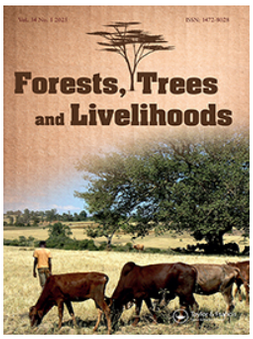

Forests, Trees and Livelihoods

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tftl20

A review of traditional ecological knowledge in resilient livelihoods and forest ecosystems: lessons for restoration sciences and practices

Thi Mai Anh Tran, Valoree S. Gagnon & Chelsea Schelly

To cite this article: Thi Mai Anh Tran, Valoree S. Gagnon & Chelsea Schelly (2025) A review of traditional ecological knowledge in resilient livelihoods and forest ecosystems: lessons for restoration sciences and practices, Forests, Trees and Livelihoods, 34:1, 27-53, DOI: 10.1080/14728028.2024.2408725

To link to this article: https://doi.org/10.1080/14728028.2024.2408725

FORESTS, TREES AND LIVELIHOODS
2025, VOL. 34, NO. 1, 27–53
https://doi.org/10.1080/14728028.2024.2408725

Taylor & Francis
Taylor & Francis Group

A review of traditional ecological knowledge in resilient livelihoods and forest ecosystems: lessons for restoration sciences and practices

Thi Mai Anh Tran[a], Valoree S. Gagnon[a], and Chelsea Schelly[b]

[a]College of Forest Resources and Environmental Science, Michigan Technological University, Houghton, MI, USA; [b]Department of Social Sciences, Michigan Technological University, Houghton, MI, USA

ABSTRACT

In recent years, Traditional Ecological Knowledge (TEK) has gained prominence in ecosystem science and governance, enhancing understanding of landscape conditions, systems dynamics, and ethical restoration practices. However, Indigenous community engagement in science and practice remains limited. In this paper, we investigate TEK's contribution to forest ecosystem research for resilient livelihoods, methods for bridging TEK with Western science, and share insights from Ojibwa perspectives on ecological restoration and well-being. A systematic review of TEK literature from 2001 to 2022 was conducted using Web of Science, with bibliometric analysis and narrative review using VOSviewer and Biblioshiny. Our findings suggest that while TEK is prevalent in social-ecological resilience and climate change mitigation research, forest ecosystem restoration receives less attention. Most literature considers Indigenous peoples as research participants rather than collaborative research partners. Differences in ontologies and sociological barriers between Indigenous peoples and government agencies may hinder TEK's inclusion in restoration practices. Reflecting on the wild rice restoration efforts of Ojibwa in the Keweenaw Bay Indian Community, we discuss timescale dimensions of research partnerships and restoration projects with Indigenous communities. Guided by Indigenous knowledge systems, we conclude that restoration activities have the potential to strengthen human-ecosystem livelihoods in our shared landscapes and futures.

KEYWORDS

Indigenous knowledge; TEK, resiliency; research partnership; forest livelihood, climate change, manoomin restoration

1. Introduction

In 2021, the United Nations estimated that there were at least 476 million Indigenous people living in 90 countries. Despite comprising less than five percent of the world's population, Indigenous people protect 80 percent of the world's biodiversity (Sobrevila 2008). During the Commonwealth People's Forum 2015, Indigenous knowledge was recognized as a crucial factor in society's resilience (Rustomjee 2016). Although many are displaced and dislocated from their historical lands, Indigenous peoples maintain deep connections to their environment and possess invaluable knowledge that offers insight into necessary livelihood and adaptation strategies when addressing climate change impacts (Riedlinger and Berkes 2001; Teaiwa 2014; Velázquez et al. 2015). For example, Ojibwa communities in

CONTACT Valoree S. Gagnon vsgagnon@mtu.edu
Supplemental data for this article can be accessed online at https://doi.org/10.1080/14728028.2024.2408725.

the Great Lakes region have successfully leveraged TEK to restore wild rice habitat, manage fisheries, and enhance biodiversity and ecological resilience (van Deelen 2022; Holtgren and Auer 2022).

While Indigenous knowledges are critical for long term ecosystem stewardship relationships, they have been ignored and marginalised for centuries because of colonialism and discrimination from Western knowledge systems (Gagnon 2016). This historical neglect of Indigenous knowledges has constrained their contributions in current research literatures addressing global strategies for resilient livelihoods, sustainable forest ecosystems, and sustainable environmental protection (Malapane et al. 2022). Further, the absence of Indigenous knowledges also creates injustice and inequality in the involvement of Indigenous communities in the shared responsibility to care for the Earth and all its inhabitants (Whyte 2017).

In the twenty-first century, as climate change increasingly threatens the survival of humans and many species, there is a growing interest in Indigenous knowledge for sustainable practices and solutions (Intergovernmental Panel on Climate Change [IPCC] 2018; Malapane et al. 2022). Across disciplines, scholars increasingly seek methods to bridge Indigenous knowledges into research projects, facilitating more holistic understanding and equitable decision-making in ecological management. The US government has acknowledged the role of Traditional Ecological Knowledge (TEK) in technological, scientific, and economic advancement, with a 2021 presidential memorandum to mandate its inclusion in federal decision-making (United States 2022). Developing collaborative partnerships with Indigenous communities is now becoming a priority for research and policymaking which addresses environmental challenges (Whyte 2017; IPCC 2018; Malapane et al. 2022).

Indigenous knowledges, also known as TEK, first emerged in the resource and environmental management fields in the early 1980s (Berkes 1993). As a result of the World Commission on Environment and Development's 1987 advocacy for integrating Indigenous knowledges in sustainable development, the term became widespread and recognized internationally (UNWCED 1987). Fikret Berkes, in 1993, was the first scholar to define TEK as 'an accumulation of knowledge, practice, and belief about how living beings (including humans) interact with each other and with their environment, based on adaptive processes and passed down from generation to generation via cultural transmission' (Berkes 1993, p. 3). Since then, numerous studies have adopted Berkes' definition and integrated TEK to gain new biological and ecological insights. In 2000, amidst uncertainty about climate change impacts, Berkes and his colleagues advocated for the use of TEK in social-ecological practice (Berkes et al. 2000). This sparked a 'second wave' of literature incorporating TEK into resilience studies.

