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A Bibliometric Systematic Literature Review (B-SLR) of sustainability assessment: Global trends and knowledge mapping

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Abstract

The concept of sustainability has evolved from an ecological focus to a multidimensional framework encompassing environmental, economic, and social objectives. This study conducted a Bibliometric-Systematic Literature Review (B-SLR) to analyse a final dataset of 422 research documents from the Scopus database (2001-2025), along with additional literature from Google Scholar on sustainability assessment frameworks. The dataset was imported and managed in Zotero and reviewed qualitatively to develop a conceptual framework. Using the R-package bibliometrix and its Biblioshiny interface, the annual scientific production, prominent sources, frequently occurring words, conceptual structure, and thematic mapping of the field were identified. By integrating theoretical frameworks with bibliometric mapping, this research identified core motor themes and emerging niche areas in the field. Findings revealed a significant shift towards integrated computational approaches, particularly fuzzy logic and the Analytic Hierarchy Process, within Multi-Criteria Decision-Making research. Results further indicated that Sustainability was the leading journal, with China and India emerging as the most productive geographic hubs. Thematically, decision making existed as the core motor theme, while fuzzy logic and machine learning were the less explored, critical niche areas. This review consolidated the findings for identifying future directions in sustainability assessment methods.

Keywords: Bibliometric analysis, sustainability, sustainability assessment, MCDM, fuzzy logic, bibliometrix, biblioshiny

Introduction

Sustainability is commonly understood as the ability to satisfy today's needs without limiting future generations' capacity to meet their own needs, a definition first articulated by the Brundtland Commission, which reframed sustainability as an intergenerational responsibility (World Commission on Environment and Development, 1987) ^[1]. In its earlier interpretations, sustainability was viewed only through an ecological lens, emphasizing conservation of natural resources, biodiversity protection, and ecological balance, explaining the need for environmental conservation while neglecting economic and social dimensions.

By the early 1990s, the concept began to expand into a multidimensional framework. The Food and Agriculture Organization (FAO, 1991) ^[2] was among the first to modify the concept by introducing measurable indicators for agriculture and socio-economic development. Elkington's Triple Bottom Line (1997) ^[3] explained that sustainability requires a balance of environmental integrity, economic viability, and social equity. These works established sustainability as a holistic construct rather than only an ecological concern.

Further, Agenda 21 (United Nations, 1992) ^[4] emphasized sustainable development as a foundational principle for international policy, while the Millennium and Sustainable Development Goals in the early 2000s and 2015 extended

the concept of sustainability into global governance frameworks (United Nations, 2000, 2015) ^[5, 6]. These initiatives shifted sustainability towards systemic, site-specific, and multidimensional approaches, requiring assessment across levels from individual farms and communities to global systems.

In this era, the emerging complexity of the concept has required the computational and decision support frameworks. Multi-Criteria Decision-Making, fuzzy logic, and machine learning have emerged as dominant methodologies for addressing both qualitative and quantitative uncertainties in sustainability assessment, reflecting the growing need for integrated tools capable of handling diverse indicators and perspectives.

While earlier studies have reviewed sustainability assessment frameworks qualitatively, a gap remains in quantitatively mapping the methodological transition from earlier metrics to advanced computational models over the decades. The convergence of environmental science with machine learning and Multi-Criteria Decision-Making, has created a fragmented and vague literature base.

Despite global importance on sustainability, there is a absence of bibliometric mapping and systematic assessment frameworks in agricultural sustainability research, particularly in India. While sustainability has been widely discussed globally no proper bibliometric review exists that

captures global and Indian contributions to sustainability assessment. This gap is significant because India, and vulnerability to climate change, requires evidence based frameworks to guide extension strategies and policy.

This study adopts a Bibliometric-Systematic Literature Review of 422 research articles published from 2001 to 2025. By integrating qualitative literature with quantitative bibliometric mapping, this study provides a pathway for understanding the evolution of sustainability assessment methodologies.

Methodology

This study employed a Bibliometric-Systematic Literature Review framework, integrating analysis with qualitative review.

Data collection and search strategy: A targeted Boolean search string ("Sustainability Assessment," "Sustainable Agriculture," "Sustainable Development," "Sustainability") was applied in the Scopus database. The dataset was restricted to publications from 2001 to 2025, limited to research articles and review papers, and confined to documents published in English. The systematic search and screening process resulted in a final dataset of 422 documents, exported in CSV format for bibliometric analysis. The metadata was processed using R Studio, the R-package bibliometrix, and the Biblioshiny interface. While the 'Science Categories' field was unavailable in the data report, the metadata for 'Keywords Plus' showed a high completion rate. To ensure accuracy, an approach using both author keywords and Keywords Plus within the Biblioshiny interface which compensated for the marginal missing data and provided a comprehensive representation of the conceptual structure. Approximately 100 additional research papers, identified mostly via Google Scholar, were stored in Zotero and reviewed qualitatively to establish the theoretical foundation for sustainability assessment.

The B-SLR was conducted in three phases:

- **Data collection:** 422 research articles in CSV format from the Scopus database.

- **Bibliometric analysis:** performance analysis, including citations, annual production, sources, and authors, using the R-package bibliometrix (Biblioshiny interface).
- **Bibliometric synthesis:** a conceptual structure diagram, thematic map, and factorial analysis were produced, and research topics were classified into motor, niche, emerging, and basic themes, enabling identification of dominant and underexplored areas; the social structure analysis included a co-citation network and a countries' collaboration world map.

Theoretical evolution and frameworks

Harrington (1992) ^[7] argued that sustainable agriculture can be understood through three complementary lenses: agroecology, equity, and sustainable growth. The agroecological perspective emphasizes resilience, efficient input use, and nutrient recycling; the equity perspective highlights intergenerational fairness and recognition of the rights of non-human species; while the sustainable growth perspective focuses on maintaining agricultural productivity alongside preservation of resource quality. Jones (1993) ^[8] found that any concept of agricultural sustainability must include the dynamic, and sometimes conflicting, interaction between agricultural activities, environment, and society.

Roling and Wagemakers (2000) ^[9] described sustainable agriculture as a regenerative approach that prioritizes efficient use of locally available resources and natural ecological processes, such as nutrient cycling and biodiversity enhancement, minimizing reliance on external inputs like agrochemicals, mined minerals, and non-renewable energy sources. Velten *et al.* (2015) ^[10] described sustainable agriculture as a vague and ambiguous concept but highlighted its value as a framework for integrating ecological, economic, and social dimensions. El Bilali *et al.* (2021) ^[11] argued that while environmental aspects are well studied, social, economic, and governance dimensions remain underrepresented, and called for a holistic approach encompassing planet, people, profit, and policy.

