

Global Research Disparities in the Use of Indigenous Knowledge in Enhancing Species Conservation: A 25 -Year Bibliometric Analysis (2000 – 2025)

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Abstract

Indigenous knowledge (IK) is increasingly recognized as important for biodiversity conservation, yet the global structure of this research and the conservation practices represented in the scientific literature remain unevenly understood. This study combined bibliometric analysis and evidence synthesis to examine global research on IK and biodiversity conservation from 2000 to 2025. Following PRISMA-guided screening, we analyzed 1,387 eligible research articles retrieved from Web of Science, Scopus, and Google Scholar using Bibliometrix and thematic coding. Publication output expanded markedly, particularly after 2019, demonstrating growing scientific recognition of IK in conservation. However, research production was geographically uneven, with the United States and Canada leading publication output, alongside important contributions from India, Brazil, Australia, China, Mexico, South Africa, and Ethiopia. Three interconnected intellectual themes emerged: traditional ecological knowledge (TEK) and resource management; IK, biodiversity, and sustainable development; and ethnobotanical and plant-based knowledge. Taxonomic coverage was strongly skewed towards plants (59%) and mammals (16.4%), while amphibians, fungi, molluscs, and crustaceans remained low represented. Across ecosystems, Indigenous conservation practices were dominated by sustainable and seasonal harvesting, sacred and ritual restrictions, customary institutions, collaborative management, and traditional fire management. These practices supported conservation through adaptive, context-specific resource management and culturally embedded restrictions on resource exploitation. Despite growing recognition, substantial geographical and taxonomic evidence gaps persist. Addressing these disparities requires expanding research into underrepresented regions and taxa while moving beyond documenting IK towards Indigenous-led research, knowledge governance, equitable partnerships, and recognition of customary institutions in biodiversity conservation.

1 Introduction

Biodiversity loss has emerged as one of the most pressing global environmental crises of the 21st century, driven by anthropogenic pressures including habitat degradation, climate change, and unsustainable resource exploitation (IPBES, 2019; WWF, 2024). The accelerating rate of species extinction and ecosystem collapse has prompted urgent calls for more inclusive, effective, and socially just conservation approaches (CBD, 2020). In response, IK, also referred to as Traditional Ecological Knowledge (TEK), has gained increasing recognition as a valuable, place-based, and intergenerationally transmitted body of observations, practices, and beliefs developed through long-term interactions between Indigenous peoples and their environments (Berkes, 2012; Reyes-García et al., 2019). Indigenous peoples and local communities (IPLCs) manage or influence a substantial proportion of the world's remaining high-biodiversity landscapes, and their stewardship practices have repeatedly demonstrated contributions to ecosystem resilience, sustainable resource use, and adaptive management (UNESCO, 2017; IUCN, 2025). Consequently, international frameworks such as the Convention on Biological Diversity (CBD), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), and UNESCO have increasingly emphasized integrating IK into global biodiversity governance and conservation policy (IPBES, 2019; UNESCO, 2026).

A growing body of scholarly literature has documented the relevance of IK across multiple conservation domains, including ethnobotany, community-based natural resource management, climate adaptation, and protected area governance (Gadgil et al., 1993; Folke et al., 2005; Charnley et al., 2007; Bohensky & Maru, 2011). Recent review studies have confirmed a steady increase in scientific output on IK systems, particularly since the early 2000s, reflecting expanding interdisciplinary interest across environmental sciences, ethnobiology, and sustainability studies (Liu et al., 2022; Ebhuoma, 2024; Borolla et al., 2024; Gondo, 2025).

Despite this growing scholarship, several important gaps remain in existing review studies. First, many reviews rely on a single bibliographic database, such as Web of Science or Scopus, potentially introducing disciplinary and geographical coverage biases. Second, previous syntheses have often focused on specific domains of IK, including climate adaptation and agriculture, rather than examining its broader contribution to biodiversity conservation. Third, little attention has been given to the taxonomic composition of the evidence base, including which taxa and species have been most extensively studied and which remain underrepresented. Fourth, few global reviews have systematically examined how Indigenous conservation practices vary across ecosystems and the mechanisms through which these practices are linked with biodiversity outcomes. Consequently, the global evidence base remains fragmented across disciplines, ecosystems, taxa, and geographical regions, limiting a comprehensive understanding of how IK contributes to biodiversity conservation.

To address these gaps, this study combines bibliometric analysis with a systematic evidence synthesis to examine global research on IK in biodiversity conservation between 2000 and 2025. (Jeyashree et al, 2026). Unlike previous reviews that have primarily focused on publication trends or specific applications of IK, this study integrates science mapping with taxonomic, ecosystem-specific, and conservation-outcome analyses. Specifically, it examines the geographical and institutional structure of knowledge production, identifies the taxa and ecosystems represented in the literature, documents Indigenous conservation practices across major ecosystem types, and synthesizes the mechanisms and reported biodiversity outcomes associated with these practices. By linking patterns of scientific knowledge production with the ecological and institutional pathways through which IK contributes to conservation, the study provides a more comprehensive assessment of both the development and substantive conservation contribution of this field.

Thus, this study addresses the following research questions:

1. How has global research on IK and biodiversity conservation evolved between 2000 and 2025 in terms of publication output and major research themes?
2. How is IK-based biodiversity conservation distributed geographically across the globe?
3. Which ecosystems and taxonomic groups have received the greatest research attention, and which remain underrepresented in the IK research

4. What Indigenous conservation practices are currently in practice across the globe?
5. Through what mechanisms does IK contribute to biodiversity conservation, and what conservation outcomes are reported in the existing literature?

2 Materials and Methods

2.1. Study Design and Bibliometric Approach

This study employed a quantitative bibliometric approach to systematically map and evaluate global research on IK in biodiversity conservation. Bibliometric analysis was selected because it enables the quantitative assessment of publication trends and thematic development within a scientific field (Donthu et al., 2021). This approach is particularly well-suited for interdisciplinary fields such as IK research, where knowledge production spans the natural sciences, social sciences, and humanities. The analysis followed established protocols for science mapping and performance analysis (Zupic & Čater, 2015; Aria & Cuccurullo, 2017), incorporating performance indicators (such as publication volume) and science mapping techniques (such as keyword co-occurrence)

2.2 Database Selection and Search Strategy

2.2.1 Database Selection

Bibliographic data were retrieved from three multidisciplinary databases, such as Web of Science Core Collection, Scopus, and Google Scholar. These databases were selected for three reasons. First, they collectively provide comprehensive coverage of peer-reviewed literature across natural sciences, social sciences, and humanities, which is essential for capturing the interdisciplinary nature of IK research (Mongeon & Paul-Hus, 2016). Second, both databases supply reliable bibliographic metadata for bibliometric analysis, including citations, author affiliations, and funding acknowledgments (Harzing & Alakangas, 2016). Third, using two complementary databases reduces the risk of omitting relevant publications, as Web of Science typically offers stronger coverage of natural sciences while Scopus provides broader journal coverage, including regional and interdisciplinary titles (Mongeon & Paul-Hus, 2016).

2.2.2 Search Query Construction

The search strategy was developed iteratively to maximize the retrieval of relevant literature on IK and biodiversity conservation, following best practices for bibliometric searches (Harzing & Alakangas, 2016). We used a two-stage search approach because it helps to balance high recall (finding all relevant studies) with high precision (reducing irrelevant records). The search strings used are:

Primary search string

("indigenous knowledge" OR "traditional ecological knowledge" OR "traditional knowledge" OR "local ecological knowledge" OR TEK) AND (conservation OR biodiversity OR "species conservation" OR

"wildlife conservation")

Secondary search string ("indigenous knowledge" OR "traditional ecological knowledge") AND (conservation OR biodiversity) AND (mechanism* OR practice* OR governance OR taboo* OR "sacred site*" OR "traditional management")

The search was restricted to article titles, abstracts, and author keywords to minimize the retrieval of irrelevant documents and ensure substantive relevance to the research topic (Abas et al., 2025). The final search query was executed identically in both databases on the same date to ensure temporal consistency.

2.3 Temporal Scope and Document Type

The review included the articles published between the years 2000 and 2025. The documents analyzed were limited to research articles. Editorial, review, conference papers, book chapters, and notes were excluded from the main analysis to ensure methodological consistency, as research articles involve original studies conducted using peer-reviewed methodology. However, review articles were also considered separately to provide historical context for intellectual developments in the field. The language used was restricted to English to maintain text homogeneity and to use available metadata from the chosen databases (Liu et al., 2022).

