-oriented, focusing on mitigation, adaptation, and sustainable land management strategies. Overall, this treemap reveals that the field is evolving toward an interdisciplinary framework that combines spatial technologies, ecological assessment, and sustainability science to address complex interactions between land-use dynamics and climate change impacts.

The treemap visualization provides a comprehensive overview of the dominant and the treemap visualization shows that research on land use and climate change is dominated by themes such as land use, land use change, climate change, and land cover, reflecting strong global attention to how landscape transformations drive and respond to climate processes (Justino et al., 2025). China's prominence indicates a major geographical focus driven by rapid urbanization and large-scale land management efforts (Zhu et al., 2022). Supporting themes, including remote sensing, GIS, and spatiotemporal analysis which highlight the central role of geospatial technologies in monitoring land dynamics. Emerging interests in ecosystem services, urbanization, watershed processes, and agricultural land point to increasing concern for ecological and hydrological impacts. Broader topics such as biodiversity, sustainability, deforestation, and decision-making demonstrate a shift toward interdisciplinary, solution-oriented approaches. Overall, the field is moving toward integrated frameworks that merge ecological assessment, technological tools, and sustainability science to better understand and manage land-use and climate interactions.

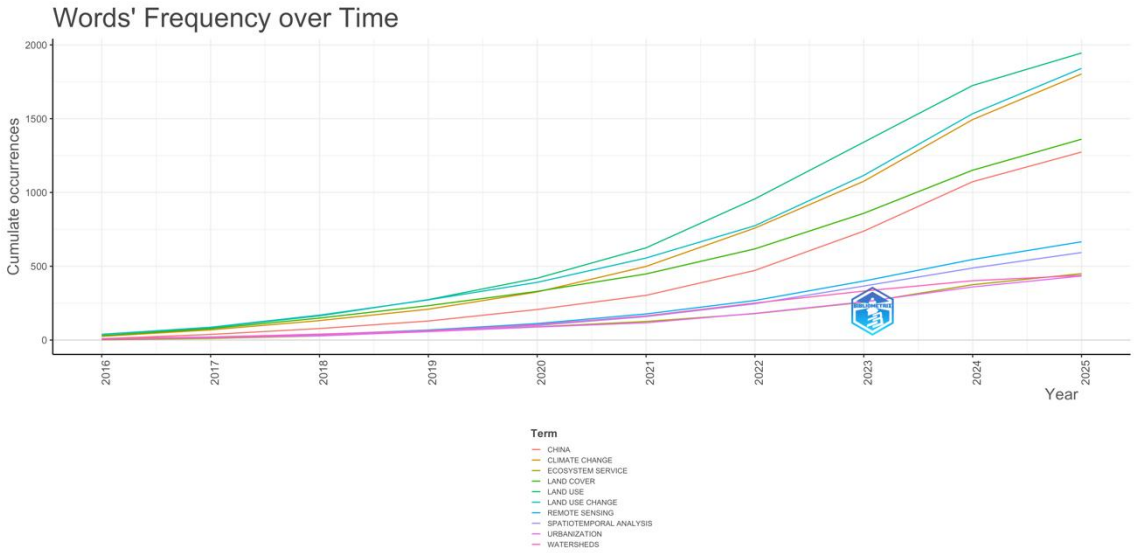


Fig. 7. Research trend based on words frequency over time

The temporal analysis of keyword frequency (2015–2025) reveals a steady increase in publications related to land use change and climate change, signifying their growing interconnection in environmental research. After 2020, these terms exhibit accelerated growth, likely driven by intensified policy attention and advancements in geospatial

monitoring. The consistent rise of land cover, ecosystem services, and China as frequent keywords reflects expanding research on regional dynamics and ecological assessments. Meanwhile, the increasing occurrence of remote sensing and spatiotemporal analysis highlights the reliance on spatial data and modeling to evaluate landscape changes and climate impacts. Collectively, the upward trajectories demonstrate that the LULC–climate research field has matured into a multidisciplinary domain integrating technology, ecology, and sustainability perspectives.