Table 1: Major sustainability assessment frameworks in the literature

Year	Framework	Purpose	Dimensions/Components	Indicators	Strengths
1994	PSR (OECD, 1994) ^[12]	Foundational framework for environmental sustainability	Pressure, State, Response	Pressure (emissions, waste), State (water quality, ozone depletion), Response (policies, taxes, laws)	Simple, clear chain for environmental policy
2003	RISE (Hani <i>et al.</i> , 2003) ^[13]	Farm level diagnostic tool	12 sustainability indicators (soil use, biodiversity, energy, water, animal husbandry, economic viability, etc.)	More than 60 parameters, broken into state and drive indicators	Practical, farmer-oriented
2006	DPSIR (Rao and Rogers, 2006) ^[14]	Expanded framework for sustainability in agricultural systems	Driving forces, Pressures, State, Impacts, Responses	Indicators linked to human activities, environmental pressures, ecosystem or human health impacts, and policy responses	Holistic, systems based; builds on PSR; integrates socio-economic drivers and impacts
2006	MOTIFS (Van Calker <i>et al.</i> , 2006) ^[15]	Monitoring tool for integrated farm sustainability	5 dimensions: environmental, economic, social, animal welfare, product quality	Nutrient management, biodiversity, profitability, labour conditions, animal health, product safety	Integrative; balances environmental, economic and social sustainability with animal welfare and product quality
2008	IDEA (Zahm <i>et al.</i> , 2008) ^[16]	Farm sustainability assessment in European contexts	10 components: diversity of production, organization of space, farming practices, quality of products and land, ethics and	41 indicators (crop diversity, ecological buffer zones,	Strong socio-economic and ethical focus

			human development, economic viability, financial independence, transferability, efficiency	fertilization, labour intensity, financial autonomy)	
2013	SAFA (FAO, 2013) ¹⁷	Global, standardized assessment of food and agriculture systems	4 dimensions: good governance, environmental integrity, economic resilience, social well-being	21 themes, 58 sub themes, 116 indicators	Comprehensive, policy level tool; provides a harmonized global framework integrating PSR, DPSIR, RISE, MOTIFS and IDEA

The bibliometric analysis ^[18] identifies an evolution in sustainability assessment, moving from static, qualitative, indicator based frameworks towards a complex integration of Multi-Criteria Decision-Making and artificial intelligence. While earlier indicator sets such as PSR (1994) or RISE (2003) remain effective for site-specific inspection at the field level, they become complex when scaled to

regional or global systems. This has required a shift towards mathematical tools such as the Analytic Hierarchy Process and fuzzy logic, which provide the hierarchical weighting and uncertainty modelling needed to manage multidimensional complexity. Thus fuzzy networks and machine learning are used to capture the dynamic nature of sustainability.

Results and discussion

Metadata quality and scientific production

Metadata	Description	Missing Counts	Missing %	Status
AB	Abstract	0	0.00	Excellent
AU	Author	0	0.00	Excellent
DI	DOI	0	0.00	Excellent
DT	Document Type	0	0.00	Excellent
SO	Journal	0	0.00	Excellent
LA	Language	0	0.00	Excellent
PY	Publication Year	0	0.00	Excellent
TI	Title	0	0.00	Excellent
TC	Total Citation	0	0.00	Excellent
C1	Affiliation	1	0.24	Good
CR	Cited References	2	0.47	Good
DE	Keywords	7	1.66	Good
RP	Corresponding Author	20	4.74	Good
ID	Keywords Plus	65	15.40	Acceptable
WC	Science Categories	422	100.00	Completely missing

Fig 1: Metadata quality overview

The bibliometric dataset was evaluated for metadata completeness to ensure the reliability of the analysis. Major bibliometric attributes such as abstracts, authors, DOIs, document types, journals, language, publication year, titles, and citation counts were fully available, with no missing entries, and were therefore rated as excellent. Affiliation data, cited references, author keywords, and corresponding author information were largely complete, with very less

missing values, and were rated as good. Keywords Plus were available for the majority of records but showed a missing rate of 15.4 per cent, considered acceptable. A significant gap was observed in 'Science Categories,' which were absent in 422 records. This absence is a known limitation of Scopus exports and was adjusted by relying on co-word analysis and thematic clustering.

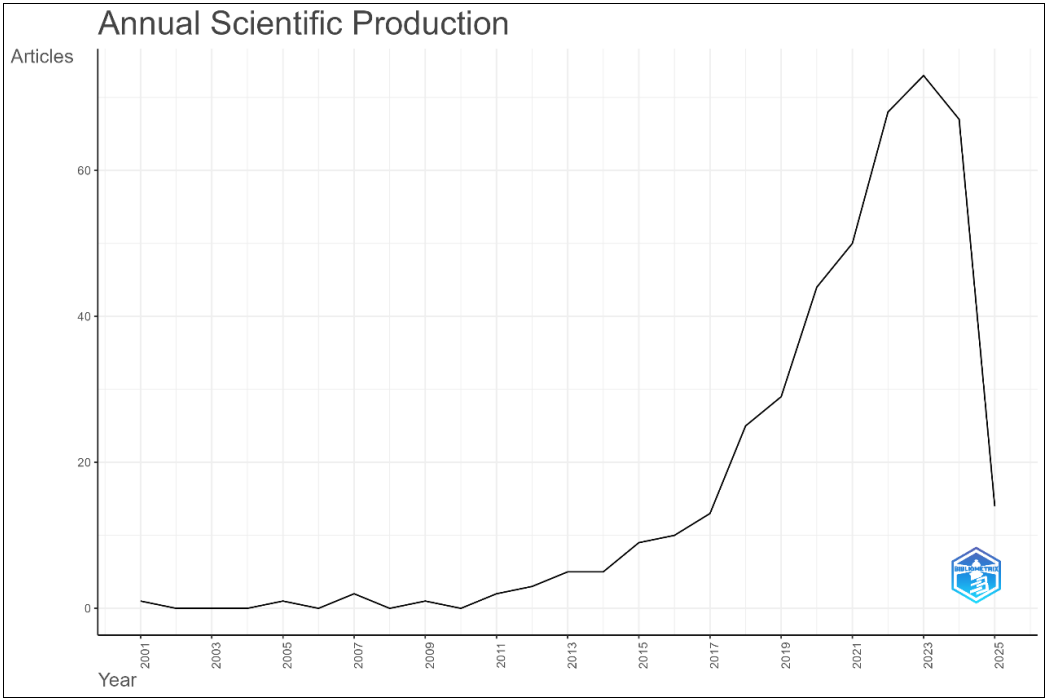


Fig 2: Annual scientific production

The analysis of annual scientific production showed that sustainability assessment research remained relatively modest until 2015, after which it rose sharply, peaking in 2022 with 60 publications. This rise may reflect the influence of global policy milestones such as the

Sustainable Development Goals and Paris Agreement, which increased academic engagement with sustainability frameworks. The decline observed in 2024-2025 is most likely due to dataset coverage and indexing delays rather than a substantive reduction in research activity.

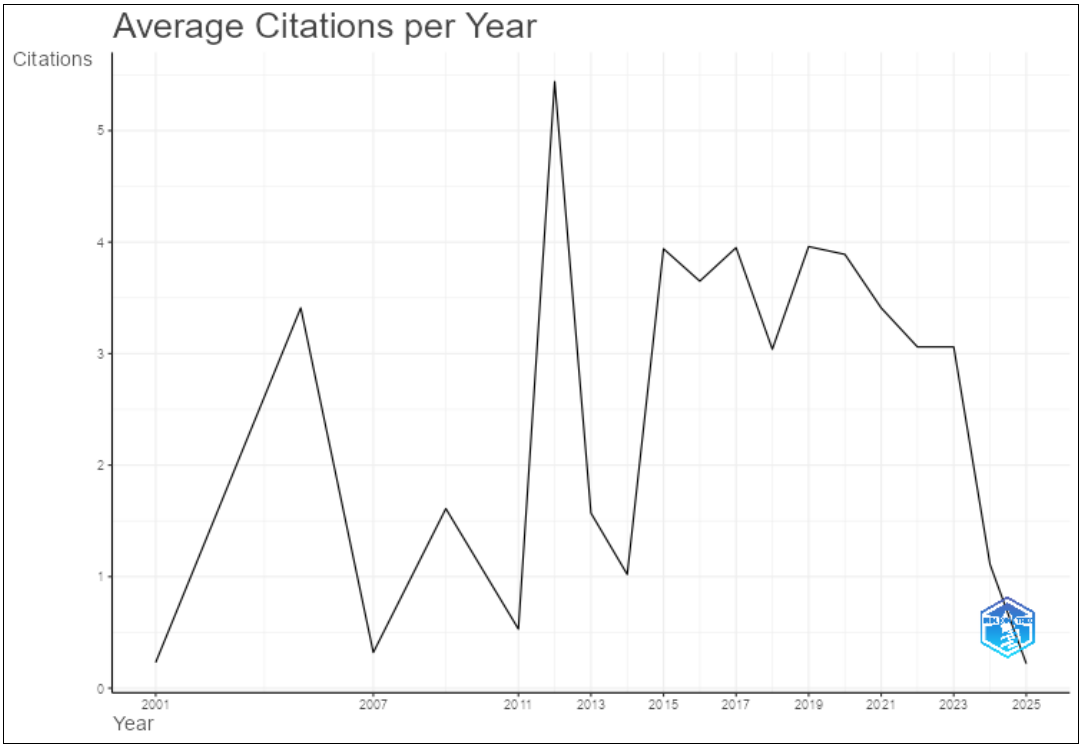


Fig 3: Average citations per year

In contrast, average citations per year reveal a different pattern, with pronounced peaks around 2007 and 2012, reflecting the influence of major works that shaped early methodological debates. Citations remained average through

the mid-2010s but declined sharply after 2023. This decline may not indicate reduced relevance but reflects the recency of publications, which may not yet had sufficient time to accumulate citations.