2.4 Data Processing and Eligibility Assessment

2.4.1 Data Retrieval and Duplicate Removal

The initial search yielded 18,497 papers: Web of Science (n = 7582), Scopus (n = 10415), and Google Scholar (n = 500). For Google Scholar, screening was restricted to the first 500 relevance-ranked records because the relevance of retrieved records declined substantially beyond this point. Google Scholar was therefore used to identify potentially relevant literature not indexed in Web of Science or Scopus. All records were exported in plain-text and CSV formats containing full bibliographic information (authors, themes or keyword co-occurrence network, taxa, species protected by IK, ecosystem types, year of publication, and funding acknowledgements). Duplicate detection and removal were performed using the Bibliometrix R package (Aria & Cuccurullo, 2017), which identifies duplicates based on digital object identifier (DOI), title, and author combinations. Suspicious records were manually verified by comparing author names, publication years, journal titles, and page numbers. A total of 8,113 duplicate records were removed, leaving 10,384 records for screening.

2.4.2 Eligibility Screening Using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-Based)

Screening followed the PRISMA guidelines, adapted for bibliometric studies (Page et al., 2021; Moyo et al., 2025). Two screening phases were applied. First, titles and abstracts were reviewed against

predefined inclusion criteria: (a) peer-reviewed research articles; (b) written in English; (c) content explicitly addressing IK, TEK, or local knowledge in the context of biodiversity conservation, nature conservation, or natural resource management; and (d) complete bibliographic metadata available. Exclusion criteria included: (a) non-English publications; (b) review articles, editorials, commentaries, or book reviews; (c) studies focused exclusively on agricultural knowledge without biodiversity conservation elements; and (d) articles where IK was not central to the research content. Two reviewers independently screened titles and abstracts against the predefined eligibility criteria. Disagreements were resolved through discussion and consensus. Out of 10,384 papers, 8997 papers were excluded primarily because they did not address IK, lacked conservation elements, or were not original research articles and were not published between 2000 and 2025. The final analytical sample comprised 1,387 research articles.

2.5 Data analysis

2.5.1 Publication Trend Analysis

To understand the publication trend in IK within the temporal scale of our analysis, we calculated the annual publication trend by extracting the total number of papers per year from the 1,387 included articles. The Compound Annual Growth Rate (CAGR) was calculated using the formula such as those of Bornmann & Mutz (2015).

$$\text{CAGR} (\%) = \left[\left(\frac{P_t}{P_0} \right)^{\frac{1}{n}} - 1 \right] \times 100$$

where P_0 is the number of publications in the initial year, P_t is the number in the final year, and n is the number of years between the two observations. To report CAGR as a percentage:

2.5.2 Analysis of the relationship between country's publication and development level

We conducted the correlation analysis to test whether a country's level of income development was related to its country-level knowledge production in IK and conservation research using negative binomial regression. The model was chosen because the number of publications per country was count data. The Gross national income (GNI) per capita for 2023, expressed in purchasing-power-parity-adjusted 2021 US dollars, was used to reflect the country's level of economic development. The data were obtained from the Human Development Report dataset (Refs). The data were natural-log transformed to reduce right skewness and permit elasticity-based interpretation. The model was estimated with a log link using the glm function in the MASS package in R, with statistical significance assessed at $p < .05$. The model used the following formula:

$$\text{Papers}_i \sim \text{NB}(\mu_i, \theta), \quad \log(\mu_i) = \beta_0 + \beta_1 \log(\text{GNIpc}_i)$$

Where: $\mu_i = E(\text{Papers}_i)$, θ is the dispersion parameter, and i denotes country

2.5.3. Similarity Index

Species-level commonality among countries was assessed using an incidence-based country-by-species matrix in which a value of one indicated that a species benefiting from IK was documented in a country and zero indicated its absence from the reviewed literature. Pairwise Jaccard similarity coefficients were calculated to quantify the proportion of species shared between countries, while Sørensen similarity was used as a sensitivity measure. Countries were assigned to Africa, the Americas, Asia, Europe or the Pacific using United Nations regional classifications. Regional differences in documented species composition were tested using permutational multivariate analysis of variance with 9,999 permutations, controlling for country-level publication effort. Homogeneity of multivariate dispersion was examined before interpreting the PERMANOVA results. Total Jaccard dissimilarity was further partitioned into turnover and nestedness components to determine whether geographical differences reflected species replacement or variation in documented species richness.

2.5.4. Identification and Classification of Indigenous Conservation Practices

To investigate how IK contributes to biodiversity conservation, eligible studies were further examined to identify Indigenous conservation practices across major ecosystem categories: forest, coastal/marine, freshwater, agroecosystem, wetlands, mountain, grassland/rangeland and wildlife ecosystems. Following title and abstract screening, the bibliographic database was imported into Microsoft Excel for thematic coding, with particular attention given to the abstract (AB) field because it provides concise information on study objectives, conservation practices, and principal findings. A deductive coding approach was applied using a predefined framework derived from the IK and conservation literature. Each abstract was systematically examined for explicit references to Indigenous conservation practices and synonymous or closely related terminology. For each eligible study, the paper identifier, ecosystem category, identified Indigenous conservation practice(s), and geographical location (country or study area) were extracted and recorded in a standardized database for subsequent synthesis.

The coding framework incorporated ecosystem-specific practices. Forest practices included sacred forests and groves, customary tenure, selective and rotational harvesting, traditional fire management, and community-based forest governance; coastal/marine practices included customary marine tenure, seasonal closures, traditional no-take areas, gear restrictions, rotational fishing grounds, and protection of spawning or culturally important marine habitats; and freshwater practices included customary fishing rules, seasonal fishing calendars and closures, sacred rivers, lakes and pools, gear restrictions, and community fisheries management. Agroecosystem practices encompassed agroforestry, traditional crop and seed conservation, intercropping, crop rotation, and maintenance of agrobiodiversity, while wetland-practices included seasonal access restrictions, customary harvesting rules, sacred wetlands, and community stewardship. Mountain practices included sacred mountain landscapes, customary management of highland forests and pastures, rotational grazing, and culturally regulated resource use.

Finally, wildlife practices included hunting taboos and seasonal restrictions, totem and clan-based species protection, sacred wildlife areas, selective hunting, customary hunting prohibitions, and Indigenous tracking and monitoring. Closely related terminology was included where appropriate to capture variation in how Indigenous conservation practices were described across studies and geographical contexts.

2.5.5. Content analysis

Following extraction, Indigenous conservation practices were grouped according to ecosystem type (forest, freshwater, marine/aquatic, wetlands, agroecosystem, mountain, grassland/rangeland and wildlife) and summarized descriptively. Studies reporting multiple Indigenous practices were coded under all applicable categories. The resulting evidence tables were used to identify the diversity and geographical distribution of Indigenous conservation practices and to synthesize the principal mechanisms through which IK may potentially contribute to biodiversity conservation across different ecological systems. This ecosystem-specific classification provided the basis for subsequent content analysis linking Indigenous conservation practices to reported biodiversity outcomes.

Source: Modified from Moyo et al. (2025).

Table 1
Inclusion and exclusion criteria

Category of criteria	Inclusion	Exclusion
Document type	Articles	Review, editorial material, notes
Language	English	Non-English
Scope	Local knowledge, traditional knowledge, Traditional ecological knowledge	
Temporal scale	2000–2025	Before 2000

3 Results

3.1 Global IK Production trend over time

The annual publication trend shows a substantial long-term expansion of Indigenous conservation research between 2000 and 2025 (Fig. 2). Publication output increased from approximately eight papers in 2000 to 225 papers in 2025, representing more than a 28-fold increase over the study period. The trajectory can be divided into three broad phases: a low-output formative period from 2000 to 2008, a period of gradual but fluctuating growth from 2009 to 2018, and a phase of rapid expansion from 2019 onward. Despite several short-term declines, the overall trend remained strongly upward.

During the formative period, annual output generally remained below 25 publications. Approximately eight papers were published annually in 2000 and 2001, followed by minor fluctuations and a temporary decline to about five publications in 2004. Output subsequently increased steadily from approximately 14 papers in 2005 to 24 in 2008. The following decade was characterized by higher but more variable productivity, rising from approximately 32 publications in 2009 to 61 in 2018. Notable fluctuations occurred during this period, including declines from about 47 papers in 2014 to 31 in 2015 and from 56 in 2016 to 42 in 2017, followed in each case by a strong recovery.

The most pronounced growth occurred from 2019 onward. Annual output increased from approximately 81 publications in 2019 to 94 in 2020 and exceeded 100 papers for the first time in 2021. The number of publications continued to rise to about 109 in 2022, 114 in 2023, and 142 in 2024 before reaching a peak of 225 in 2025. The increase of approximately 83 papers between 2024 and 2025, equivalent to nearly 59%, was the largest annual rise observed across the entire period. The temporal trend indicates that Indigenous conservation research has transitioned from a relatively small field with limited annual output into a rapidly expanding area of global scholarship.