To our awareness, no literature has fully summarized the integration of TEK in forest ecosystem management and resilient livelihoods research. Our study aims to address this gap by providing a comprehensive analysis of the current state of TEK literature focusing on resilience and livelihoods in forest ecosystems, expanding beyond previous geography or ecosystem-specific reviews (Ens et al. 2015; Guerrero-Gatica et al. 2020; Loch and Riechers 2021; Malapane et al. 2022). We employ bibliometric visualizations to illustrate research trends and topic relationships. As TEK is increasingly recognized as a collaborative concept that bridges cross-cultural and cross-situational divides between Western science and Indigenous knowledge (Whyte 2013), our study not only reviews the literature but also actively engages with this approach. We include a case study on the Keweenaw Bay Indian Community's manoomin restoration efforts to demonstrate our engagement with the

insights gained from our literature review. This case study allows us to offer insights into methodologies for bridging TEK in research partnerships with Indigenous communities and addressing current gaps in collaborative research practices (Benyei et al. 2019; Loch and Riechers 2021).

Our study specific objectives are: (1) to investigate how TEK has contributed to forest ecosystem research for resilient livelihoods in the last two decades; (2) to describe methods for bridging TEK with Western science in contemporary research; and (3) to share insights from Ojibwa perspectives on ecological restoration and well-being based on the gap identified in current literature.

As policymakers seek to achieve resilient livelihoods through sustainable forest relations, this paper is particularly timely for understanding the current state of TEK in forest management. Ultimately, this study aspires to increase collaboration between Indigenous communities, policymakers, and research institutions.

2. Materials and methods

This paper analysed studies derived from Berkes et al. (2000) to understand the current state of TEK and its contemporary application to the resilience of forests and livelihoods. We used the Web of Science as a comprehensive database and retrieved data on 5 October 2022, via the Michigan Technological Library database website. We started by searching through literature which cited Berkes et al. (2000) using the keyword 'Traditional Ecological Knowledge'. The research returned 754 documents. To filter the result, we added keywords: 'resilience', 'livelihood', 'forest ecosystem', and 'Indigenous people', which yielded 317 relevant documents. Titles, abstracts, keywords, citations, authors, affiliations publications, and journals were all examined during this query process. Finally, the data was imported into VOSviewer and Biblioshiny in R for analysis and visualization. A list of articles is included in the Appendix for reference.

From the list of 317 articles, we randomly selected 64 articles (20 percent) for a full reading and narrative review. During the full reading process, we synthesized each article based on its objectives and findings, and then categorized them into themes to capture the major focus as concisely as possible. Next, the findings of each theme were assembled to find common patterns, discussions, and research gaps. Our method approach was guided by Green et al. (2006) and Siddaway et al. (2019). Our review was presented following the recommended structure of Ferrari (2015).

3. Results

The results are divided into four parts: 1) Trends and development of TEK over two decades (2001–2022); 2) Prevalent themes and topics of TEK in resilient livelihood and forest ecosystems; 3) Status of collaborations with Indigenous communities; and 4) Insights from engagement with Ojibwa knowledge on ecological restoration and well-being.

3.1. Trend and development of traditional ecological knowledge in the last 20 years

This analysis covers 317 documents, including 291 research articles, 24 review articles, four early access papers, four conference proceedings, and two editorial materials. These

documents span 41 research areas, with the majority (63%) focused on the environmental sciences and ecology, followed by biodiversity (16%), and science and technology (10%). The documents were authored by 1,229 researchers from 78 countries worldwide. The United States contributed the highest number of publications (31%), followed by Canada (16%), Spain (11%), Australia (8%), and the United Kingdom (8%). However, when considering citation impact, Canada led with an average of 65 citations per year, followed by Spain (55 citations per year), Zambia (50 citations per year), and Kenya (48 citations per year).

Figure 1 illustrates the growth in publications from the top five most productive countries between 2001 and 2021. Notably, the period from 2007 to 2020 witnessed a significant increase in the number of articles published on TEK.

TEK is mentioned in the data with 23 associated terms, including nine terms with definitions (Table 1) and 13 terms without definitions. Terms that were not provided with definitions include Rural knowledge; Folk knowledge; Ethnosciences; Indigenous technical knowledge; Traditional knowledge systems; Indigenous ways of knowing; Indigenous ecological knowledge; Traditional agroecological knowledge; Farmer's ecological knowledge; Māori knowledge; Ethnobiological knowledge; Indigenous environmental knowledge; and Traditional zoological knowledge.

Overall, there are both similarities and differences between these terms. Indigenous knowledge, traditional knowledge, and local knowledge all refer to place-based, community-rooted forms of knowledge that have been developed, maintained, and passed down over generations. They are grounded in the lived experiences, practices, and relationships of particular cultural groups with their natural environments. However, the terms differ in their specific contexts. Indigenous knowledge is intrinsically tied to the histories, worldviews, and cultural identities of Indigenous people. Traditional knowledge refers to the skills, practices, and belief systems that have been transmitted within a community, often as part of its cultural or spiritual heritage. Local knowledge, on the other hand, refers to the

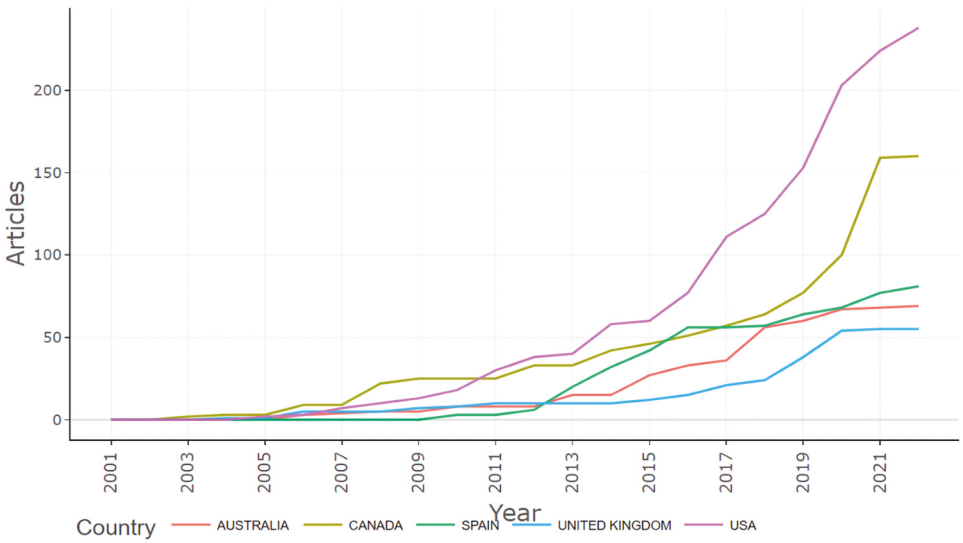

Figure 1. Countries' production over time in documents that cited Berkes et al. (2000).1

Table 1. Terms associated with traditional ecological knowledge which used in documents citing Berkes et al. (2000).