Leading sources, authors and thematic structure

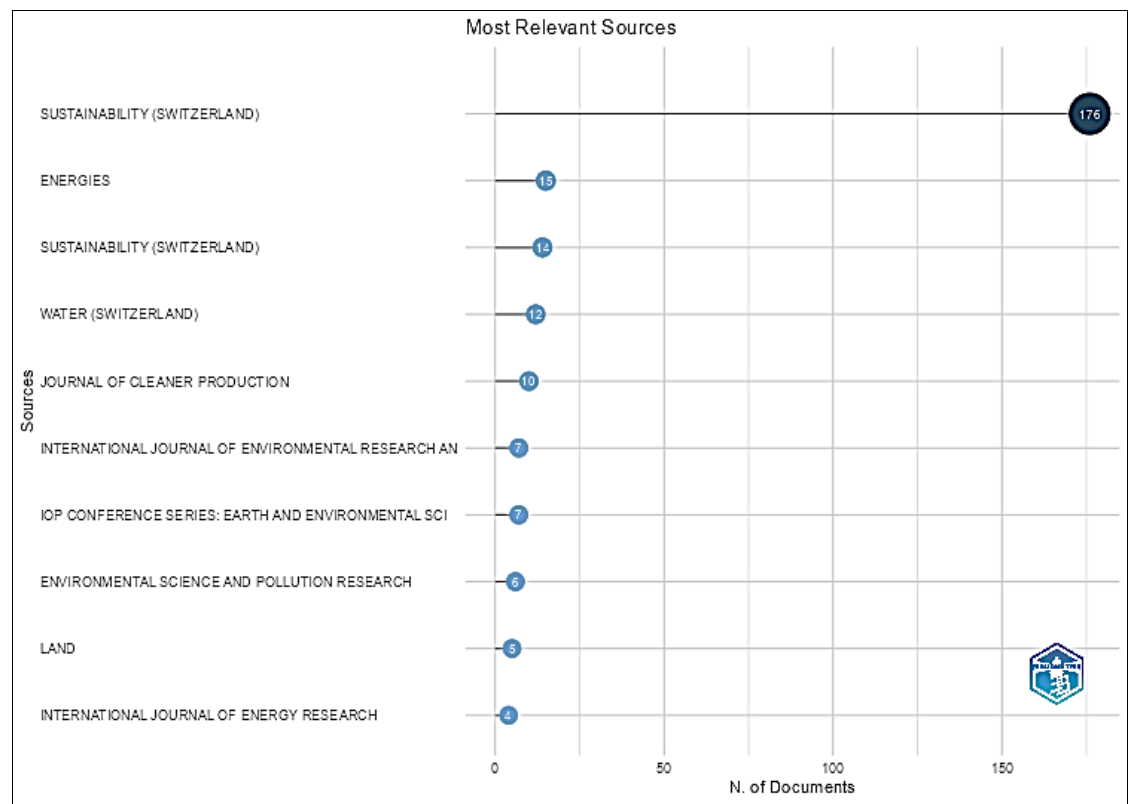


Fig 4: Most relevant sources

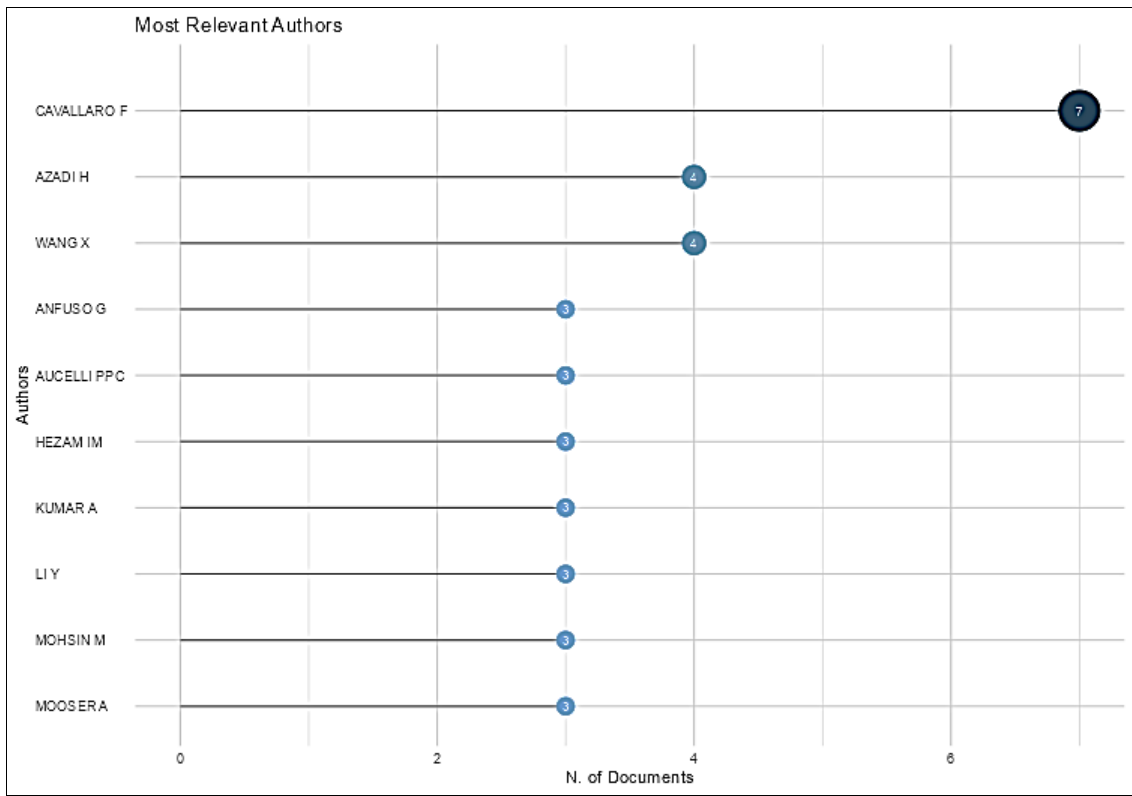


Fig 5: Most relevant authors

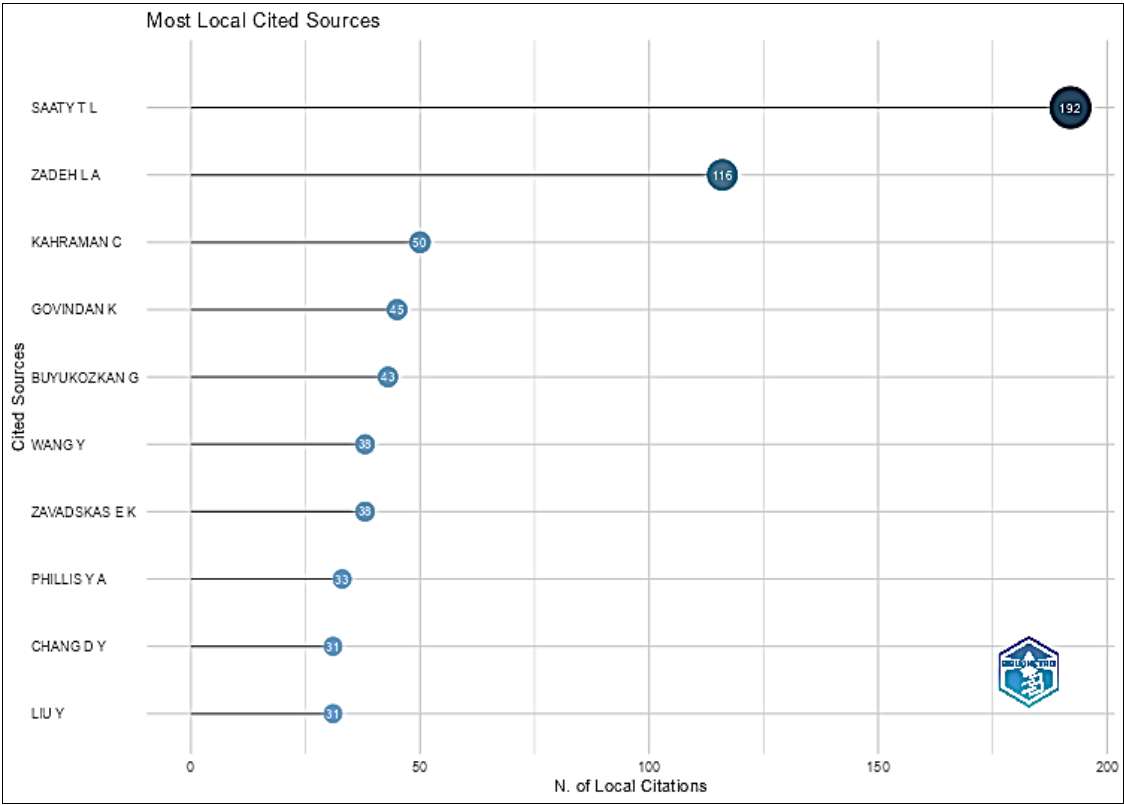


Fig 6: Most local cited sources

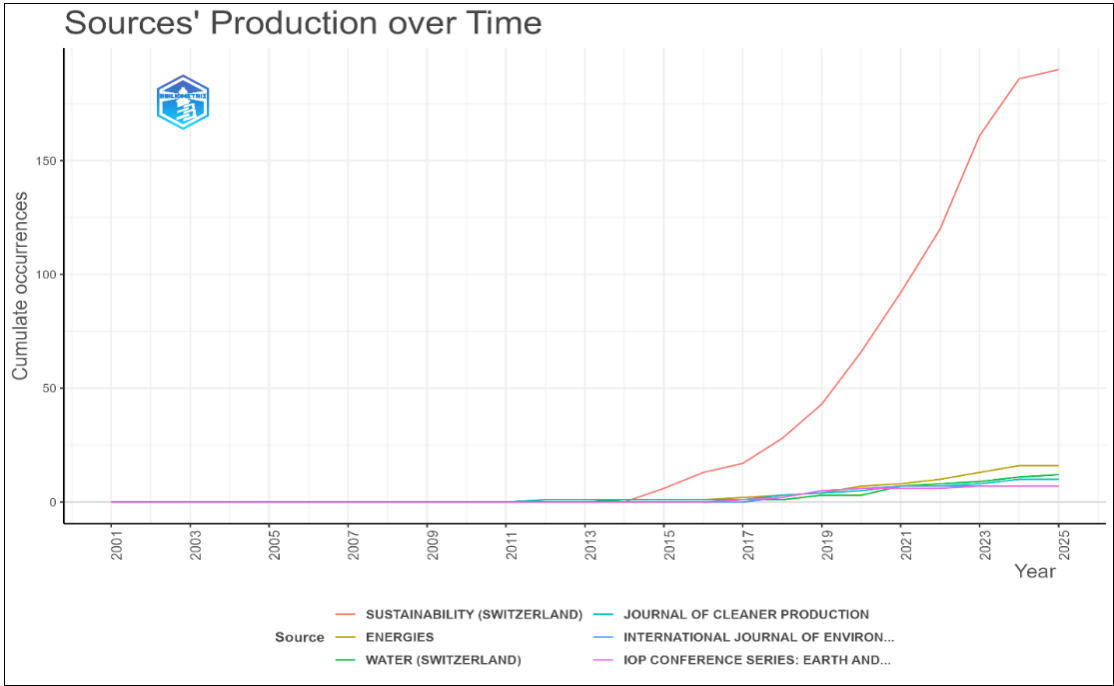


Fig 7: Sources production over time

The journal Sustainability (MDPI) is identified as the most relevant source, followed by Energies and also the Journal of Cleaner Production. The work of many authors such as Cavalcante and Adid represents the high-impact core of this dataset. Citation analysis identifies Saaty as most frequently cited author, with 192 local citations, reflecting the foundational role of the Analytic Hierarchy Process in multi-criteria decision-making for sustainability. Zadeh follows with 116 citations, underscoring the importance of

fuzzy set theory in addressing uncertainty within sustainability assessments. Other highly cited contributors include Kahraman (50 citations), Govindan (45 citations), and Buyukozkan (41 citations), who have advanced applications of Multi-Criteria Decision Making and fuzzy logic in environmental and agricultural contexts. These citation patterns highlight the backbone of the field, where classical methods continue to provide conceptual grounding alongside the integration of computational approaches.