3.3. Spatial Distribution of the Use of IK in Biodiversity Conservation

Global distribution of research on IK and biodiversity conservation. The geographical distribution of publications revealed a highly uneven pattern of country-level research productivity (Fig. 4). The United States recorded the largest output, with 422 publications, followed by Canada with 351. India ranked third with 290 publications, closely followed by Brazil with 283, while Australia and China contributed 222 and 160 publications, respectively. These six countries formed the principal global centers of Indigenous conservation scholarship. Mexico also recorded a comparatively substantial output of 119 publications, indicating that the highest productivity was concentrated in a limited number of countries across North America, South America, Asia, and Oceania.

The observed disparities were also seen within regions. In the Americas, publication output was dominated by the United States, Canada, Brazil, and Mexico, whereas Colombia and Peru recorded substantially smaller totals of 36 and 23 publications, respectively. European productivity was more widely distributed but remained below that of the leading countries: Spain produced 94 publications, Germany 76, and the United Kingdom 57. In Asia, India and China were the dominant contributors, substantially exceeding the output of other countries in the region. Australia was the leading contributor in Oceania, with 222 publications, making it one of the six most productive countries globally.

Africa showed a geographically dispersed but comparatively low level of research productivity. South Africa was the continent's leading contributor with 107 publications, followed by Ethiopia with 91 and Kenya with 30. Most other African countries recorded fewer than 20 publications, while several countries had either very limited output or no visible representation.

Generally, the geographical distribution shows that Ik conservation research has a global presence but remains spatially concentrated in a small number of highly productive countries. (Fig. 4).

Furthermore, negative binomial regression results (Table 2) showed that log-transformed GNI per capita significantly predicted the number of publications ($\beta = 0.55$, $SE = 0.138$, $p < 0.05$). This indicates that a 1% increase in GNI per capita is associated with an expected increase in publication output of approximately 0.55%. Although the model reduced deviance from 208.84 to 195.14, the low dispersion parameter ($\theta = 0.205$) indicated considerable unexplained heterogeneity across countries. Overall, these results suggest that highly developed countries produce a higher number of publications on IK and biodiversity conservation research than less developed countries.

Table 2 Negative binomial regression of country-level Indigenous knowledge conservation research productivity on Gross National Income (GNI)					
Predictor	β	SE	95% CI for β	IRR	z
Intercept	-2.425	1.324	-5.020, 0.170	0.089	-1.831
Log (GNI per capita)	0.550**	0.138	0.281, 0.820	1.734	4.000

Notes: *sign* ** $p < 0.01$, * $p < 0.05$. The dependent variable is the number of publications on IK and conservation produced by each country. GNI per capita was measured in 2023 purchasing-power-parity-adjusted 2021 US dollars and was natural-log transformed. IRR = incidence-rate ratio; CI = confidence interval.

3.5 Primary research themes on IK for biodiversity conservation

The keyword co-occurrence network revealed three major research themes (Fig. 5). The first and largest theme, represented by the red cluster, centered on TEK, conservation, and natural-resource management. “Conservation” was the most prominent and highly connected keyword, with strong links to “TEK” and “management.” Other associated keywords, including “local ecological knowledge,” “governance,” “resilience,” “protected areas,” “ecosystem services,” “fisheries,” “forest,” “communities,” “climate change,” and “biocultural diversity”, indicate that this body of research primarily examines how community-based knowledge and practices contribute to biodiversity conservation, ecosystem management, and responses to environmental change.

The second theme represented by the blue cluster focused on Indigenous knowledge, biodiversity, and sustainable development. Its principal keywords, “IK,” “traditional knowledge,” and “biodiversity”, were closely associated with “Indigenous peoples,” “Indigenous communities,” “conservation management,” “sustainability,” “adaptation,” “food security,” and “sustainable development.”

The third theme represented by the green cluster is a smaller and more specialized theme concerned with ethnobotanical and plant-based knowledge, comprising keywords such as “ethnobotany,”

“ethnoecology,” “plants,” “medicinal plants,” “diversity,” and “resources.” The dense connections among the three clusters, particularly through “conservation,” “biodiversity,” “traditional knowledge,” and “IK”, show that the literature is interdisciplinary, linking ecological knowledge systems with conservation practice, community livelihoods, and the sustainable use of biological resources.

3.6 Taxonomic Distribution and Species Protected Under IK Research

Taxonomic concentration in studies examining IK and biodiversity conservation. The results show a total of 157 species were identified, and that plants accounted for more than half of all identified taxonomic records (59%), making them the dominant focus of the literature. Mammals were the second most frequently represented group (16.4%), followed by fish (8.4%) and insects (6.2%). Together, plants and mammals constituted 75.4% of the recorded taxonomic coverage, demonstrating that published evidence on Indigenous conservation knowledge has centered primarily on plant resources and mammalian species. Birds (3.9%) and reptiles (3.3%) received comparatively limited attention.

The remaining taxonomic groups were sparsely represented: molluscs accounted for 1.3% of records, fungi for 1.2%, while crustaceans were the least represented group at 0.9%. Overall, the results reveal a substantial taxonomic imbalance in the available evidence, with research on plants being approximately seven times more common than research on fish and nearly ten times more common than research on insects. This concentration identifies an important knowledge gap concerning how IK contributes to the conservation of fungi, amphibians, molluscs, crustaceans, reptiles, and invertebrates. However, their limited representation in the dataset reflects gaps in the documented scientific literature and should not be interpreted as evidence that IK concerning these taxa is absent.

The relationship between total research frequency and the number of distinct species documented was not proportional. Although plants dominated the research records (59%), they represented 36.9% of the scientific names listed in (Appendix 1). Conversely, mammals constituted only 16.4% of the research distribution but accounted for the largest proportion of named species (40.8%), suggesting broader species-level coverage within mammal-focused studies. Birds similarly represented only 3.9% of the research records but accounted for 13 species (8.3%), including the grey crowned crane (*Balearica regulorum*), military macaw (*Ara militaris*), and Raggiana bird-of-paradise (*Paradisaea raggiana*). Less represented groups included insects such as *Apis cerana* and *Apis mellifera*, crustaceans such as *Ucides cordatus* and *Pandalus borealis*, and amphibians such as *Andrias davidianus*.

Furthermore, the results of the similarity index with unadjusted country-pair comparisons showed generally low commonality, with the mean Jaccard similarity ($J = 0.056$) for countries within the same region and 0.048 for countries from different regions. The most similar country pairs were Ethiopia and Nepal ($J = 0.344$), Zimbabwe and Nepal ($J = 0.333$), and Zimbabwe and Malaysia ($J = 0.308$), although these cross-regional similarities were partly associated with shared broad taxonomic categories. Among countries within the same region, Colombia and Peru exhibited relatively high overlap ($J = 0.250$), followed by Cameroon and Nigeria ($J = 0.227$), and Nigeria and Zimbabwe ($J = 0.222$).

The mean Jaccard similarity was higher within regions ($J = 0.101$) than between regions ($J = 0.083$). Within-region similarity was highest among Asian countries ($J = 0.123$), followed by African countries ($J = 0.113$), whereas similarity among countries in the Americas was lower ($J = 0.063$). Cross-regional overlap was highest between African and Asian countries ($J = 0.113$), followed by countries in the Americas and Asia ($J = 0.087$). These findings indicate that geographical proximity was associated with slightly greater taxonomic commonality, although considerable sharing also occurred across regions.

3.7 The IK practices across various ecosystems

Ecosystem and indigenous practices from the reviewed studies. (Table 3). Harvesting emerged as the most frequently recorded practice across all ecosystem categories. It was most prevalent in freshwater ecosystems ($n = 181$), forests ($n = 146$), coastal/marine ecosystems ($n = 77$), agroecosystems ($n = 66$), and wildlife systems ($n = 50$). Harvesting was also the leading practice in mountain ($n = 27$), grassland/rangeland ($n = 12$), and wetland ecosystems ($n = 7$).

Seasonal practices were particularly prominent in aquatic ($n = 104$) and coastal/marine ecosystems ($n = 49$), whereas ritual practices were most frequently associated with forests ($n = 63$), aquatic ecosystems ($n = 59$), agroecosystems ($n = 52$), and wildlife systems ($n = 45$). Sacred practices were concentrated in forests ($n = 80$), followed by aquatic ecosystems ($n = 29$), wildlife systems ($n = 13$), and mountain ecosystems ($n = 8$). Customary practices and taboos were also more frequently documented in forest and wildlife contexts than in agricultural, wetland, or grassland systems.