This result indicating their increasing conceptual and practical linkage in environmental studies. The sharp rise after 2020 suggests growing global attention driven by policy agendas, climate commitments, and improved accessibility to geospatial datasets and analytical tools. The steady increase in keywords such as land cover, ecosystem services, and China reflects expanding regional case studies and the heightened focus on ecological assessments within rapidly changing landscapes. At the same time, the sustained growth of remote sensing and spatiotemporal analysis highlights the central role of technological innovation in monitoring and modeling land dynamics. The main advantages of remote sensing are its ability to cover large areas efficiently, enable repeated observations for change monitoring, access difficult-to-reach locations, and save costs compared to traditional field surveys. It provides a synoptic overview, allows for data collection across various scales and resolutions, and can be used for real-time applications in fields like disaster response (Zhu et al., 2022). Overall, these trends demonstrate the maturation of LULC–climate research into a more integrated, multidisciplinary field that blends technological, ecological, and sustainability perspectives to better understand and address global environmental change.

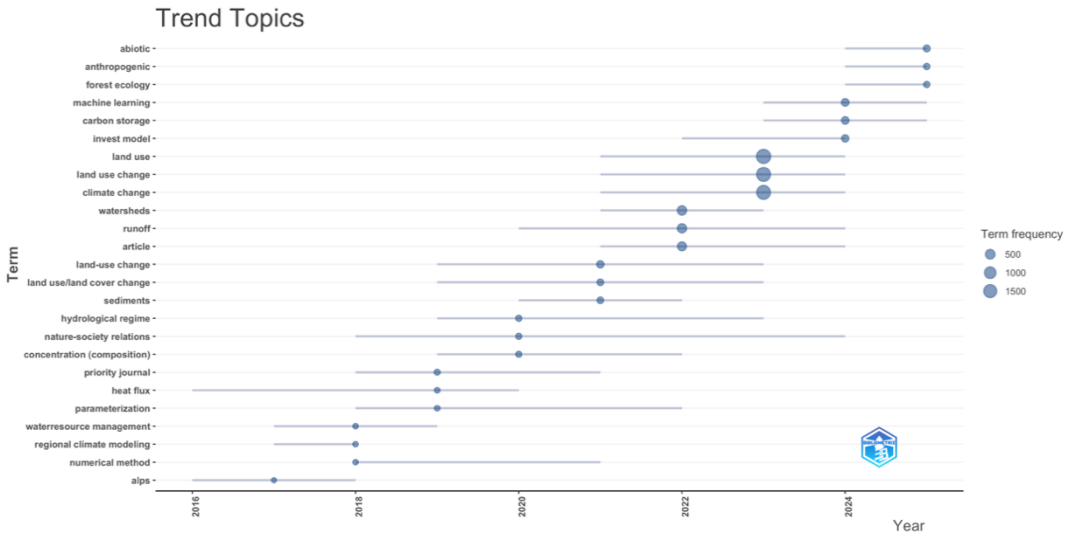


Fig. 8. Trend analysis of research topics between 2015 and 2025

The trend analysis of research topics from 2015 to 2025 reveals a clear and dynamic evolution within the Climate Change–LULC field, reflecting broader shifts in scientific priorities, methodological innovation, and global environmental challenges. Early research, concentrated around 2015–2018, was heavily rooted in hydrological regimes, regional climate modeling, and parameterization, underscoring a foundational phase in which scholars focused on understanding physical processes, refining models, and establishing baseline relationships between climate systems and land-surface characteristics. Beginning around 2019, there was a noticeable transition toward themes such as land use change, climate change, and watershed dynamics, demonstrating a growing emphasis on how land-surface transformations interact with climate variability and environmental risk. This period marks an increasing recognition that land systems play a pivotal role in shaping local and regional climate responses, prompting researchers to examine the biophysical consequences of urban expansion, deforestation, and agricultural intensification.

By 2023–2025, the field entered a more advanced and interdisciplinary stage, characterized by the rise of machine learning, carbon storage, forest ecology, and anthropogenic factors. These emerging topics indicate a methodological shift toward data-driven prediction, integrated ecological modeling, and ecosystem-based management strategies aimed at addressing complex socio-environmental problems. Such developments demonstrate growing interest in leveraging artificial intelligence, satellite data, and high-resolution spatial analysis to predict land-change outcomes and evaluate climate mitigation potentials (Tan et al., 2025). Overall, these trends highlight not only the diversification and increasing sophistication of global research but also the expanding integration of ecological, technological, and human dimensions. This evolution underscores a broader movement toward holistic, solution-oriented approaches capable of informing sustainable land governance, climate resilience planning, and evidence-based policy interventions in an era of accelerating environmental change.