Terms (Abbreviation)	Definition	Source
Indigenous knowledge	'Indigenous knowledge is defined as a place-based knowledge system maintained and developed by communities with extended histories of interaction and relation with all aspects of their natural environment based on social, physical, and spiritual understandings' (Yazzie et al. 2019, p. 10).	Malapane et al. (2022); Ens et al. (2015); Berkes (2004); Yazzie et al. (2019)
Traditional knowledge	'Traditional knowledge refers to knowledge, skills, and practices that are developed, sustained, and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity' (Macnight et al. 2018, p. 2).	Malapane et al. (2022); Ens et al. (2015); Luna-José and Aguilar (2012); Macnight et al. (2018)
Local knowledge	'Local knowledge refers to knowledge that people in each community have developed over time and continue to develop. It is based on experience, often tested over centuries, adapted to the local culture and environment, and embedded in community practices, institutions, relationships, and rituals' (Macnight et al. 2018, p. 2).	Malapane et al. (2022); Ens et al. (2015); Loch and Riechers (2021); Macnight et al. (2018)
Indigenous biocultural knowledge (IBK)	'Indigenous biocultural knowledge is the knowledge that encompasses people, language, and culture and their relationship to the environment' (Ens et al. 2015, p. 3).	Ens et al. (2015)
Traditional ecological knowledge (TEK)	'Traditional ecological knowledge is the knowledge and insights acquired through extensive observation of an area or species. TEK can be used to understand and predict environmental events upon which the livelihood or even survival of individuals depends' (Watson et al. 2003, p. 2).	Ens et al. (2014); Watson et al. (2003); LaRochelle and Berkes (2003)
Local ecological knowledge	'Local ecological knowledge is in the definition of ecological knowledge including local, indigenous, traditional, and rural and which may be held by an indigenous community and/or local/rural communities from developing or industrialized nations' (Aswani et al. 2018, p. 1).	Aswani et al. (2018)
Indigenous and local knowledge (ILK)	'Indigenous and local knowledge is an integrated, holistic, social and ecological knowledge, practices, and beliefs pertaining to the relationship of living beings including people, with one another and with their environments; grounded in the territory, highly diverse and continuously evolving through the interaction of experiences, innovations and various types of knowledge (written, oral, visual, tacit, gendered, practical and scientific); empirically tested, applied, contested and validated through different means in different contexts' (Loch and Riechers 2021).	Benyei et al. (2019); Loch and Riechers (2021); Cámara-Leret and Dennehy (2019)
Fisher knowledge (FK)	'Fisher knowledge is experience-based knowledge about marine or coastal ecosystems and resources' (Loch and Riechers 2021). 'Fisher knowledge mostly comes from qualitative experiences in fisheries, while a distinct feature of the conventional scientific knowledge used in fisheries management is its reliance on quantitative data collected and analyzed systematically' (Björkvik et al. 2021, p. 1).	Björkvik et al. (2021); Loch and Riechers (2021)
Traditional fire knowledge systems (TFKS)	'Traditional fire knowledge systems as the body of empirically acquired knowledge, beliefs, and practices developed over time, which dictates the burning practices of local inhabitants in each landscape' (Martínez-Torres et al. 2016, p. 1).	Martínez-Torres et al. (2016)

context-specific understandings and adaptations developed by people within a particular region.

Terms like fisher knowledge and traditional fire knowledge systems highlight the specialized domains of knowledge that have evolved within certain communities based on their livelihood practices and ecological contexts.

VOSviewer was used to analyze the co-occurrences of the author keywords and keywords plus (words or phrases that frequently appear in the titles of an article's reference, generated by Web of Science) in the data. A total of 120 keywords were identified, with a minimum relationship between terms set to 5. There were keywords conveying the same meaning but different characters used such as 'traditional ecological knowledge (tek)' and 'traditional ecological knowledge', or 'climate change' and 'climate-change' or 'forests' and 'forest'. We then removed the one that had a smaller number of occurrences. Finally, the total number of keywords was 100, clustered into four groups: red, green, yellow, and blue. We used LinLog/modularity to visualize the relational maps. Keywords that are displayed in the same color were often used together. The size of the circle and letters correlated positively with the number of occurrences of author keywords and keyword-plus. In this visual representation, closer distances between nodes indicate a stronger relationship while lines connecting two keywords represent their co-occurrence frequency (Van Eck and Waltman 2018). Additionally, VOSviewer offers three different types of bibliometric mapping visualizations: network visualization (Figure 2(a)), overlay visualization (Figure 2(b)), and density visualization (Figure 2(c)).

Overall, the top 10 keywords with the highest occurrences number in the author's keywords and keywords plus were *traditional ecological knowledge* (192 occurrences), *conservation* (98 occurrences), *resilience* (86 occurrences), *management* (83 occurrences), *indigenous knowledge* (192 occurrences), *biodiversity* (192 occurrences), *ecological knowledge* (51 occurrences), *traditional knowledge* (34 occurrences), *climate change* (32 occurrences), and *ecosystem services* (30 occurrences). Figure 2(a) illustrates clusters of studied topic areas in documents that cited Berkes et al. (2000). Keywords sharing the same color, such as those within green circles (e.g., *biodiversity*, *forest*, *ecosystem services*, and *ethnoecology*), indicate close relationships and frequent co-occurrence. The size of the *biodiversity* node is bigger than *forest*, as *biodiversity* keyword has 56 occurrences and 83 links with other nodes, while *forest* has 29 occurrences and 63 links. Figure 2(b) depicts the temporal trends in the usage of different keywords in documents that cited Berkes et al. (2000), with colors ranging from blue to red. On average, the published year of keywords *traditional ecological knowledge* and *conservation* were 2016, while *resilience* and *management* were 2015. Further, keywords such as *resource management*, and *adaptive management* were popular before 2013, while *ecosystem services, ethnobotany, and ethnoecology* gained popularity in 2018. Figure 2(c) represents the depth of research in documents that cited Berkes et al. (2000), with more concentrated colors indicating a greater number of studies containing those keywords being conducted. It can be seen that keywords such as *traditional ecological knowledge*, *management*, *resilience*, and *conservation* were mentioned by most researchers.