Governance and knowledge-transmission practices occurred less frequently but displayed ecosystem-specific patterns. Co-management was most common in aquatic ($n = 27$) and coastal/marine ecosystems ($n = 20$), while oral traditions were primarily reported in freshwater ($n = 22$) and coastal/marine settings ($n = 16$). Rotational practices were uncommon and occurred mainly in aquatic and coastal/marine ecosystems, whereas traditional fire, totemic practices, and community management were recorded only sporadically.

Table 3
IK practices by ecosystems

Ecosystems	Indigenous practices (frequency)
Freshwater	Harvesting (181), seasonal practices (104), rituals (59), sacred practices (29), co-management (27), customary practices (24), oral traditions (22), taboos (14), rotational practices (4), and traditional fire (2).
Forest	Harvesting (146), sacred practices (80), rituals (63), customary practices (47), taboos (24), seasonal practices (15), totemic practices (7), rotational practices (2), oral traditions (2), and co-management (1).
Coastal/Marine	Harvesting (77), seasonal practices (49), rituals (41), co-management (20), customary practices (18), oral traditions (16), taboos (8), sacred practices (7), rotational practices (3), and traditional fire (2).
Agroecosystem	Harvesting (66), rituals (52), seasonal practices (18), customary practices (11), sacred practices (6), oral traditions (3), rotational practices (1), taboos (1), and co-management (1).
Wildlife	Harvesting (50), rituals (45), customary practices (13), sacred practices (13), taboos (13), co-management (4), totemic practices (1), oral traditions (1), and community management (1).
Mountain	Harvesting (27), rituals (8), sacred practices (8), customary practices (2), taboos (1), and seasonal practices (1).
Grassland/Rangeland	Harvesting (12), rituals (7), co-management (5), seasonal practices (2), taboos (1), rotational practices (1), and customary practices (1).
Wetland	Harvesting (7), rotational practices (2), and seasonal practices (1).
Mixed-ecosystem	Harvesting (23), customary practices (13), rituals (10), taboos (6), sacred practices (4), totemic practices (4), co-management (4), traditional fire (3), and community management (1).

3.8 Global Distribution of IK in Conservation Research Across Ecosystems

The geographical distribution of IK research reveals substantial variation across ecosystem types and regions. Research on forest, freshwater, wildlife, and coastal/marine ecosystems shows the broadest geographical coverage, with particularly high research intensity in North America, Brazil, China, India, parts of Southeast Asia, and Australia, although the relative concentration varies by ecosystem. Forest-related IK research is especially prominent in India, China, Brazil, and parts of Southeast Asia, while freshwater research exhibits strong concentrations in North America, Brazil, India, China, Australia, and selected African countries. Wildlife research is comparatively concentrated in Brazil, India, China, and parts of southern Africa, whereas coastal and marine research is particularly prominent in North America, Brazil, China, Southeast Asia, Australia, and South Africa. In contrast, wetland, grassland/rangeland, and mountain ecosystems have much more restricted geographical coverage, with large parts of the world showing no documented studies; mountain research is particularly concentrated in India, China, and South Africa, while grassland research is most visible in China. Agroecosystem

research is more geographically widespread than these less-studied ecosystems, with notable concentrations in Mexico, India, China, Australia, Brazil, and parts of Africa.

3.9 Potential contribution of IK to biodiversity conservation

The synthesis identified five main categories through which IK contributed to species and biodiversity conservation. Sustainable and seasonal harvesting accounted for the largest number of coded biodiversity-outcome occurrences (29), followed by sacred and ritual restrictions (26), customary knowledge and institutions (14), community-based and collaborative management (9), and traditional fire management (2). Sustainable harvesting practices, including seasonal closures, rotational harvesting, and locally regulated resource extraction, were associated with sustainable harvests, habitat protection and restoration, and species abundance. Sacred sites, taboos, rituals, and totemic restrictions also supported conservation by limiting access to ecologically or culturally important species and habitats. Customary institutions and community management further enabled the transmission and collective enforcement of conservation knowledge and rules.

Across the 80 coded mechanism-outcome occurrences, the dominant mechanism was the use of traditional or local ecological knowledge to support adaptive and context-specific resource management (54 occurrences; 67.5%). Cultural norms restricting the exploitation of protected species constituted the second most frequent mechanism (23; 28.8%), while spatial rotation that allowed harvested areas or populations to recover occurred less frequently (3; 3.8%). The most reported outcomes were general conservation (47) and biodiversity conservation (19), followed by increased or maintained species abundance (5), sustainable harvesting (4), habitat protection (2), ecosystem resilience (2), and habitat restoration (1).

Table 4

Indigenous Conservation Practices, Possible underlying Mechanisms, and Biodiversity Outcomes

Merged Indigenous practice (category)	Indigenous practice	Conservation mechanism	Biodiversity conservation outcomes (frequency)
Sustainable and seasonal harvesting	harvest; seasonal; rotational	Traditional/local ecological knowledge informs adaptive and context-specific resource management	conservation (11); biodiversity conservation (4); sustainable harvest (3); habitat protection (1); habitat restoration (1); species abundance (1)
Sacred and ritual restrictions	ritual; sacred; taboo; totem	Traditional/local ecological knowledge informs adaptive and context-specific resource management	conservation (8); biodiversity conservation (4); ecosystem resilience (1); habitat protection (1); sustainable harvest (1)
Sacred and ritual restrictions	ritual; sacred; taboo; totem	Cultural norms restrict exploitation of protected species	conservation (7); biodiversity conservation (3); species abundance (1)
Customary knowledge and institutions	customary; oral tradition	Traditional/local ecological knowledge informs adaptive and context-specific resource management	conservation (6); biodiversity conservation (2); ecosystem resilience (1)
Community-based and collaborative management	co-management; community management	Traditional/local ecological knowledge informs adaptive and context-specific resource management	conservation (5); biodiversity conservation (2)
Customary knowledge and institutions	customary; oral tradition	Cultural norms restrict exploitation of protected species	conservation (3); biodiversity conservation (1); species abundance (1)
Sustainable and seasonal harvesting	harvest; seasonal; rotational	Cultural norms restrict exploitation of protected species	conservation (3); biodiversity conservation (1); species abundance (1)
Sustainable and seasonal harvesting	harvest; seasonal; rotational	Spatial rotation allows harvested areas or populations to recover	conservation (2); biodiversity conservation (1)
Community-based and collaborative management	co-management; community management	Cultural norms restrict exploitation of protected species	conservation (1); species abundance (1)
Traditional fire management	traditional fire	Traditional/local ecological knowledge informs adaptive and context-specific resource management	biodiversity conservation (1); conservation (1)

4 Discussion

This review revealed that research on IK in species conservation has moved from a comparatively small to a rapidly expanding scholarly discipline. The temporal trajectory indicates both maturation and a change in the normative center of the field. The early phase was dominated by demonstrations that local observations could improve ecological monitoring, harvest regulation and species management. This orientation is consistent with foundational accounts of TEK as a form of adaptive management grounded in cumulative observation, feedback and learning (Berkes et al., 2000; Johannes, 2002). The pronounced post-2019 publication acceleration coincides with broader recognition of Indigenous Peoples and local communities in global biodiversity and climate governance, including the IPBES Global Assessment and the Kunming–Montreal Global Biodiversity Framework (CBD, 2022; IPBES, 2019). However, publication growth should not be equated with epistemic inclusion. An expanding literature may still reproduce asymmetries if Indigenous Peoples are positioned mainly as data providers, case-study populations or holders of knowledge that becomes authoritative only after scientific translation. Thus, the trend suggests that discipline has become significant in biodiversity conservation, while the quality of participation, leadership, consent and benefit sharing remains an empirical question.

The geography of publication reveals a research system that is more diverse than a simple North–South dichotomy but still shaped by unequal scientific capacity. This is also reinforced by the analysis on the relationship between countries' IK production and their development level, where highly developed countries had a higher number of publications. The United States and Canada lead national outputs, while Oxford and other institutions in Europe, North America and Australia feature prominently among the most productive organisations. At the same time, high output from India, Brazil, China and Mexico, and the presence of institutions in Benin, Ghana and Pakistan, demonstrate important regional centres of expertise. This implies that knowledge production is distributed across several regions, yet access to funding, research infrastructure, English-language publishing networks and high-visibility journals remains uneven and shapes knowledge productivity levels. Comparable structural disparities have been documented across climate-change research and conservation science (Blicharska et al., 2017; Clark & May, 2002), while the known coverage biases of Web of Science and Scopus can further reduce the visibility of locally published and non-English scholarship (Mongeon & Paul-Hus, 2016). Consequently, low-indexed output should not be read as weak local knowledge or limited conservation practice; it may instead reflect the location and rules of the scholarly communication system.