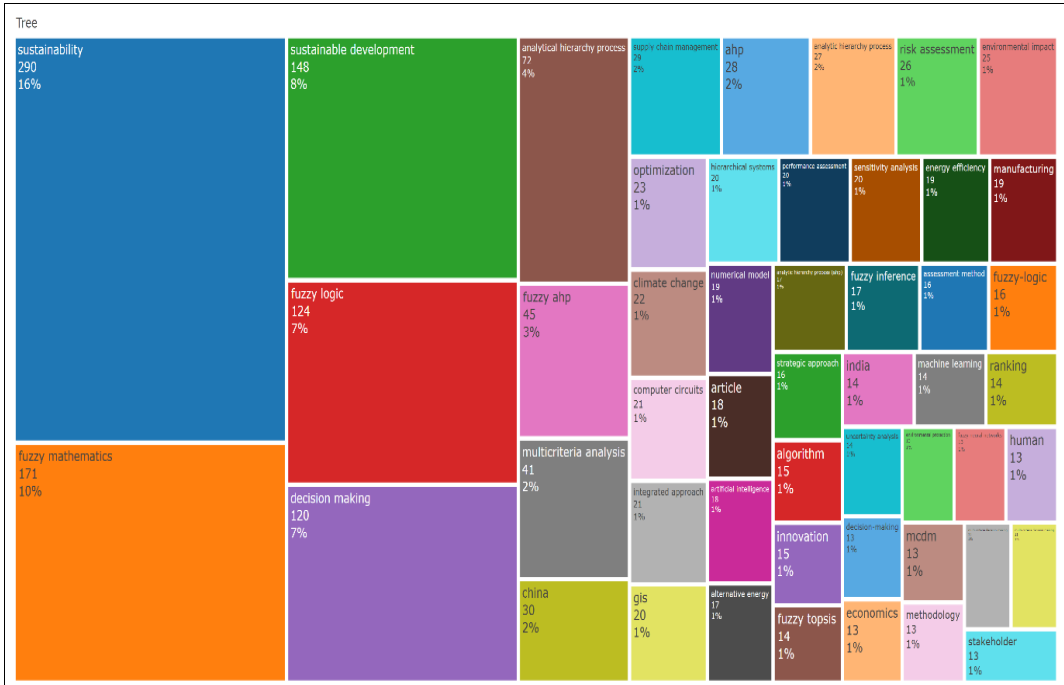


Fig 8: Tree map of prominent concepts

The tree map visualization highlights the prominent concepts in sustainability assessment research. The largest block is 'sustainability' (260 occurrences, 16 per cent), confirming it as the main anchor of the field. Strong methodological terms such as 'fuzzy mathematics' (171, 10 per cent), 'fuzzy logic' (124, 7 per cent), and 'decision making' (120, 7 per cent) show the central role of computational and multi-criteria approaches. Policy-related concepts such as 'sustainable development' (148, 8 per cent) connect the literature to global governance agendas. Smaller

but significant blocks represent specialized applications such as Analytic Hierarchy Process, fuzzy AHP, and multi-criteria analysis, while applied domains such as river basin, risk assessment, concrete mix, climate change, and circular design reflect sector specific implementations. Geographic and contextual terms such as India and China indicate regional relevance, while technical extensions such as fuzzy TOPSIS, GIS, and algorithm show methodological diversification.