Figure 2(a–c) collectively illustrate that within our dataset, while research on *traditional ecological knowledge*, *resilience*, *conservation, management* dominates the field, studies

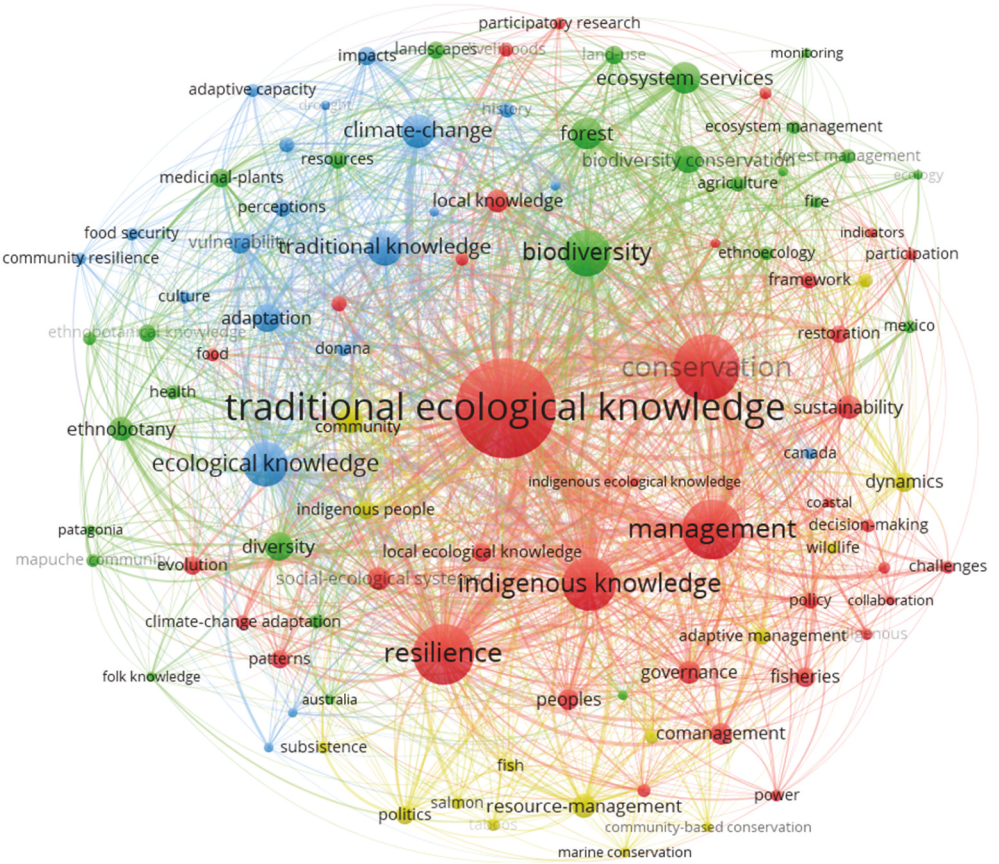

Figure 2a. Visualization topic area in documents that cited Berkes et al. (2000) using network visualization based on VOSviewer.

including *ethnobotany*, *restoration*, *governance*, and *Indigenous peoples* receive relatively limited attention.

Figure 3 displays an overlay visualization of the citation network between countries from documents that cited Berkes et al. (2000). The nodes (representing countries) and lines are colored according to the year, with links indicating co-occurrence in citations. The minimum threshold was set at five documents per country. It can be observed that Canada, Australia, Sweden, and India had cited Berkes et al. (2000) and conducted research on TEK before 2015. The USA, Spain, Switzerland, and Mexico cited Berkes (200) in 2016, while Brazil, Chile, Taiwan, Ecuador, and Hungary started citing Berkes et al. (2000) in 2019.

3.2. Topics of interest that cited Berkes et al. (2000) from 2001–2022

In this section, we will summarise the themes and topics of each theme of the reviewed articles. The most dominant theme is social-ecological resilience (31 articles), followed by cultural preservation (14 articles), conservation (9 articles), climate change (6 articles), and ecosystem restoration (4 articles).

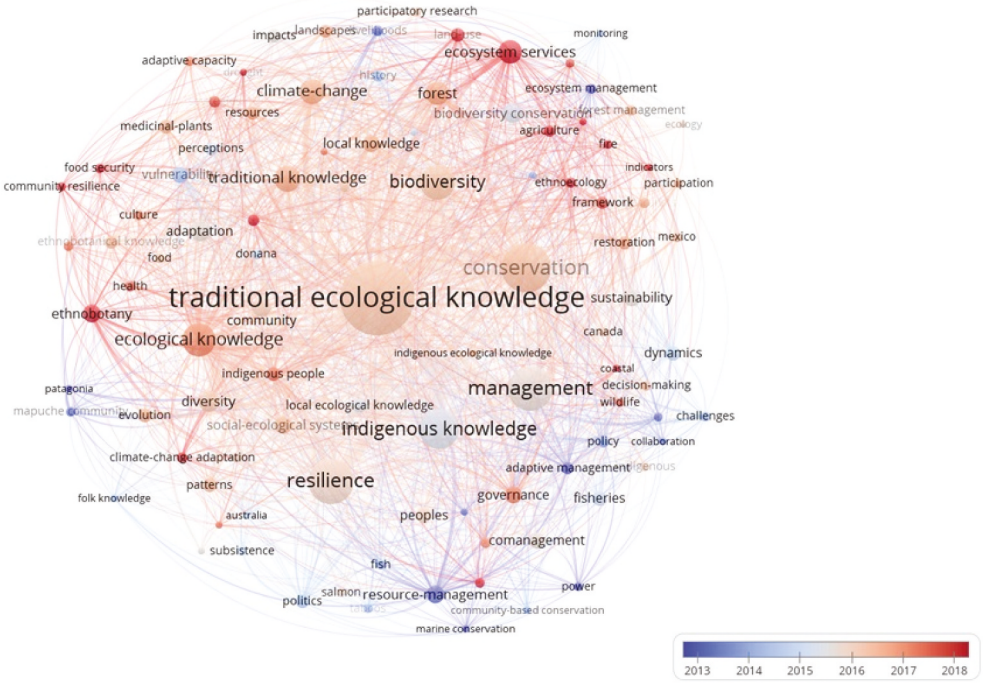

Figure 2b. Visualization topic area in documents that cited Berkes et al. (2000) using overlay visualization based on VOSviewer.

3.2.1. Social-ecological resilience

The social-ecological resilience is the most studied theme. Studies tended to focus on three main topics: (1) foundations of social-ecological resilience; (2) Indigenous practices and resilience strategies (reciprocity, diversification, gender roles, and sustainable use and management); (3) challenges and conflicts in resilience efforts. We synthesized each topic as follows.