The co-occurrence network reinforces this interpretation. The centrality of conservation, traditional ecological knowledge, management, Indigenous knowledge and biodiversity shows that the field is held together by a practical concern with governing social–ecological systems. The first cluster links TEK to governance, resilience, protected areas, fisheries, forests and ecosystem services; the second links IK and biodiversity to sustainable development, adaptation and food security; and the third concentrates on ethnobotany, medicinal plants and ethnoecology. These clusters should not be treated as isolated subfields. Their dense cross-links imply a shared recognition that biodiversity outcomes are generated through relationships among knowledge, livelihood, institutions and place. The pattern is consistent with

the multiple-evidence-based approach, which seeks complementarities among knowledge systems without requiring one to be validated through another, and with resilience scholarship that locates conservation capacity in community institutions as well as ecological information (Ruiz-Mallén & Corbera, 2013; Tengö et al., 2014, 2017).

Taxonomic patterns show both the strengths and the blind spots of this knowledge base. Plants account for 59% of taxon-specific studies, a concentration that is coherent with the ethnobotanical cluster and with the importance of food, medicine, materials and culturally significant species in everyday livelihood systems. Mammals, although represented in fewer studies, account for the largest share of unique scientific-name entries, suggesting broad species-level attention that may reflect the policy prominence, detectability and cultural salience of vertebrates. In contrast, fungi, amphibians, crustaceans, molluscs and other invertebrates remain sparsely represented. Similar taxonomic biases are pervasive in conservation science, where well-described taxa receive disproportionate attention (Clark & May 2002; Troudet et al., 2017). Furthermore, the reviewed literature exhibited limited overlap in the taxon labels associated with IK conservation across countries. Within-region similarity was only marginally greater than between-region similarity, while turnover dominated the observed dissimilarity. These patterns imply the geographical structure of the published evidence base rather than verified differences in species benefiting from IK

The ecosystem and IK practice results demonstrate that practices contribute to conservation efforts by operating bundles of knowledge, norms and institutions rather than through discrete techniques. Harvesting and seasonal practices are most frequent in freshwater, forest, coastal and agroecosystems, while sacred restrictions are especially prominent in forests. This pattern is ecologically plausible: temporal closures, selective harvesting and access rules can align extraction with species phenology, migration or recruitment, while sacred sites and social taboos can function as locally legitimate restrictions on use (Bhagwat & Rutte, 2006; Colding & Folke, 2001). The prominence of customary knowledge and institutions similarly supports the view that successful resource governance depends on shared rules, monitoring and authority, not information alone (Cinner & Aswani, 2007; Ostrom, 1990). The limited empirical representation of rotational use, totemic practices, community management and fire stewardship should not be interpreted as marginal conservation value. Some practices are geographically specific, poorly indexed or described with heterogeneous terminology; fire stewardship, for example, has strong documented effects on habitat heterogeneity and biodiversity despite appearing infrequently in the coded corpus (Hoffman et al., 2021).

The coded mechanisms provide the clearest evidence for how IK contributes to conservation. Approximately two-thirds of recorded plausible pathways involved adaptive, context-specific management, and more than one-quarter involved cultural norms that restrict exploitation. Most reported outcomes concerned conservation or biodiversity conservation, with smaller numbers addressing species abundance, sustainable harvesting, habitat protection, resilience and restoration. These findings support a plausible pathway in which repeated observation informs decisions, customary norms regulate behaviour, and community institutions maintain compliance over time. They also caution

against reducing IK to a supplementary dataset for conventional management. Knowledge is inseparable from the relationships, responsibilities and governance systems through which it is generated and enacted (Berkes, 2018; Bohensky & Maru, 2011).

Findings of this review have several implications for biodiversity policy and practices. The Kunming–Montreal Global Biodiversity Framework explicitly calls for the effective participation of Indigenous Peoples and local communities and respect for their rights, knowledge and territories (CBD, 2022). The present results indicate that these commitments should be operationalized through funding and evaluation rules, not only through acknowledgement. Funders and journals could require transparent statements on community governance, consent, data stewardship, authorship and benefit sharing; allocate resources directly to Indigenous organizations and under-resourced regional institutions; and support outputs in locally relevant languages and formats. Conservation agencies should also evaluate customary institutions as governance arrangements rather than treating sacred restrictions, seasonal rules and collaborative management as informal supplements to state protection. This is consistent with evidence that Indigenous-managed lands can sustain vertebrate biodiversity at levels comparable to protected areas (Schuster et al., 2019) and that equitable conservation is more likely where local institutions and agency are recognized (Dawson et al., 2021).

Furthermore, future research should combine bibliometric analyses with in-depth relational and outcome-based analysis. First, scholarship should target the geographic gaps identified in North Africa, the Sahel, the Middle East, Central Asia, the Caribbean and parts of South America, while ensuring that gap-filling is locally led rather than externally extractive. Second, taxonomic coverage should extend to fungi, amphibians and invertebrates and incorporate folk classifications and multispecies relationships. Third, studies should test conservation outcomes using designs selected with communities, including longitudinal and comparative approaches where appropriate, while avoiding the assumption that Western ecological indicators exhaust what counts as success. Fourth, future bibliometric analyses should analyze local-language databases and grey literature. Finally, research evaluation should move beyond publication and citation counts to indicators of governance quality, continuity of stewardship, locally defined benefits and the durability of conservation outcomes.

5 Conclusion and Recommendations

The literature reviewed here has expanded rapidly and now presents IK as central to biodiversity conservation, climate adaptation and natural-resource governance. Its empirical core is strong: seasonal and sustainable harvesting, sacred and ritual restrictions, customary institutions, collaborative management and fire stewardship connect place-based knowledge to conservation outcomes. At the same time, the geography of authorship and institutional visibility remains unequal, and bibliometric recognition cannot be assumed to constitute epistemic justice. Moreover, IK studies should therefore be judged not only by how often IK is cited or incorporated, but by whether Indigenous Peoples and local communities shape research agendas, govern knowledge and data, receive material and intellectual benefits, and retain authority over their territories and stewardship institutions. A transition from

inclusion to IK governance would make conservation research both more equitable and more capable of responding to biodiversity loss. From this study, we recommend that: i. IK be integrated into modern biodiversity conservation since it has been revealed that IK has contributed to species, habitats, and ecosystem conservation to sustain species and ecosystems at large; ii. Future research on the contribution of IK to conservation at the localized level is recommended; iii. Building IK research capacity in low-income regions by empowering local universities, since Africa is underrepresented in IK production in biodiversity conservation.

Declarations

Conflict of Interest

The authors declared that they have no conflicts of interest

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Author Contribution

GAM wrote the proposal with the guidance of RB, RK, ARA, OH, and EN. Data collection was conducted by GAM. Methodology was written by GAM. Formal analysis and investigation were done by GAM with the guidance of RB, ARA, EN, RK, and OH. Writing—the original draft was done by GAM and edited by RB, RK, ARA, EN, and OH

Data Availability Statement

The bibliometric data used in this study were obtained from the Web of Science Core Collection, Scopus databases, and Google Scholar. Due to database licensing restrictions, the raw bibliographic records may not be publicly redistributed. Processed datasets and analytical scripts used for the bibliometric analysis are available from the corresponding author upon reasonable request. Researchers with access to the Web of Science, Scopus, and Google Scholar databases can replicate the study using the search strategy and methodological procedures described in this article.

I, **Gregory Alphonse Mtega**, declare that this manuscript is my own original work and that it has not been submitted to any other journals for a similar or any other publication.