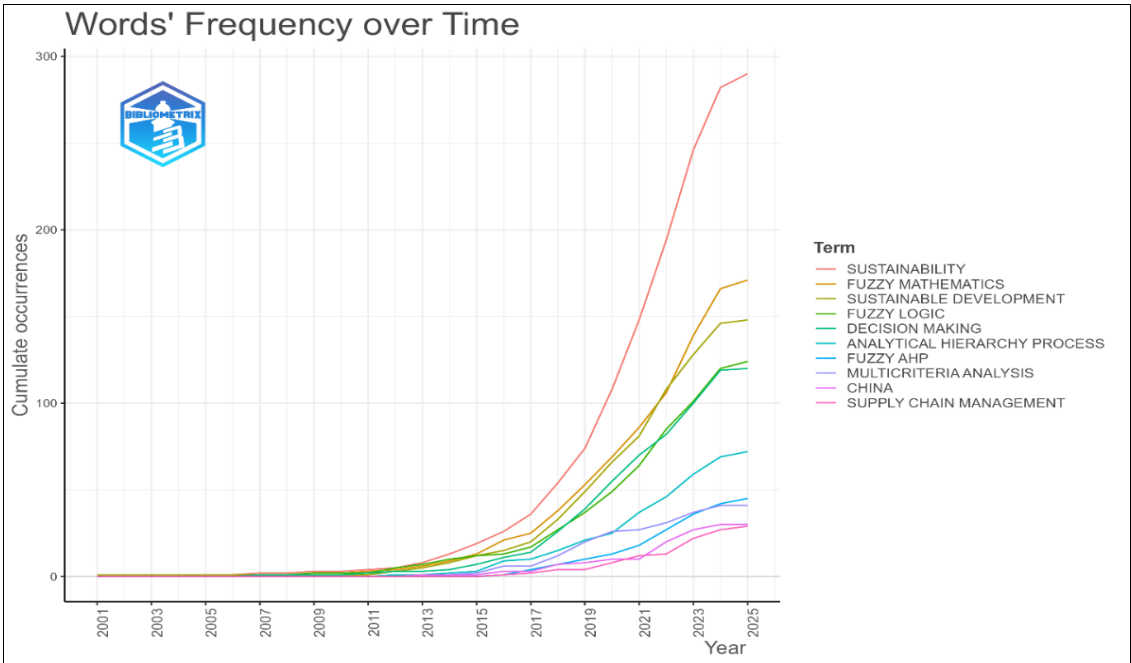


Fig 9: Word frequency over time

The keyword analysis shows how research priorities in sustainability assessment have evolved between 2001 and

2025. The term 'sustainability' dominates, with a rise after 2015 that may reflect the influence of global policy

frameworks such as the Sustainable Development Goals. 'Fuzzy mathematics' and 'sustainable development' also show strong growth. 'Fuzzy logic' and 'decision making' increased steadily, highlighting the continuity of computational and multi-criteria approaches. More specialized terms such as the Analytic Hierarchy Process,

fuzzy AHP, and multi-criteria analysis grow at a slower pace but remain consistent, showing methodological stability. Applied contexts such as China and supply chain management emerge later, reflecting geographic diversification.