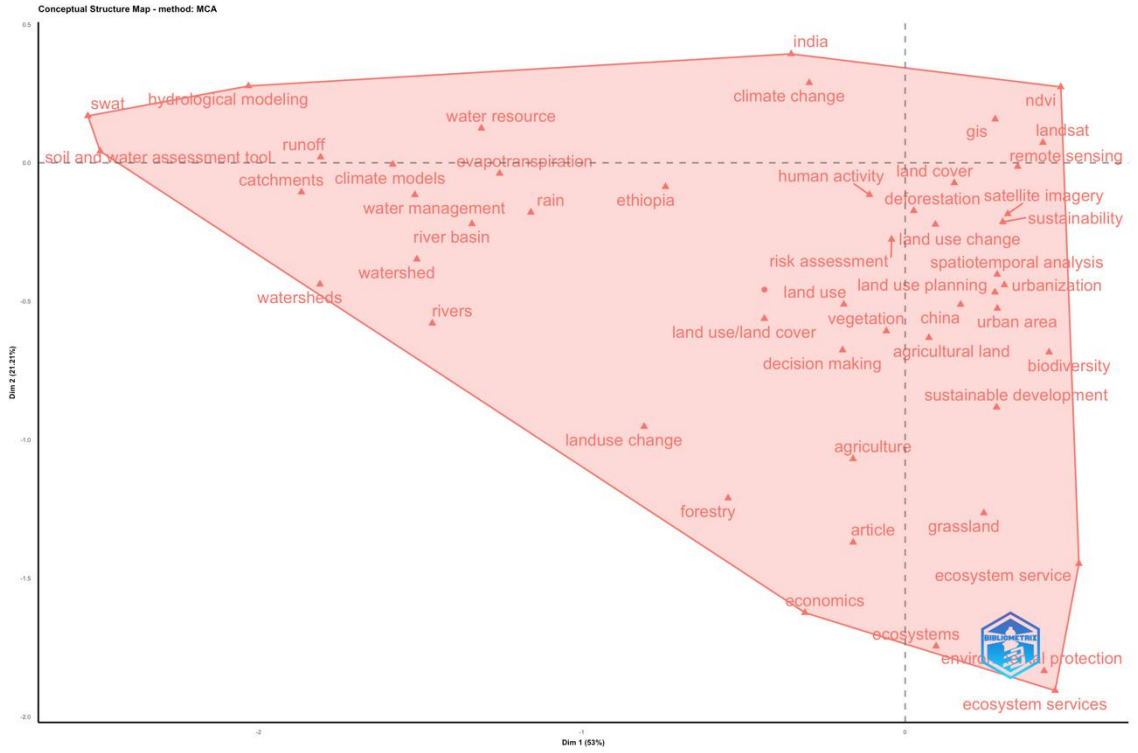


Fig. 9. The conceptual structure map generated using Multiple Correspondence Analysis (MCA)

The conceptual structure map generated using Multiple Correspondence Analysis (MCA) reveals the main thematic orientations within the analyzed research field. The distribution of keywords across the map indicates four interrelated clusters. The first cluster, located on the left side, centers on hydrological modeling and water resource management, featuring terms such as SWAT, soil and water assessment tool, catchments, and river basin. This theme reflects studies focusing on the simulation and evaluation of watershed processes. The second cluster, positioned in the upper-right quadrant, relates to remote sensing and land cover change, represented by keywords such as GIS, NDVI, Landsat, remote sensing, and urbanization. It emphasizes spatial and temporal monitoring of environmental transformations through satellite data and geospatial analysis. The third cluster, found in the lower-right quadrant, focuses on sustainability, biodiversity, and ecosystem services, encompassing terms like ecosystem service(s), sustainable development, agriculture, economics, and environmental protection. This theme reflects socio-ecological research addressing the link between ecosystem functioning and human well-being. The fourth cluster, positioned toward the center, integrates climate change, land use change, human activity, and decision making, highlighting interdisciplinary studies that connect land management, climate impacts, and policy decision processes. Overall, the

horizontal dimension of the map represents a conceptual continuum from biophysical modeling to socio-environmental sustainability research, while the vertical dimension distinguishes between model-driven technical approaches and ecosystem-based or policy-oriented studies.