3.2.1.1. Foundations of social-ecological resilience. Many articles discussed the role of TEK in promoting social-ecological resilience, presenting two premises: (1) TEK effectively supports social-ecological resilience, as it has been accumulated through experience, learning, and intergenerational transmission (Yacoub 2018; Li and Ford 2019; García-Jácome et al. 2020, Bayrak and Marafa 2019; Aburto et al. 2021), and (2) TEK contributes to resilient social-ecological systems when integrated with other knowledge systems (Bohensky and Maru 2011). However, research primarily focuses on the first premise, comparing TEK with government decisions and Western knowledge systems.

Several studies have demonstrated the benefits of TEK compared to government decisions, highlighting how Indigenous practices contribute to social-ecological resilience, while government interventions often undermine or erode these practices. For instance, in Chile, Aburto et al. (2021) found that local fishers' practice of migrating their harvesting sites was environmentally friendly and allowed fish and clams to rest during migration, making it a sustainable approach, in contrast to rigid government regulations. Similarly, in Mexico,

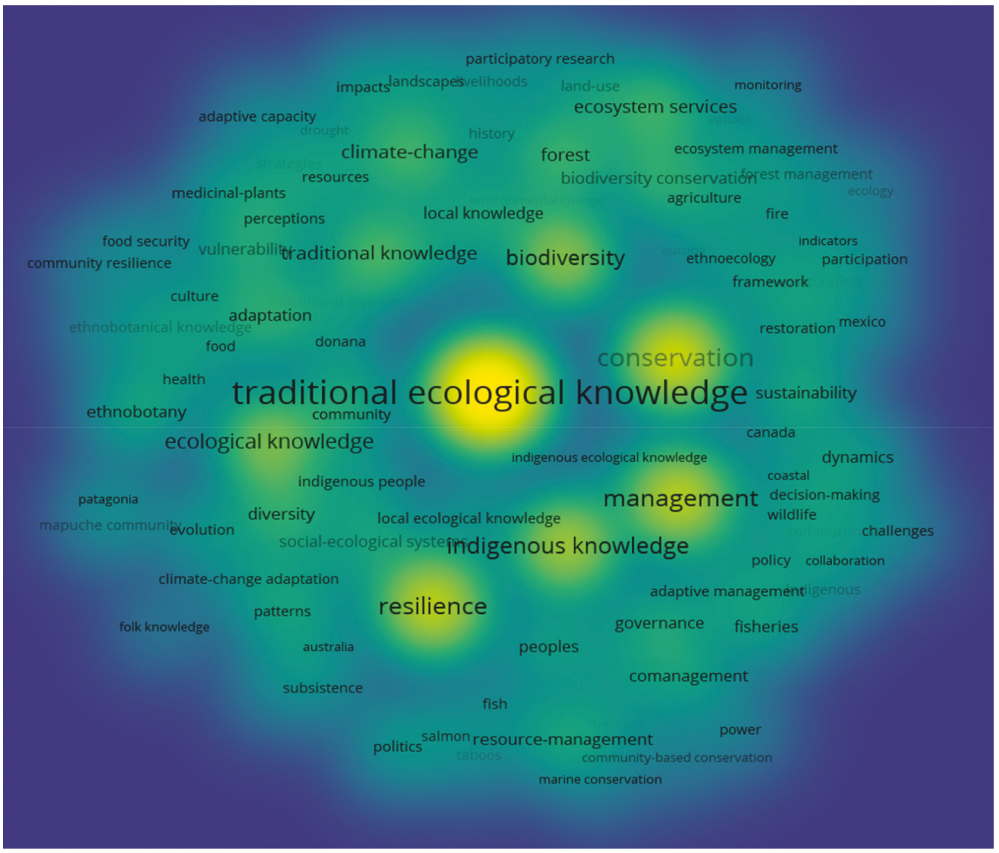

Figure 2c. Visualization topic area in documents that cited Berkes et al. (2000) using density visualization based on VOSviewer.

García-Jácome et al. (2020) showed that the multiple-use strategies employed by Yucatec Maya communities enhanced social-ecological resilience by increasing household income and food availability and creating a diverse and resilient livelihood system, while government restrictions on these strategies only benefited the local economy and negatively impacted the country's social-ecological resilience. Moreover, in Egypt, Yacoub (2018) found that the Bedouin tribe's pastoral style supported social and ecological resilience through selective grazing and controlled browsing, in contrast with the government's creation of Lake Nasser causing ecosystem changes, the dominance of unwanted species, and the depletion of native species populations, thereby adversely impact Bedouin livelihood.

When comparing traditional ecological knowledge (TEK) and modern knowledge systems, several studies highlighted challenges in integrating the two knowledge systems. For example, in Austria, Milestad (2003) found that, while local farmers claimed their TEK was similar to modern organic practices in terms of economic sustainability and environmental friendliness, organic farming promoted by agricultural policies often reduced farmers' autonomy and increased their dependence on external funding. Like Milestad, Folch and Planas (2019) also concluded that an integrated program combining traditional practices

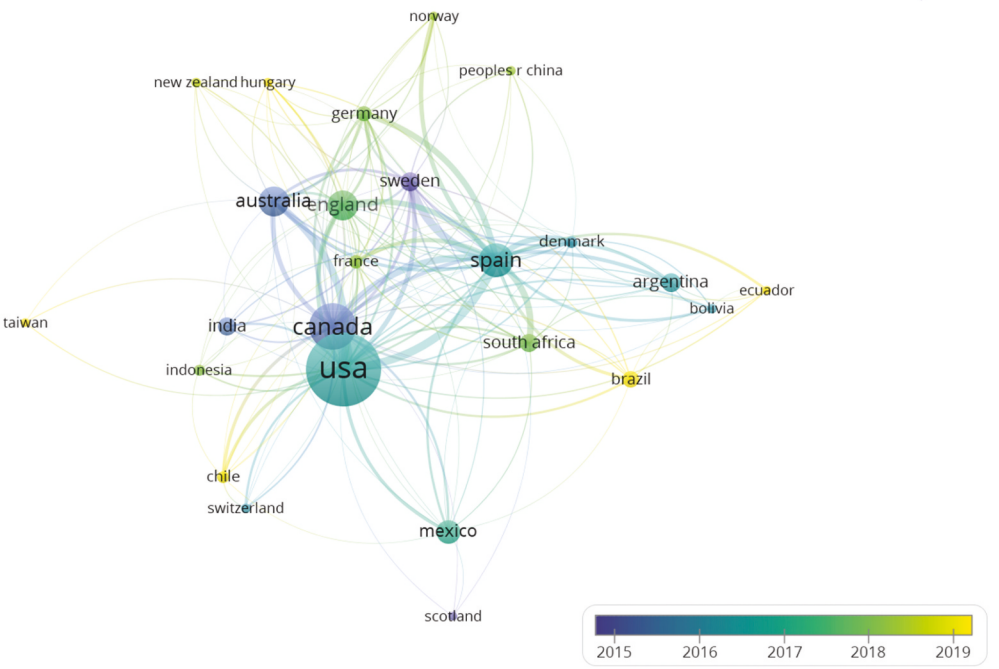

Figure 3. Overlay visualization of citation network of countries from documents that cited Berkes et al. (2000) based on VOSviewer.