Fig 10: Word cloud

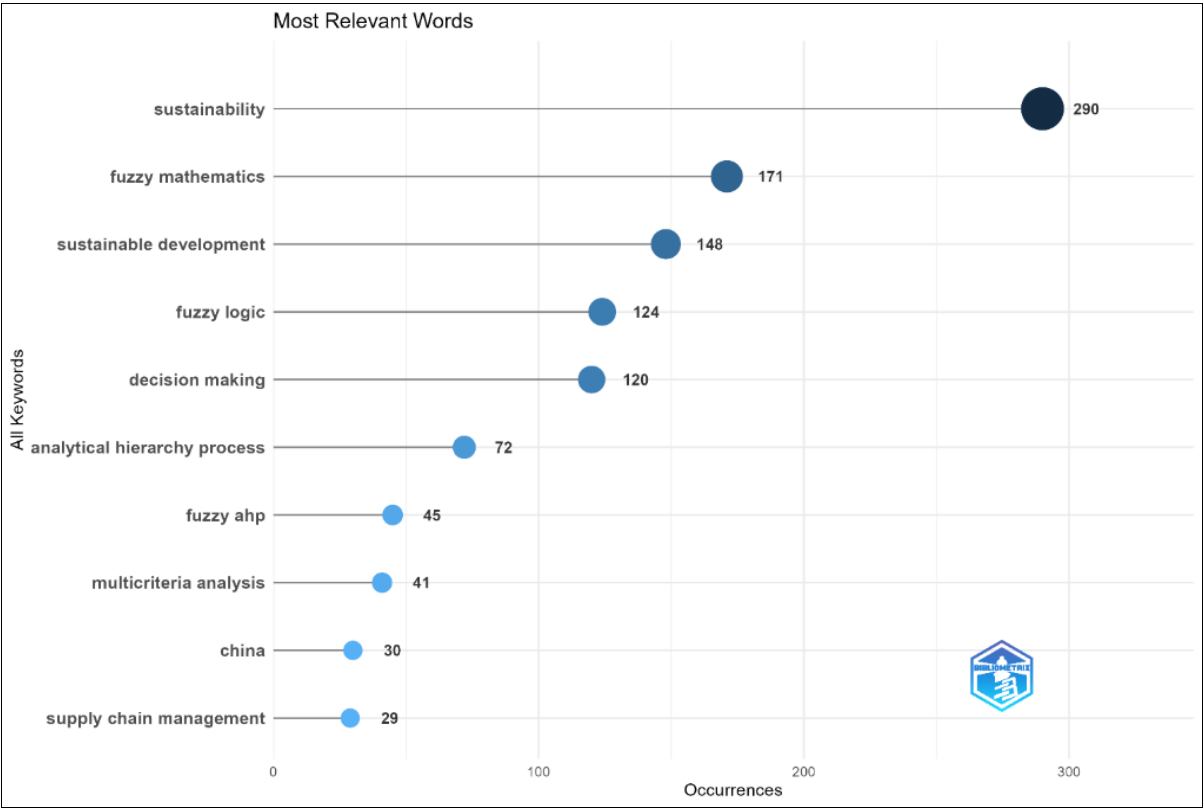


Fig 11: Most relevant words

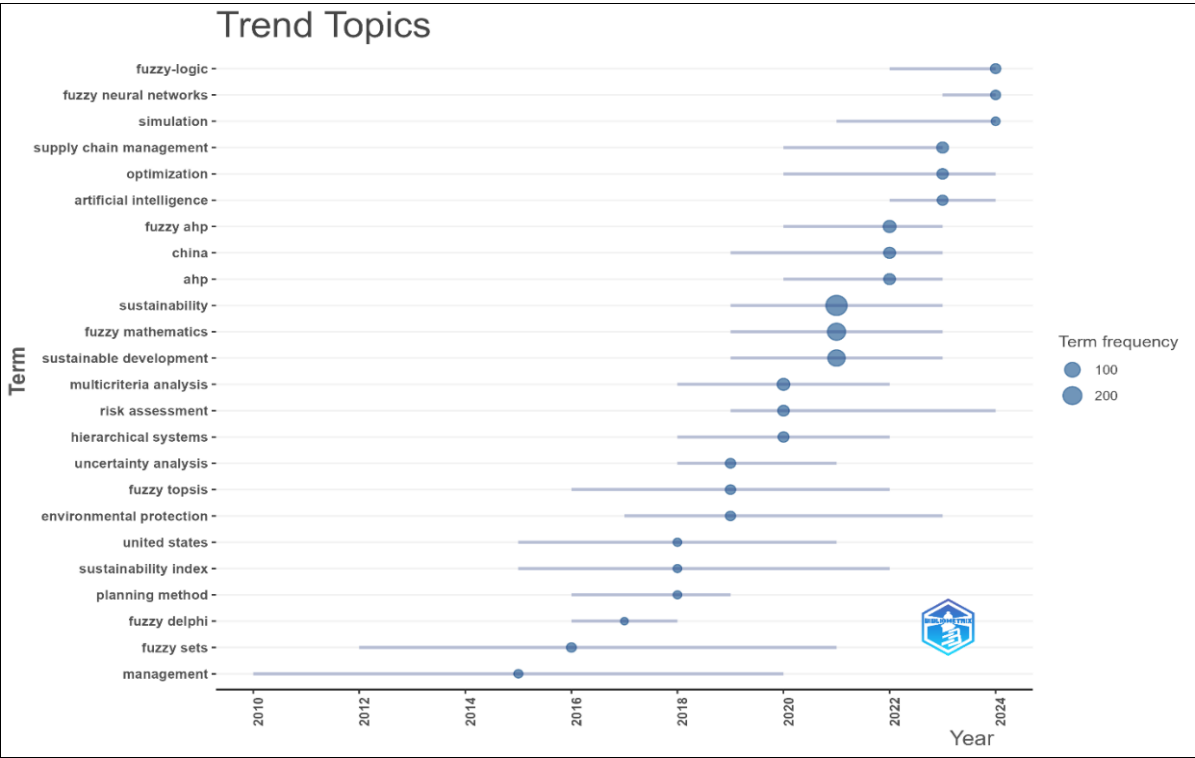


Fig 12: Trend topics

The trend topics visualization shows how sustainability assessment research evolved between 2010 and 2023, highlighting both continuity and innovation. Tools such as fuzzy logic, the Analytic Hierarchy Process, multi-criteria analysis, and hierarchical systems appear consistently across the timeline, confirming their role in decision support. From 2015, computational innovations including fuzzy neural networks, simulation, optimization, artificial intelligence, and uncertainty analysis gained prominence, showing the

integration of advanced artificial intelligence approaches into sustainability assessments. Applied domains such as supply chain management, risk assessment, environmental protection, and sustainability indices also emerged, showing diversification into sectoral and policy applications. Geographic markers such as China and the United States highlight regional contributions, while specialized techniques such as Delphi, fuzzy sets, and planning methods demonstrate methodological refinement.

Global collaboration and conceptual structure

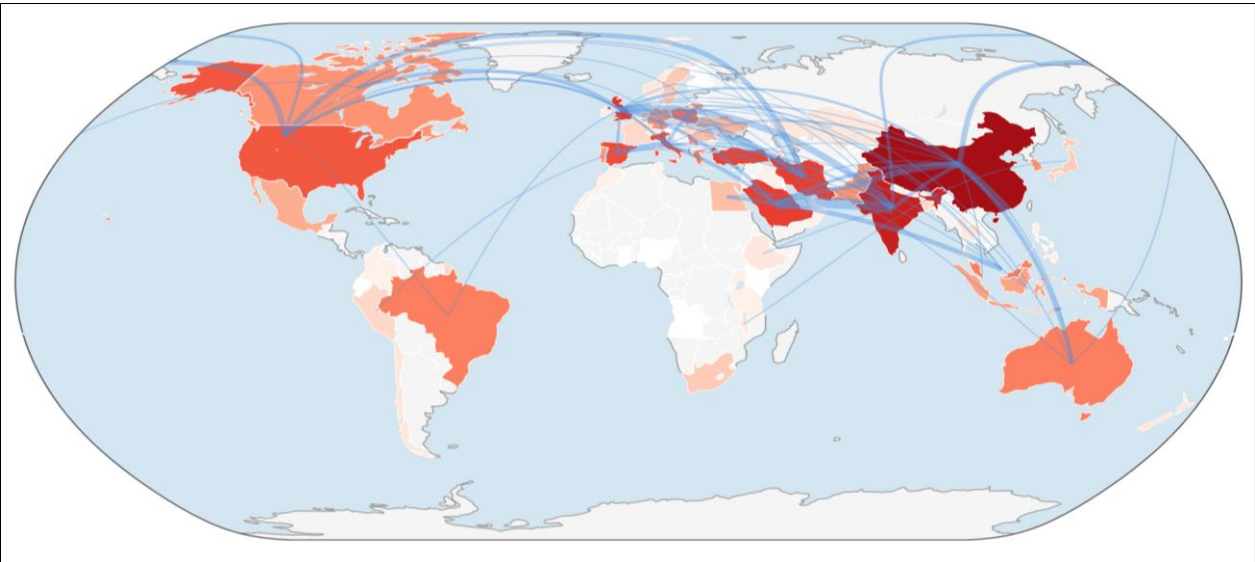


Fig 13: Global collaboration world map (part 1)

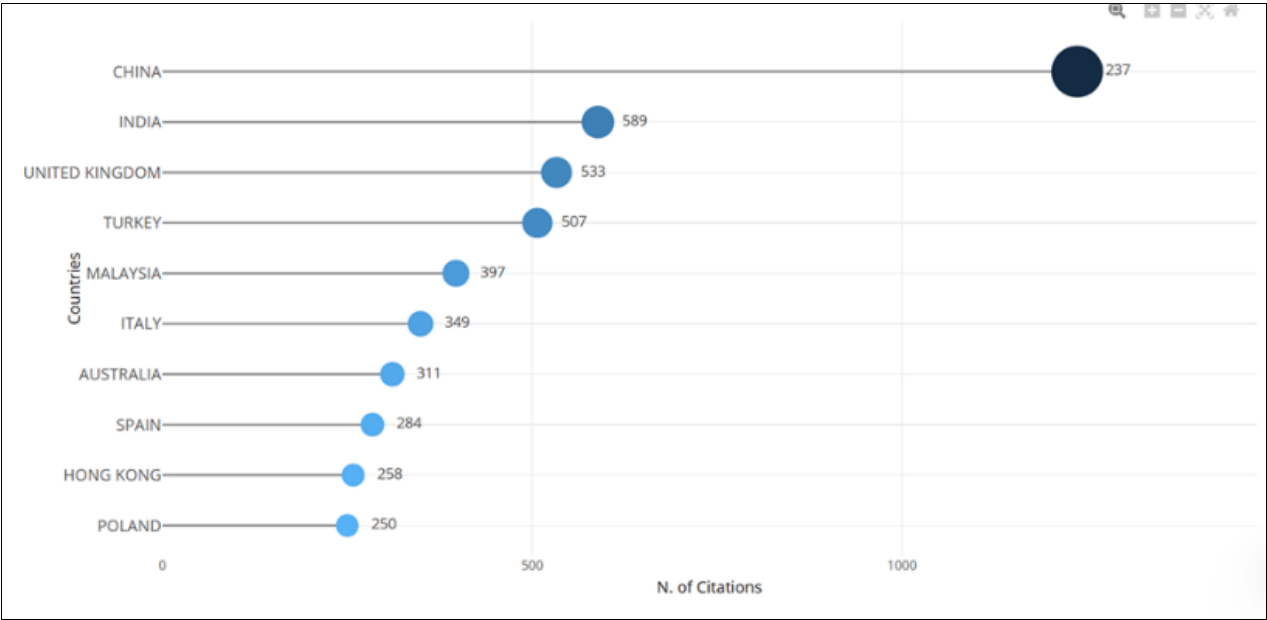


Fig 14: Global collaboration world (part 2)

The collaboration world map highlights a dominant East-West research corridor. China and India lead in total production, both countries facing high population density and climate vulnerability. The density of linkage lines

indicates a high degree of international collaboration and academic exchange between Asian, European, and North American institutions.