The findings demonstrate that global research on climate change and LULC has undergone significant growth and diversification over the last decade. The dominance of keywords such as land use change, climate change, and land cover underscore the persistent focus on understanding anthropogenic drivers of environmental transformation. The emergence of remote sensing and spatiotemporal analysis highlights how geospatial technologies have become indispensable for monitoring land dynamics and climate interactions (Alawode et al., 2025). Moreover, the increasing inclusion of terms like ecosystem services, sustainability, and urbanization suggests a paradigm shift from purely biophysical analysis toward integrated socio-ecological frameworks. Geographically, the strong representation of China, the United States, and India reflects concentrated research capacity, yet also points to regional imbalances in scientific contribution. Developing regions, especially in Africa and Southeast Asia, remain underrepresented, despite being highly vulnerable to land-use and climate impacts. This gap emphasizes the need for more inclusive collaboration and data sharing to ensure equitable climate adaptation strategies. Conceptually, the bibliometric clusters reveal that the field is moving toward multidimensional integration, connecting hydrological modeling, spatial monitoring, and sustainability assessment. For future research, expanding cross-regional studies, incorporating local socio-economic data, and linking LULC monitoring with policy evaluation will be crucial. Such directions can enhance evidence-based decision-making and support the achievement of Sustainable Development Goals (SDGs), particularly in climate action (SDG 13) and life on land (SDG 15).

Research on Land Use and Land Cover (LULC) plays a pivotal role in advancing land conservation by providing a comprehensive understanding of how human activities reshape terrestrial ecosystems and the environmental consequences that follow. By examining spatial and temporal patterns of land cover, LULC studies document essential ecological processes such as vegetation loss, soil degradation, hydrological disruption, and biodiversity decline. These insights are crucial for identifying conservation priority zones, particularly areas undergoing rapid deforestation, habitat fragmentation, and landscape homogenization—processes that severely undermine ecosystem resilience. The integration of remote sensing, GIS, and spatiotemporal modeling in LULC research enhances the capacity to detect subtle land disturbances, monitor long-term degradation trajectories, and forecast future land-use scenarios. Such predictive capabilities are vital for proactive conservation planning, allowing policymakers and land managers to intervene before ecosystems cross irreversible thresholds. For example, early detection of forest canopy thinning or watershed sedimentation can trigger restoration programs to stabilize soils, rehabilitate riparian zones, or enforce protective regulations.

From a governance perspective, LULC data provide robust empirical evidence to inform land-use zoning, establish protected area boundaries, and evaluate the effectiveness of conservation policies. Governments can use LULC indicators to monitor compliance with environmental laws, assess the impacts of agricultural expansion or urban development, and guide climate adaptation strategies based on ecosystem-based approaches. In addition, LULC research supports the implementation of international commitments such as REDD+, biodiversity conservation targets, and sustainable development goals by offering measurable indicators of land health and ecosystem service provision (Hiratsuka et al., 2021; Pati et al., 2022). On the ground, insights from LULC studies help guide sustainable land management practices. These include agroforestry systems that enhance carbon sequestration, watershed rehabilitation that improves hydrological stability, reforestation and afforestation programs that rebuild habitat connectivity, and controlled urban growth strategies that reduce encroachment into ecologically sensitive areas (Enríquez-de-Salamanca, 2022). By linking land-use patterns with ecological outcomes, LULC research fosters a socio-ecological perspective that recognizes humans as integral components of

landscapes, emphasizing the need for conservation strategies that balance ecological integrity with community livelihoods. Ultimately, the deepened understanding provided by LULC research strengthens long-term land conservation efforts by reducing anthropogenic pressures, enhancing ecosystem functionality, and promoting adaptive management in a rapidly changing climate. Through its integration of technological tools, ecological theory, and policy analysis, LULC research is indispensable for sustaining land resources and ensuring the resilience of ecosystems for future generations.