and organic coffee farming in Chiapas, Mexico had failed badly as it made local people rely heavily on external technical and financial support, finally leaving Chiapas as one of the poorest regions in Mexico (Folch and Planas 2019). Another study by Li and Ford (2019) on the food system found that Indigenous people expressed concern about the lack of nutrients in alternative food sources compared to traditional farming, making future generations suffer from market fluctuation and their livelihood system more vulnerable.

These studies collectively suggest that policies and government decisions derived from Western knowledge have proven ineffective in addressing sustainable livelihoods for Indigenous communities. While TEK supports social-ecological resilience, integrating it with modern knowledge systems poses challenges and negative impacts.

3.2.1.2. Indigenous practices and resilience strategies. Many studies suggested that social-ecological resilience can be achieved through learning from TEK, such as through practices of reciprocity (Watson et al. 2003; Jackley et al. 2016, Zhang et al. 2016; Caillon et al. 2017; Kurashima et al. 2018; Pyke et al. 2018; Ford et al. 2020; Thornton et al. 2020), diversification (Moyo and Moyo 2014; Zhang et al. 2016; Jackley et al. 2016; Mariel et al. 2021), and sustainable use and management (Moller et al. 2009; Immanuel et al. 2010; Ray et al. 2012; Martínez-Torres et al. 2016; Cervellini et al. 2017; Pyke et al. 2018; Caballero-Serrano et al. 2019; Björkvik et al. 2021; Tagliari et al. 2021).

The practice of reciprocity was explored into two primary aspects: reciprocity among humans and reciprocity between humans and nature. Among human groups, reciprocity refers to the sharing of resources, knowledge, and labor between communities to foster

social cohesion and mutual support (Jackley et al. 2016). For example, Jackley et al. (2016) show that coastal First Nations in Canada often assist each other during resources scarcity times, anticipating reciprocal support in the future, thereby avoiding the tragedy of the commons and fostering communal resilience during environmental change. Similarly, Zhang et al. (2016) found that Naxi and Bai people in Southwestern China often borrow and exchange food with each other. They also learn from each other's knowledge about wild edible plants. These reciprocal activities build trust, strengthen community bonds, and enhance their social and livelihood resilience. Reciprocity is also evident in human-nature relationships, with Indigenous groups like the Oiwi, Yshiro, Bardi Jawi, and Naxi viewing nature as the 'close relatives' of humans instead of 'natural resources' and emphasizing sustainable relationships with nature, where respectful human behavior ensures continued provision of resources (Watson et al. 2003; Zhang et al. 2016; Caillon et al. 2017; Pyke et al. 2018). This worldview of closeness to place fosters ethical responsibility to protect the environment (Ford et al. 2020). The practice of reciprocity, both among humans and between humans and nature, has been identified as a crucial aspect of Indigenous practices and resilience strategies by promoting sustainable resource use and minimizing environmental pressures.

The practice of diversification to enhance resilience was studied by several studies (Moyo and Moyo 2014; Zhang et al. 2016; Jackley et al. 2016; Mariel et al. 2021). For example, small-scale farmers in northern Malawi diversify their food crops by planting cassava along with different crops such as maize and beans, and raising livestock, tailored to soil conditions, weather patterns, and spatial considerations to enhance dietary diversity and livelihood sustainability. Similarly, Zhang et al. (2016) revealed that the Naxi people in Yunnan, China have developed situational food consumption strategies – during good weather, they consume crops, store food via traditional methods, and plant landrace crops; in drought years they consume wild plants along with preserved crops; and in severe droughts they rely on famine plants like ferns to prevent starvation. By utilizing diversification strategies, Indigenous people can reduce overexploitation, cope with resource fluctuation, and ensure long-term security (Mariel et al. 2021).

The effectiveness of TEK in practicing sustainable use and management was highlighted in many studies (Moller et al. 2009; Immanuel et al. 2010; Ray et al. 2012; Martínez-Torres et al. 2016; Cervellini et al. 2017; Pyke et al. 2018; Caballero-Serrano et al. 2019). For example, Caballero-Serrano et al. (2019) documented that Sangay gardeners actively cultivate medicinal plants to reduce wild harvesting pressure in the Ecuadorian Amazon. Similarly, Moller et al. (2009) observed sustainable mutton bird harvesting among local communities on Titi islands, which protects the species population over generations. Like Moller, Jackley et al. (2016) also found that the Heiltsuk people's territorial governance system in British Columbia effectively regulates the community's access, harvesting methods, timing, and rotational area closures, which prevent overharvesting and increase resource utilization. Several studies suggest TEK can be more effective than Western science in certain contexts. For example. Ray et al. (2012) noted Indigenous people recognized climate change impacts earlier than the national park management board, underscoring the depth of their knowledge and their longstanding land stewardship. Similarly, Björkvik et al. (2021) emphasized the importance of fishers' knowledge in management decisions, recognizing their experience

and understanding of the dynamic nature of fish spawning areas. TEK-based bottom-up conservation models are also proven to be more adaptable and self-reinforcing than rigid top-down government restrictions (Tagliari et al. 2021).

Taken together, these studies demonstrate that TEK plays a crucial role in promoting sustainable use and management of natural resources, suggesting the incorporation of TEK in resource management and conservation policies to enhance the resilience of ecosystems and support the livelihoods of Indigenous peoples through relationships based on reciprocity.

3.2.1.3. Challenges and conflicts in resilience efforts. Many researchers have noted conflicts arising between TEK and Western science due to differences in ontologies regarding human-environment relationships and land stewardship practices (Ray et al. 2012; Martínez-Torres et al. 2016; Nguyen and Ross 2017; Caillon et al. 2017; Li and Ford 2019; Aburto et al. 2021).