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Figures

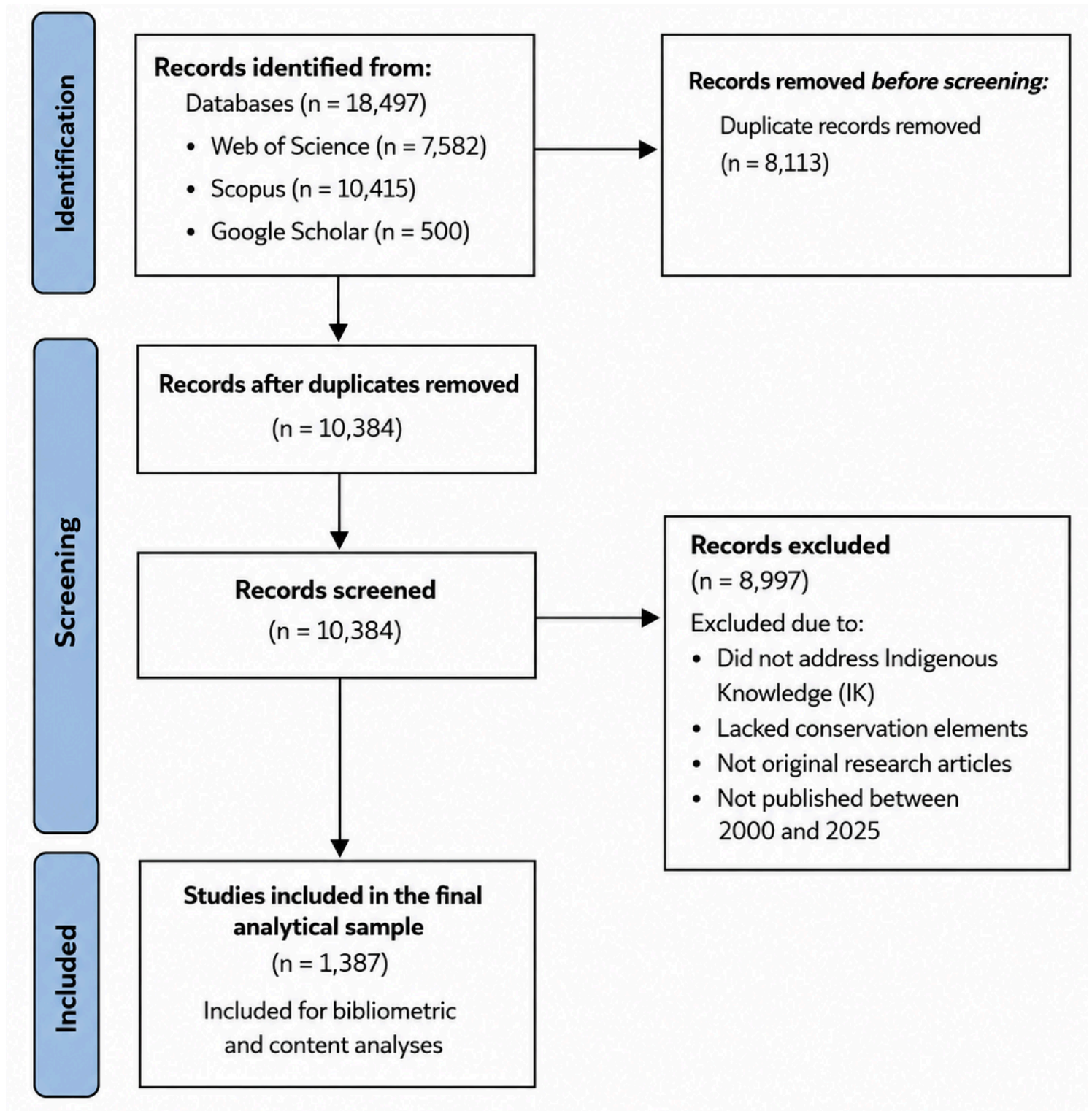


Figure 1

PRISMA diagram adopted for screening studies for bibliometric analysis

Source: Modified from Moyo et al. (2025).

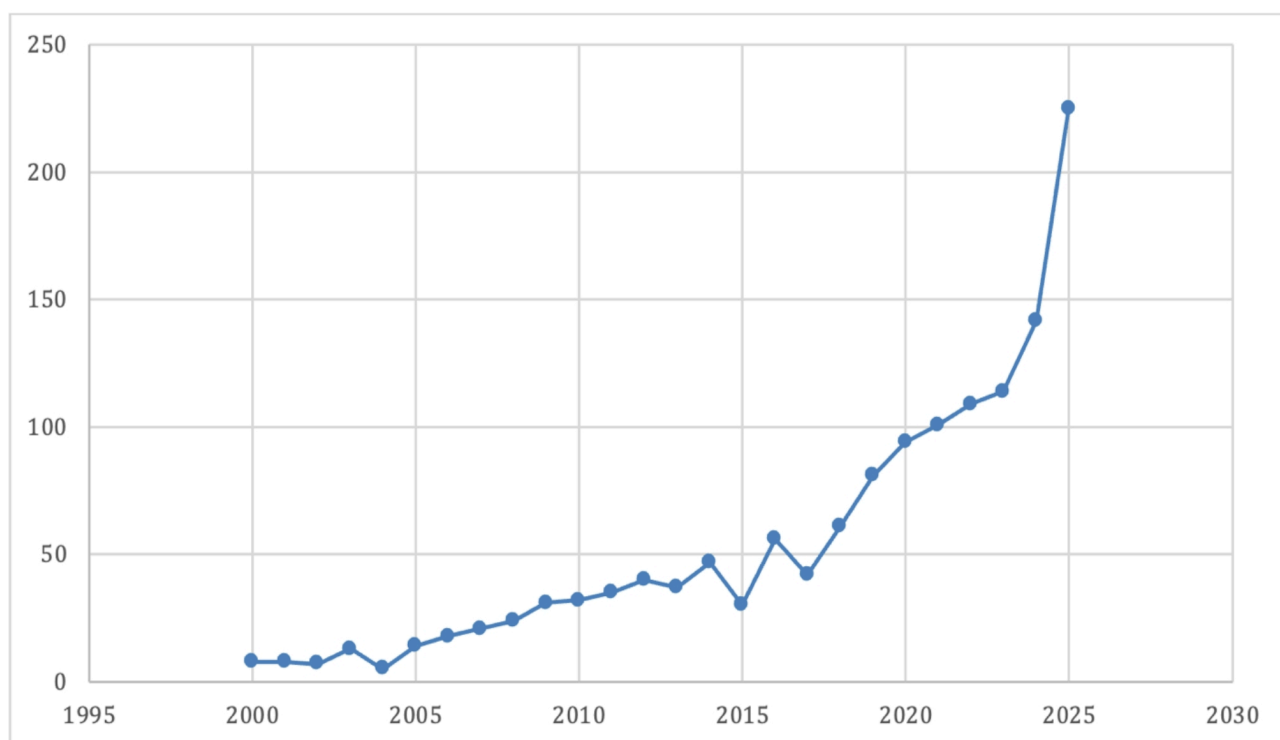


Figure 2

Trend of scientific publications on indigenous knowledge and biodiversity conservation from 2000 to 2025.