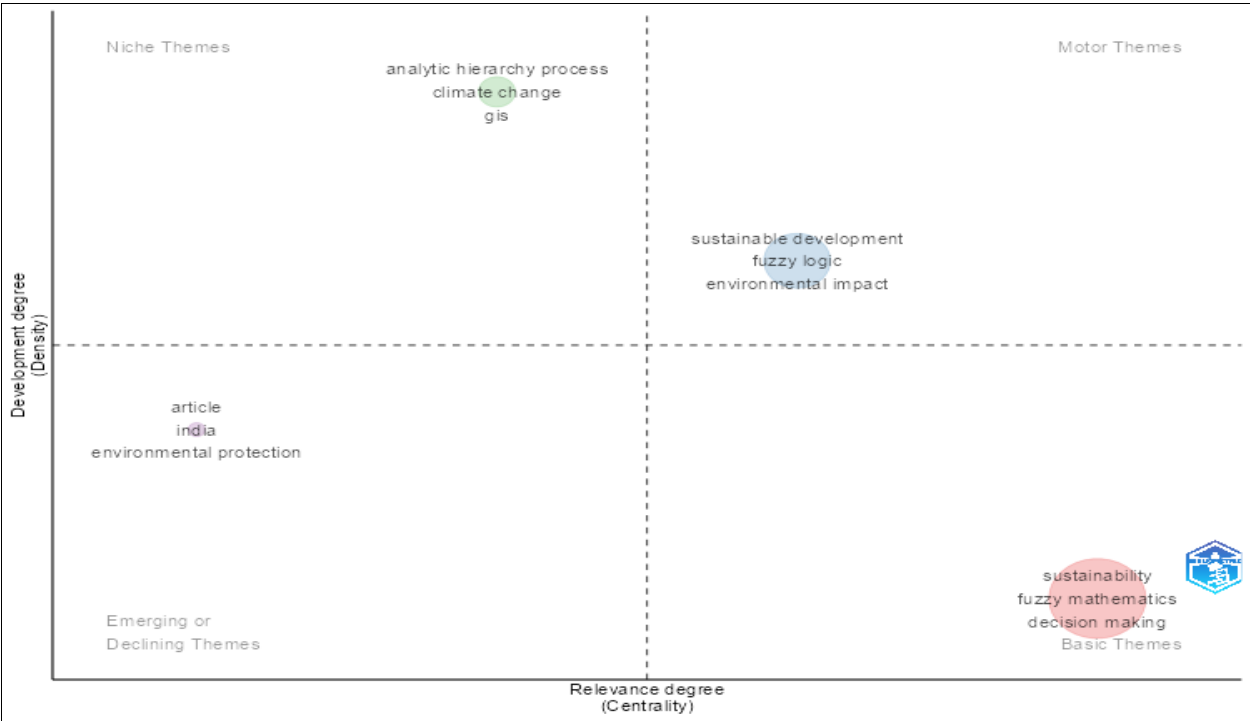


Fig 15: Thematic map

Motor themes of high relevance include environmental impact, human, and article, representing major topics that highlight sustainability research in environmental and societal concerns. Basic themes of high relevance but lower development include sustainability, fuzzy mathematics, and decision making, which are foundational concepts that remain central but still evolving methodologically. Niche themes, well developed but of lower relevance, include the Analytic Hierarchy Process, climate change, and

hierarchical systems. Emerging or declining themes, of low density and lower relevance, include sustainable development, fuzzy logic, and optimization, representing topics in transition that are either gaining traction as new directions or declining in emphasis. The rapid emergence of fuzzy logic and machine learning as critical niche areas suggests the field is moving away from linear indicators toward adaptive frameworks better able to interpret the complexity of socio-ecological systems.

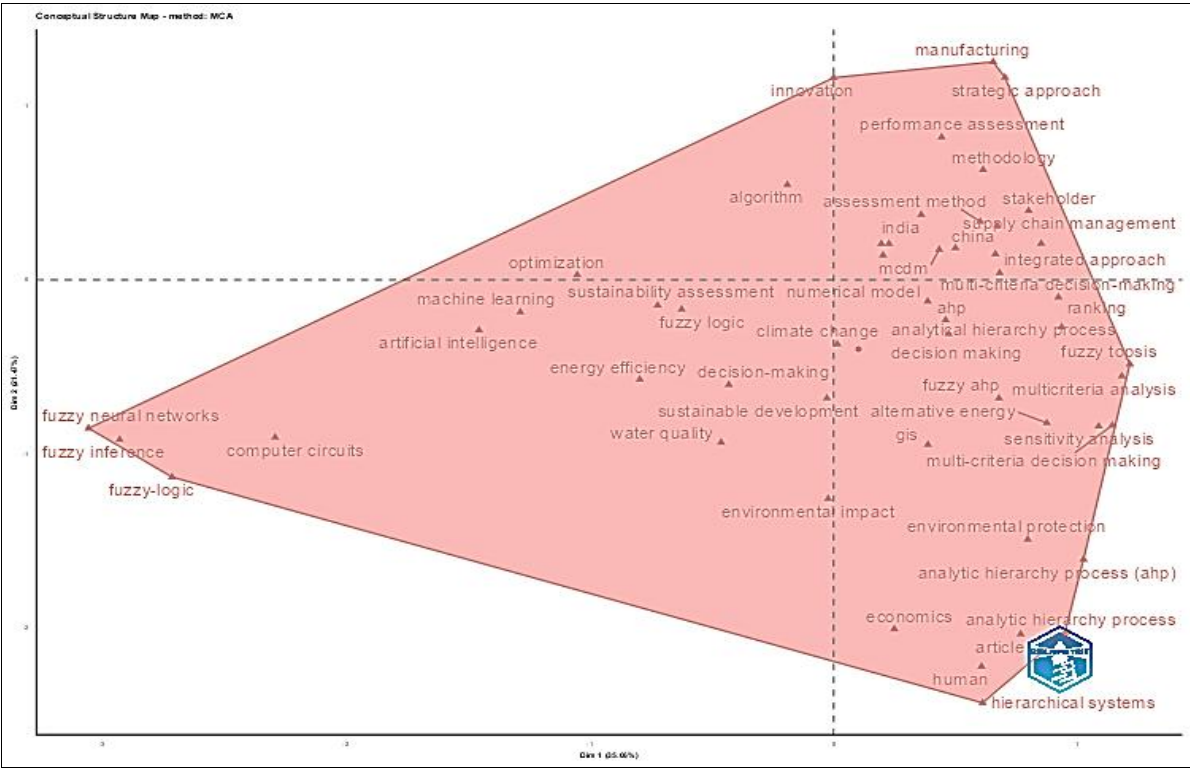


Fig 16: Conceptual structure map

The conceptual structure map, generated in Biblioshiny using Multiple Correspondence Analysis, visualizes how concepts in the dataset are related and grouped into thematic clusters. Dividing lines split the map into four quadrants, with a distinct conceptual orientation; each point represents a keyword or concept extracted from the dataset, and proximity indicates co-occurrence and thematic similarity. The cluster within the highlighted region combines fuzzy logic, fuzzy inference, fuzzy neural networks, machine learning, optimization, sustainability assessment, climate change, energy efficiency, and water quality, showing the integration of artificial intelligence methods with sustainability assessment and emphasizing computational

approaches to environmental challenges. Other clusters include terms such as the Analytic Hierarchy Process, multi-criteria analysis, and sensitivity analysis, representing Multi-Criteria Decision-Making approaches; concepts such as supply chain management, stakeholder, environmental protection, and economics highlight practical applications of sustainability frameworks; and terms such as innovation, integrated approach, and performance assessment reflect management and policy dimensions. Together, these clusters confirm that sustainability literature is structured around both methodological innovation and practical implementation.