As for the human-environment relationship, Nguyen and Ross (2017) observed the disagreements between Indigenous communities and government staff in perspectives on resource ownership. Indigenous people view nature as belonging to nobody and being shared by everyone. In contrast, the government asserts its ownership over natural resources which leads to dismissals of TEK from decision-making processes. Similarly, Caillon et al. (2017) noted the differences in interpreting social-ecological resilience between Indigenous people and government officials, with TEK's holistic view of humans as part of nature and advocating for cultural and spiritual dimensions. While the government often prioritizes quantifiable metrics such as GDP and overlooks cultural and spiritual value.

As for land stewardship practices, Ray et al. (2012) observed tensions between communities and agencies regarding wildfire management, with communities perceiving wildfire as a natural process for reducing fuels and improving habitats, while federal managers viewed it as a more negative effect. This conflict is also mentioned by Martínez-Torres et al. (2016) who documented the traditional burning practices in Mexico, where government policies prohibited burning despite local views of it being preferable to herbicides and other modern techniques.

Overall, many authors agreed that the conflicts between TEK and Western science stem from differing worldviews and priorities regarding resource management and resilience. However, when Indigenous peoples' livelihoods depend on nature's health, TEK remains a vital source of ecological knowledge and adaptation planning (Li and Ford 2019; Aburto et al. 2021), highlighting the need to bridge ontological divides through collaboration and respectful dialogue.

3.2.2. Cultural preservation

We identified two strands of research on the topic of cultural preservation. One strand expresses concern over the declining presence of TEK and advocates for efforts to document, revive, and transmit TEK to future generations (Paniagua-Zambrana et al. 2014; Cámara-Leret and Dennehy 2019; Marcinek and Hunt 2019; Abdul Aziz et al. 2020; Friday and Scasta 2020; Lyver et al. 2021). The other stand contends that TEK is not static but evolves over time in response to changing environmental and societal dynamics (Hamlin and Salick 2003; Aswani et al. 2018; Caballero-Serrano et al. 2019). We synthesized both strands as follows.

3.2.2.1. Factors of TEK loss and revival strategies. Many researchers in the first strand of cultural preservation explore the factors contributing to the decline of TEK and advocate for its revival. Factors like globalization, tourism, pollution, colonialism, and assimilation processes have been identified as key drivers contributing to this loss (Marcinek and Hunt 2019; Lyver et al. 2021). According to Lyver et al. (2021), globalization impacts TEK's survival by introducing imported products that compete with local ones, resulting in the loss of wild foods and associated ethnobotanical knowledge. Marcinek and Hunt (2019) also noted that while tourism can help spread TEK and support the local economy, inappropriate representations and incorrect interpretations of TEK can ultimately erode knowledge authenticity. Further, pollution degrades traditional food sources, driving a shift towards processed Western diets and damaging community-environment linkages vital for TEK transmission (Lyver et al. 2021). Colonialism and assimilation also played significant roles in eroding local knowledge and practices, with government policies and Western education prohibiting tribal traditions and disrupting intergenerational learning pathways by removing children from their cultural environment, which resulted in a loss of TEK (Paniagua-Zambrana et al. 2014; Caballero-Serrano et al. 2019; Friday and Scasta 2020).

As TEK plays a vital role to Indigenous communities in understanding and adapting to changing environmental conditions, its loss can have far-reaching consequences, affecting millions of lives globally (Aswani et al. 2018). To counter this trend, scholars advocate for strengthening the TEK transmission pathway (Singh et al. 2011; Caballero-Serrano et al. 2019; Khakurel et al. 2021), supporting knowledge keepers such as elders and women (Martínez-Torres et al. 2016), utilizing innovation mediums like podcasting (Mulki and Ormsby 2021), and ensuring equal partnership processes that acknowledge Indigenous knowledge and territorial rights (Berkes 2004) to enable the revitalization and preservation of TEK.

3.2.2.2. Knowledge adaptation and hybridization. On the second strand, some researchers contend that TEK systems are more likely to adapt and incorporate new elements rather than disappear entirely. This perspective views TEK as a dynamic process of knowledge accumulation and adaptation to changing contexts and needs (Aswani et al. 2018). For example, Hamlin and Salick's (2003) research among the Yanesha people in the upper Peruvian Amazon found that to adapt to environmental changes, Indigenous people have to continuously adapt and modify their agricultural techniques. Similarly, Caballero-Serrano et al. (2019) observed that Ecuadorian Amazon residents cultivate up to 36 percent of exotic plants in their gardens. They argue that the presence of exotic plants in local medicine signifies not the erosion of traditional knowledge but rather a diversification strategy to enhance the variety of medicinal resources, thereby benefiting local communities' livelihood.

3.2.3. Conservation

Research on conservation encompasses two main areas: (1) the role of taboo and cultural belief systems in conservation (Colding and Folke 2001; Charnley et al. 2007; Schipper et al. 2008; Irakiza et al. 2016; Zhang et al. 2020; Sebele et al. 2022), and (2) TEK as social institutions and customary laws (Ford et al. 2020; LaRochelle and Berkes 2003; Luna-José and Aguilar 2012; Singh et al. 2011; Ens et al. 2015; Ford et al. 2020).

3.2.3.1. Taboo and cultural belief systems in conservation. TEK and taboos held by Indigenous communities can play an important role in biodiversity conservation. Many cultures have long standing taboos against harming certain species or disturbing sacred natural areas, motivated by beliefs that such acts will bring misfortune or anger spiritual forces, contributing to conservation efforts (Irakiza et al. 2016; Zhang et al. 2020). For example, Zhang et al. (2020) note that the Lisu people of China refrain from hunting gibbons due to their belief that gibbons are human ancestors, helping maintain gibbon populations. Similarly, in Rwanda, Irakiza et al. (2016) observe that villagers avoid entering the sacred Buhanga forest for fear of angering spirits, protecting rare snake species that reside there. In the same vein, Singh's et al. (2011) study on India's Monpa tribes found that taboos can also prevent pollution of water sources and ensure the diversity of plants around the watersheds. However, taboos are not always aligned with conservation goals. For example, in parts of Africa, Sebele et al. (2022) found that a taboo against owls has hindered the use of owls as natural rodent control to protect crops and other protected species. Therefore, understanding local taboos and involving Indigenous communities is crucial to developing effective and culturally appropriate conservation strategies (Charnley et al. 2007).