4. Conclusions

This bibliometric study highlights the rapid growth and interdisciplinary nature of research connecting climate change and land use/land cover change. Over the past decade, the field has evolved from descriptive analyses of land transformation to complex, data-driven approaches integrating ecological, technological, and policy perspectives. China and other leading nations have significantly advanced global contributions, though broader participation from developing regions remains limited. The analysis confirms that future climate and land management research must emphasize integrative modeling, sustainable land planning, and transdisciplinary collaboration. By aligning scientific inquiry with practical land-use policies, the global community can enhance its capacity to mitigate and adapt to climate change impacts effectively (Barati et al., 2023). Based on the findings of this bibliometric analysis, several recommendations can be made to guide future research and policy development in the field of climate change and land use/land cover change (LULC). First, strengthening international collaboration and data sharing is crucial for reducing disparities between developed and developing countries in land-use and climate research. By promoting joint research initiatives, open-access data platforms, and shared technological resources, countries can ensure more equitable participation in global scientific efforts. Such collaboration also supports capacity building through training, knowledge exchange, and researcher partnerships, enabling local experts to adopt cutting-edge methods and contribute meaningfully to global assessments.

Second, future studies should adopt a more integrative approach by combining spatial and ecological modeling with socio-economic and policy dimensions, allowing researchers to capture the full complexity of land-use dynamics. While spatial and ecological analyses reveal patterns of environmental change, they often overlook the underlying human behaviors, market forces, governance structures, and institutional incentives that drive these changes. Ultimately, such an approach would support the development of more realistic, context-sensitive solutions that address both environmental sustainability and human development needs. Third, the continued advancement of geospatial technologies, such as remote sensing, GIS, and machine learning, should be encouraged to enhance the accuracy of LULC monitoring and predictive modeling, supporting proactive land management decisions. Overall, future research should move toward an interdisciplinary, participatory, and solution-oriented framework to address the complex and interdependent challenges of land transformation and climate change effectively.

Acknowledgement

The authors would like to thank all individuals who provided support and assistance throughout the research and manuscript preparation.

Author Contribution

Conceptualization, M.K.; Methodology, M.K.; Formal Analysis, D.F.T.J.; Investigation, M.K.; Resources, D.F.T.J.; Data Curation, M.K.; Writing – Original Draft Preparation, M.K.; Writing – Review & Editing, M.K.; Visualization, M.K.

Funding

This study was conducted without any specific financial support from funding agencies,

commercial entities, or institutional grants. All research activities, including data collection, analysis, and manuscript preparation, were carried out independently by the authors.

Ethical Review Board Statement

Ethical review and approval were waived for this study because it is a bibliometric analysis based solely on secondary data derived from publicly available scientific literature, which does not involve any human or animal subjects.

Informed Consent Statement

Not available. This study did not involve human participants or the collection of personal data.

Data Availability Statement

The data used in this study were obtained from publicly available bibliographic databases (e.g., Scopus). No new data were created or analyzed in this study. Data supporting the findings are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest.

Declaration of Generative AI Use

During the preparation of this work, the authors used ChatGPT (OpenAI, San Francisco, CA, USA) to assist in improving the clarity, structure, and academic tone of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the final version of the publication.

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Biographies of Authors

Maisuna Kundariati, has a research interest on climate change, biodiversity, and environmental education. Her academic work aims to promote awareness and understanding of ecological issues through education, integrating scientific knowledge with teaching strategies to support sustainable development.

- Email: maisunakundariati@gmail.com
- ORCID: 0000-0002-8098-2352
- Web of Science ResearcherID: JZE-4257-2024
- Scopus Author ID: 57216350955
- Homepage: https://scholar.google.com/citations?user=I5PmZ3IAAAAJ&hl=en

Dea Fajria Tatarizqa Japal, has academic background reflects a strong commitment to exploring the intersection of finance, environmental sustainability, and ethical economic development. Dea's academic work aims to contribute to the development of responsible financial practices in emerging markets, with a particular focus on aligning financial innovation with environmental stewardship and social well-being.

- Email: dea.japal@uiii.ac.id
- ORCID: 0009-0000-5788-5207
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A