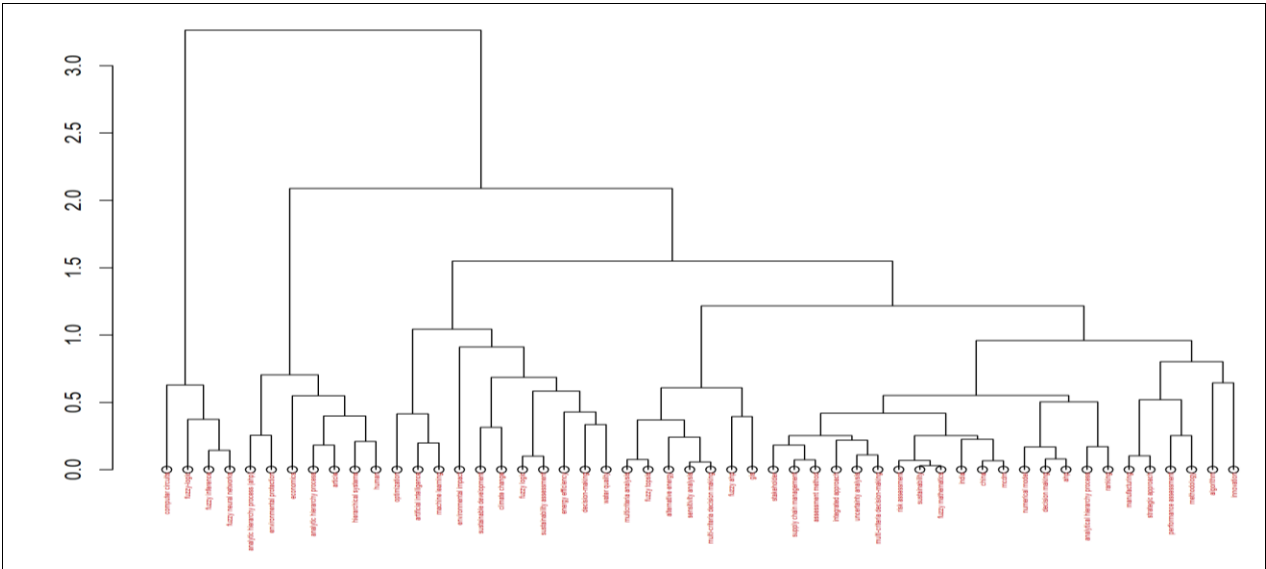


Fig 17: Dendrogram

The dendrogram visualizes how sustainability assessment publications group into distinct thematic clusters based on similarity. At the lower branches, closely related works cluster together, including specific methodologies such as Multi-Criteria Decision-Making and fuzzy logic applications. At the higher branches, broader clusters emerge, linking these methodologies with applied sustainability frameworks.

Conclusion

This Bibliometric systematic literature review using the R studio and R package shows that sustainability assessment has evolved into a globally collaborative and continuously evolving discipline spanning multiple fields. Multi-Criteria Decision-Making and fuzzy logic remain the dominant assessment methods, while artificial intelligence tools such as fuzzy neural networks and machine learning increasingly serve as complementary approaches. The leadership of China and India in research output and citations highlights the growing geographic diversification of the field, alongside the influence of open access publishing. Looking forward, research should give more attention to the policy dimension, the refinement of decision support tools, and the integration of resilience thinking with sustainability assessment, so that the field remains responsive to emerging socio-ecological challenges at both individual and global levels. India must invest in developing standardized sustainability assessment tools that integrate environmental, economic, and social dimensions, also including governance and policy indicators. Agricultural extension systems should adopt computational approaches such as multi-criteria decision-making, fuzzy logic, and machine learning to handle sustainability as an abstract concept. Strengthening collaboration along with national level institutes, State Agricultural Universities, and extension agencies will be crucial for ensuring farmer level adoption. By bridging methodological innovation with policy relevance, India can improve sustainability assessment practices and provide a strong foundation base for extension strategies, thereby aligning national agricultural development with globally recognized Sustainability Development Goals.

References

1. World Commission on Environment and Development. Our common future. Oxford: Oxford University Press; 1987.
2. Food and Agriculture Organization of the United Nations. Sustainable agriculture and rural development in Sub-Saharan Africa. Rome: FAO; 1991.
3. Elkington J. Cannibals with forks: the triple bottom line of 21st century business. Oxford: Capstone Publishing; 1997.
4. United Nations. Agenda 21: programme of action for sustainable development [Internet]. New York: United Nations; 1992 [cited 2026 Mar 1]. Available from:
5. United Nations. United Nations Millennium Declaration: resolution A/RES/55/2 [Internet]. New York: United Nations; 2000 [cited 2026 Mar 1]. Available from:
6. United Nations. Transforming our world: the 2030 Agenda for Sustainable Development: resolution A/RES/70/1 [Internet]. New York: United Nations; 2015 [cited 2026 Mar 1]. Available from:
7. Harrington L. Measuring sustainability: issues and alternatives. In: Farshad BG, editor. Let farmers judge: experiences in assessing the sustainability of agriculture. London: Intermediate Technology Publications; 1992.
8. Jones A. Sustainability and community participation in rural tourism. *Leisure Stud.* 1993;12(2):147-148.
9. Röling NG, Wagemakers MAE, editors. Facilitating sustainable agriculture: participatory learning and adaptive management in times of environmental uncertainty. Cambridge: Cambridge University Press; 2000.
10. Velten S, Leventon J, Jager N, Newig J. What is sustainable agriculture? A systematic review. *Sustainability.* 2015;7(6):7833-7865.
11. El Bilali H, Strassner C, Ben Hassen T. Sustainable agri-food systems: environment, economy, society, and policy. *Sustainability.* 2021;13(11):6260.
12. Organisation for Economic Co-operation and Development. Environmental indicators: OECD core sets. Paris: OECD Publishing; 1994.
13. Hani F, Braga F, Stämpfli A, Keller T, Fischer M, Porsche H. RISE: a tool for holistic sustainability assessment at the farm level. *Int Food Agribus Manag Rev.* 2003;6(4):78-90.
14. Rao NH, Rogers PP. Assessment of agricultural sustainability. *Curr Sci.* 2006;91(4):439-448.
15. Van Calker KJ, Berentsen PBM, Giesen GWJ, Huirne RBM. Identifying and ranking attributes that determine sustainability in Dutch dairy farming. *Agric Hum Values.* 2006;23(1):53-71.
16. Zahm F, Viaux P, Vilain L, Girardin P, Mouchet C. Assessing farm sustainability with the IDEA method: from the concept of agriculture sustainability to case studies on farms. *Sustain Dev.* 2008;16(4):271-281.
17. Food and Agriculture Organization of the United Nations. Sustainability assessment of food and agriculture systems (SAFA) guidelines 3.0. Rome: FAO; 2013.
18. Aria M, Cuccurullo C. Bibliometrix: an R-tool for comprehensive science mapping analysis. *J Informetr.* 2017;11(4):959-975.