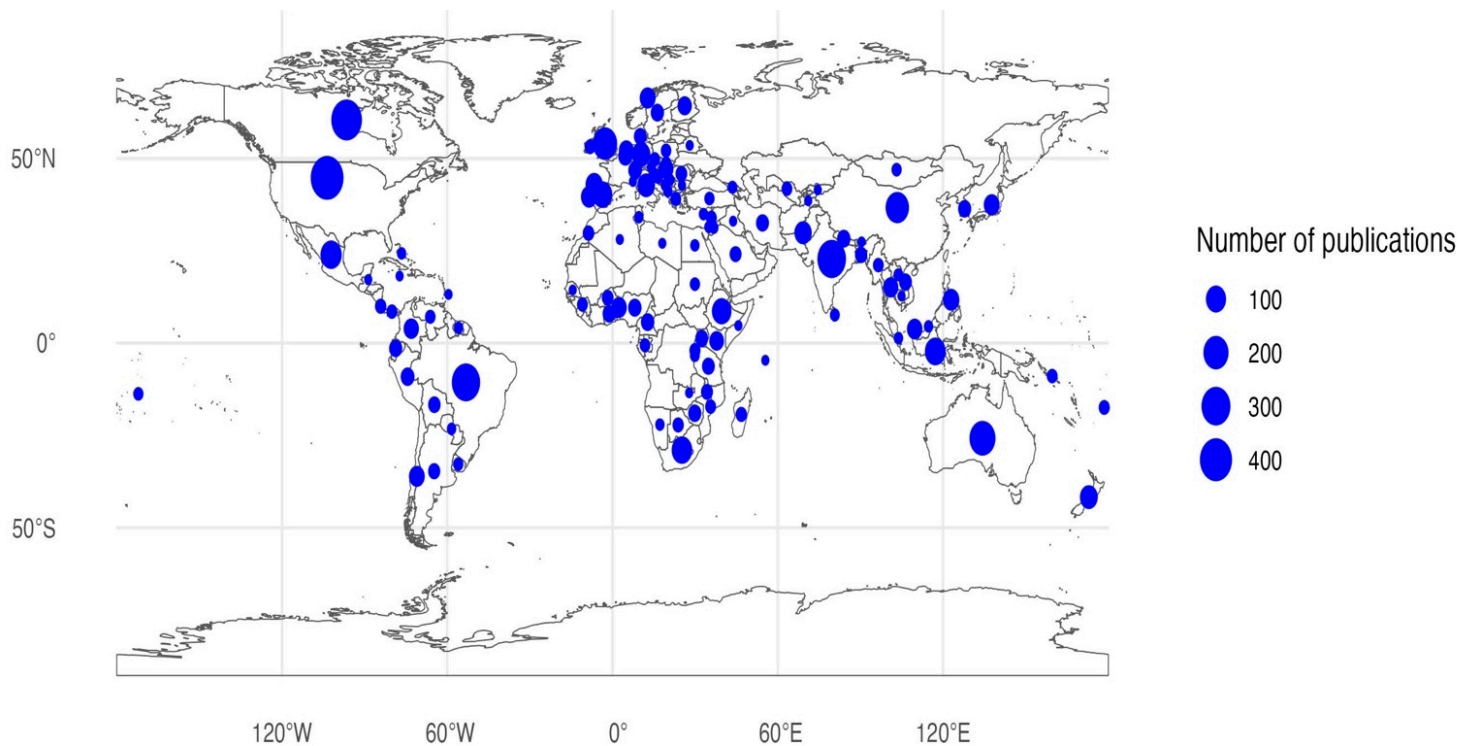


Figure 3

4. The level of publication productivity per country

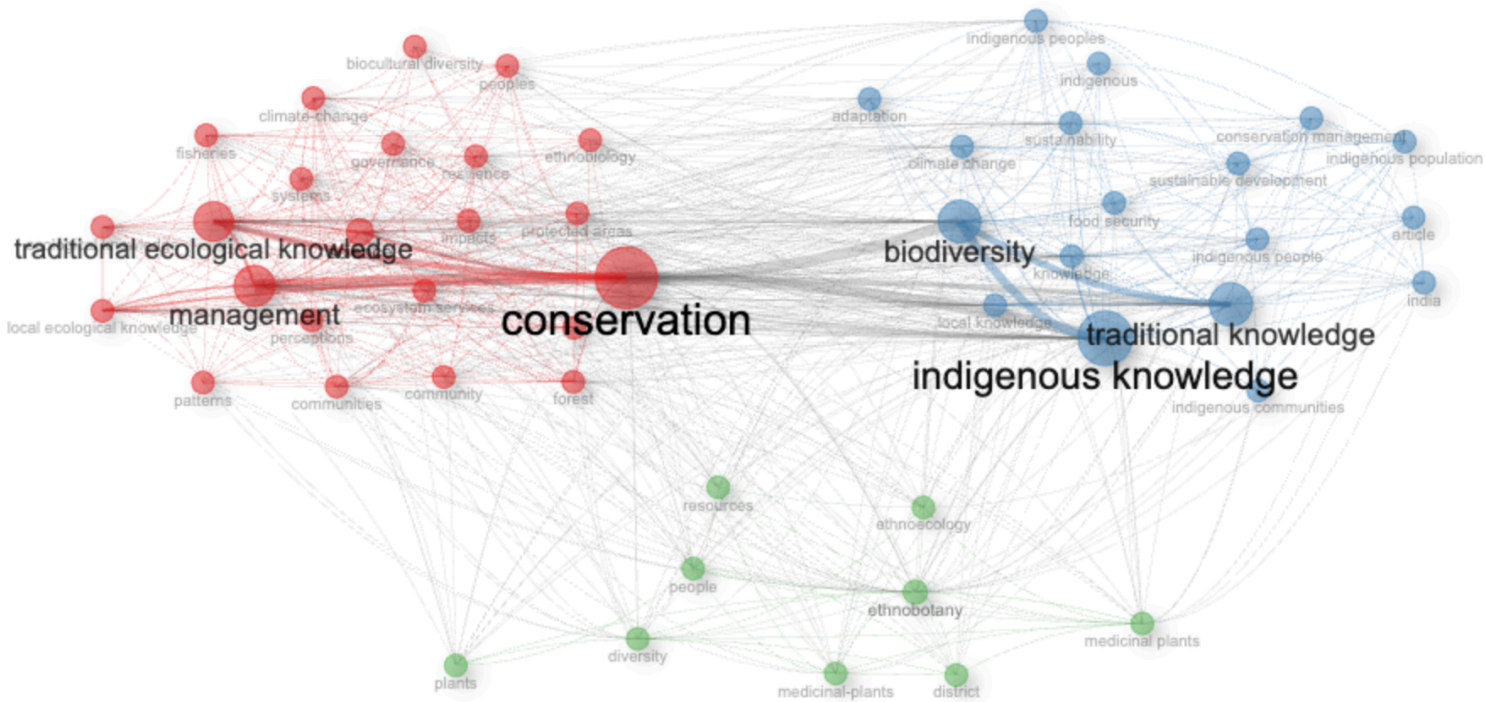


Figure 4

5. Research themes on IK for biodiversity conservation

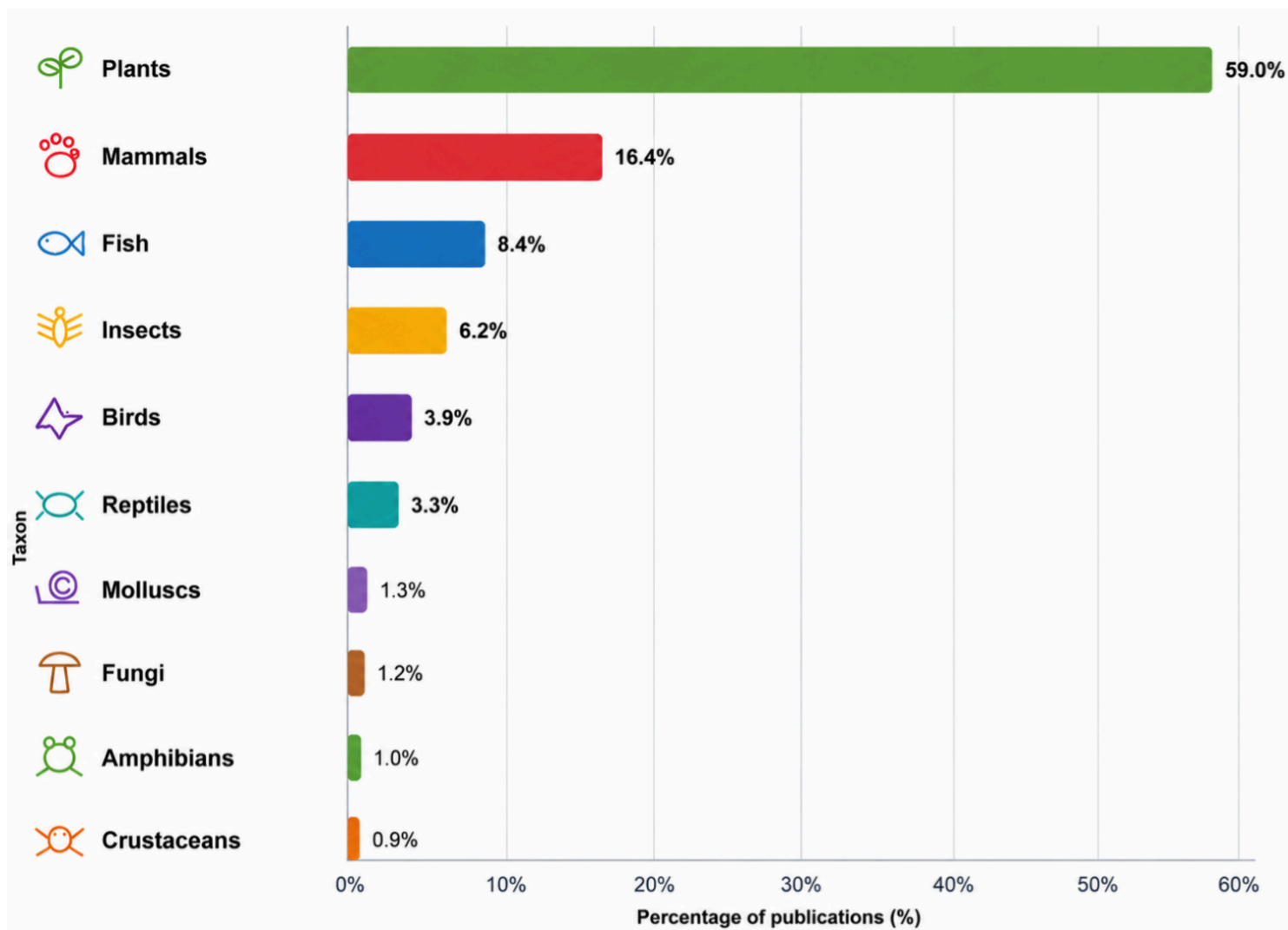
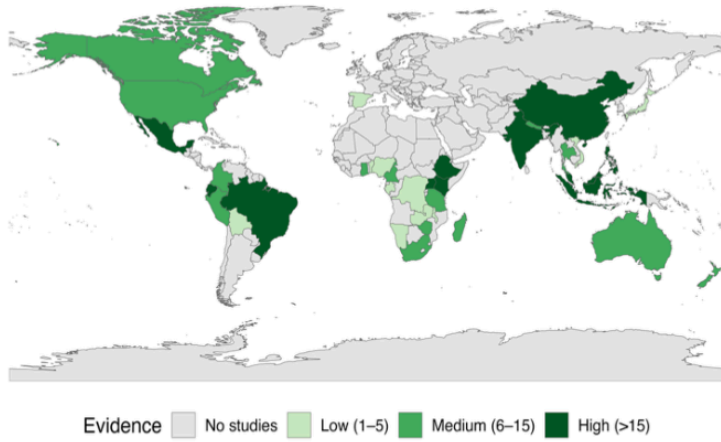


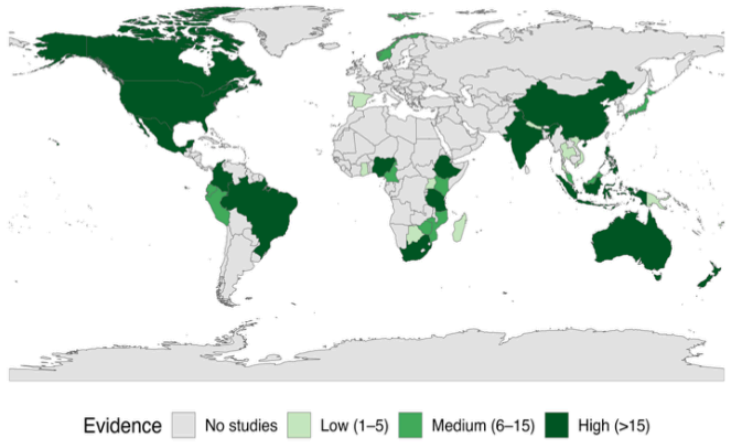
Figure 5

6. Diversity of IK practices across the globe

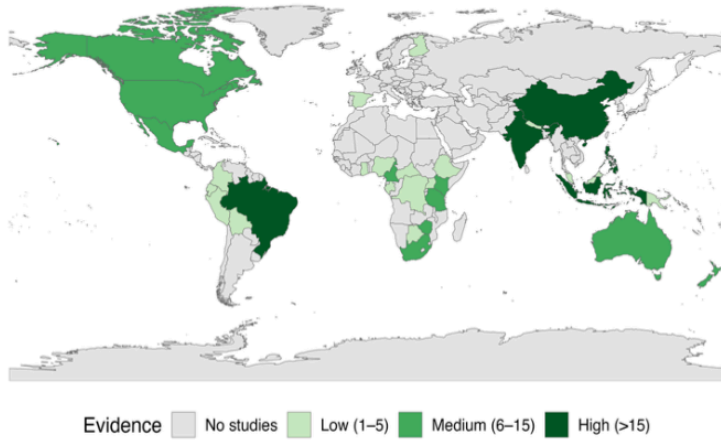
Forest Indigenous Conservation Practices



Freshwater Indigenous Conservation Practices



Wildlife Indigenous Conservation Practices



Coastal and Marine Indigenous Conservation Practices

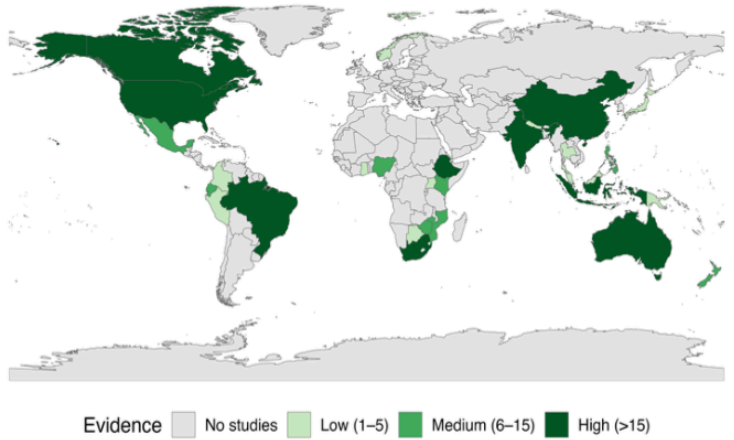
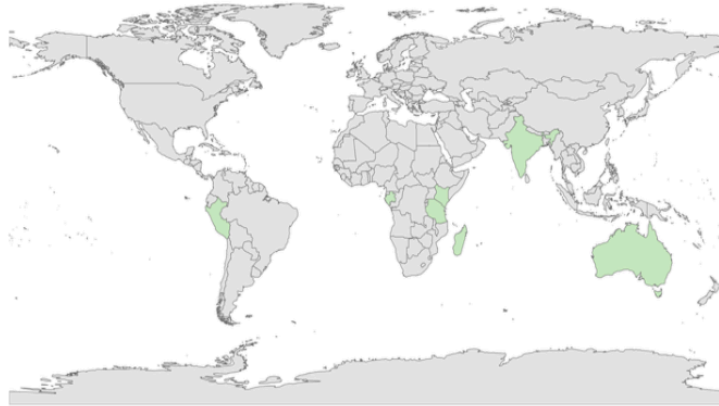


Figure 6

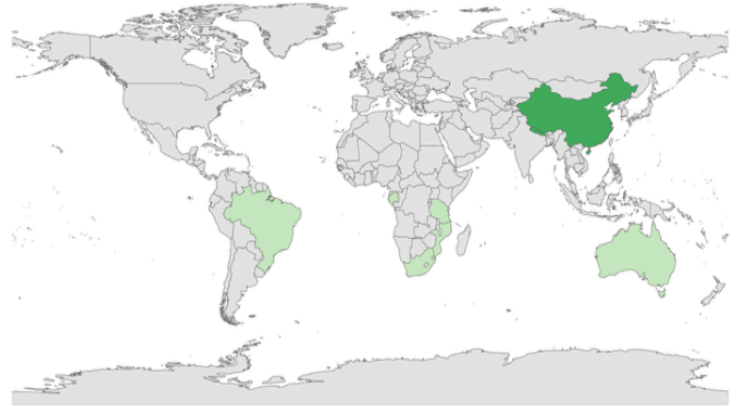
7. Global geographic distribution of the research on Indigenous conservation practices across heterogeneous ecosystems (forest, freshwater, wildlife terrestrial, and coastal–marine ecosystems).

Wetland Indigenous Conservation Practices



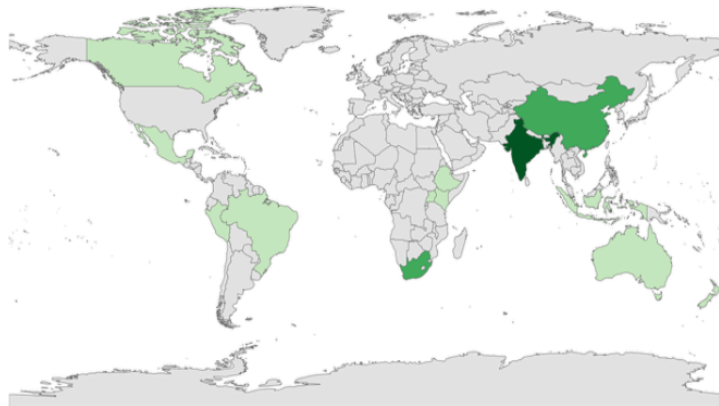
Evidence No studies Low (1–5) Medium (6–15) High (>15)

Grassland Indigenous Conservation Practices



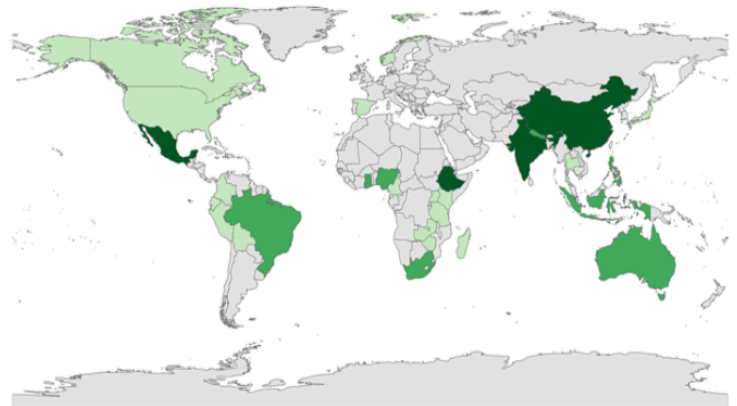
Evidence No studies Low (1–5) Medium (6–15) High (>15)

Mountainous Indigenous Conservation Practices



Evidence No studies Low (1–5) Medium (6–15) High (>15)

Agroecosystem Indigenous Conservation Practices



Evidence No studies Low (1–5) Medium (6–15) High (>15)

Figure 7

8. Global geographic distribution of the intensity of research on indigenous conservation practices across wetland, grassland, mountainous, and agroecosystem ecosystems

Supplementary Files

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