3.2.3.2. TEK as social institutions and customary laws. TEK can also function as a social institution, establishing and upholding both formal and informal norms for resource management, thereby significantly contributing to biodiversity conservation (Ford et al. 2020; LaRochelle and Berkes 2003; Luna-José and Aguilar 2012). This view is supported by Singh et al. (2011), who found that the use of 'chhopa' system by Monpa people effectively set catch limits and prohibited periods for fishing and forest access for all people in the community. Similarly, in Mexico, LaRochelle and Berkes (2003) highlight how traditional practices among the Raramuri people, such as selective harvesting and environmental modification, facilitate landscape monitoring and ensure plant health. Luna-José and Aguilar (2012) further illustrate this in Sierra, where Zapotec communities have sustained plant diversity through informed harvesting practices based on their knowledge of the local ecosystem. Rather than maximizing yields, Zapotec people prioritize plant well-being over their needs. Irakiza et al. (2016) add that local communities possess insights into optimal harvest times, often employing small-scale, short-term consumption strategies to mitigate overharvesting stress in forests. As these examples illustrate, TEK encompasses not just beliefs and practices, but also establishes norms, rules, and regulations around resource use that aid in conservation.

3.2.4. Climate change

Some researchers have explored the utilization of TEK in identifying and addressing extreme climate variability (Macnight et al. 2018; Chen and Cheng 2020; O'Gorman et al. 2022). As for predicting disaster risks, Macnight et al. (2018) found that Northern Ghanaian communities have relied on TEK for generations to predict and gauge the severity of disasters. Phenomena like snail hatchings or ant migrations serve as indicators of impending droughts. Similarly, Chen and Cheng (2020) investigated TEK use in Guogou, China, where locals interpret signals such as a dog jumping into a drain as a warning sign of approaching typhoons. As for mitigating disaster impacts, Macnight et al. (2018), Chen and Cheng (2020), and O'Gorman et al. (2022) note that Indigenous communities use TEK in building flood barriers, planting

trees as windbreaks, lowering fish pond levels before floods, creating water circulation channels, and practicing cultural burning as a preventive measure against wildfires.

3.2.5. Ecosystem restoration

TEK has been found to be useful for ecosystem restoration in several studies (Yazzie et al. 2019; Stevens 2020). For example, Yazzie et al. (2019) highlight the ethical approach of Diné communities in their adaptive management plans to support the migration of Douglas fir and Ponderosa pine. Similarly, Stevens (2020) documents similar principles of Indigenous communities in California concerning white root *Carex barbarae* Dewey and basket weaving tradition, which embodies a deep respect for plant spirits. They restore riparian habitats by limiting wild harvests, cultivating plant materials, and conducting ceremonial practices during gatherings. The use of TEK not only restores the ecosystem but also preserves cultural practices and traditions that are integral to Indigenous communities.

3.3. Bridging TEK in research partnership

Many researchers emphasize the importance of conducting collaborative, mutually beneficial research with Indigenous communities in a culturally sensitive manner (Kurashima et al. 2018; Barnhill-Dilling and Delborne 2019; O'Gorman et al. 2022). Before initiating the research partnership with Indigenous communities, O'Gorman et al. (2022) recommend acquiring a deep understanding of place, culture, and Indigenous land stewardship. This involves acknowledging tribal authority, honoring the role of TEK, and recognizing Indigenous involvement in protecting ecosystems, land, and society (Kurashima et al. 2018). However, we found only a few studies have focused on this topic and documented the processes involved in their methods (Ban et al. 2008; Pyke et al. 2018).

To build trust and relationships, an immersive approach is recommended, including spending time in the community, having informal conversations with Indigenous people inside their territories, and participating in community events (Ban et al. 2008). For example, Pyke et al. (2018) lived within a community for one year, regularly interacting with locals and Indigenous research teams. Research should prioritize addressing the concerns, priorities and obtaining consent from Indigenous people (Pyke et al. 2018; Barnhill-Dilling and Delborne 2019). This involves presenting the proposed approach to community chiefs and councils for approval (Ban et al. 2008). Accommodating Indigenous languages and customs can further improve engagement (Olivero 2016).

During collecting data, sensitive information should be carefully protected to safeguard local natural systems and tribal knowledge (Friday and Scasta 2020). Moller et al. (2009), Jurjonas et al. (2020), and Thornton et al. (2020) suggested recruiting Indigenous researchers or descendants to facilitate access, build trust with participants, and enable co-construction of knowledge bridging TEK and Western perspectives. When publishing and sharing data, Ban et al. (2008) suggested researchers should only proceed with permission from Indigenous partners and limit the use of results to approved purposes. Including Indigenous co-authors and properly acknowledging communities' contributions is necessary (Jurjonas et al. 2020; Thornton et al. 2020).

Sustaining respectful partnerships by upholding commitments facilitates continued collaboration and knowledge sharing between researchers and Indigenous communities. While very few of the studies reviewed for this analysis provide specific guidance in their

methods, such protocols are vital for conducting ethical, equitable research benefiting all partners. Respectful partnerships require a commitment to sustaining relationships throughout and beyond a specific project period, and future research would benefit from reporting on how relationships are maintained with Indigenous communities throughout and beyond the life of a single published study.

4. Discussion

In this section, we first discuss the limitations of the reviewed studies, identify several gaps in research topics and methodologies, and propose a future research agenda. We also provide our insights on bridging TEK in restoration projects and research partnership with Indigenous communities.

4.1. Limitations, research gaps, and future research agenda

There are several limitations and gaps in the current research on integrating TEK into forest ecosystem and livelihoods research. Within the resilience theme, we found a notable emphasis on comparing TEK with government decisions and Western knowledge systems. However, limited exploration was dedicated to effectively bridging these two knowledge systems.

Research on cultural preservation revealed contrasting perspectives, with some scholars advocating for TEK revival efforts, while others viewed TEK as a dynamic, adaptive system capable of incorporating new elements. Unfortunately, there was a lack of investigation into the appropriate balance between preserving traditional practices and facilitating knowledge evolution in response to changing contexts.

In the conservation theme, studies explored the role of taboos, cultural beliefs, and TEK-based social institutions in biodiversity protection. However, specific suggestions for culturally appropriate conservation strategies or policies that harmonize traditional practices with modern conservation goals were lacking. Compared to the extensive research conducted on the social-ecological resilience theme that cited Berkes et al. (2000), research related to climate change adaptation and ecosystem restoration received limited attention. While some studies examined the utilization of TEK in predicting and mitigating climate-related disasters, comprehensive models for climate change adaptation strategies integrating TEK were not well studied. Additionally, the ecosystem restoration theme lacked specific case studies demonstrating how TEK principles and practices can inform ecosystem restoration initiatives across diverse contexts.

It is important to note that these identified gaps are specific to our dataset of papers citing Berkes et al. (2000). Different or broader search parameters may reveal different results.

In our review, we also found it crucial to distinguish between TEK and other forms of place-based knowledge. As TEK tends to align more closely with the generalizable nature of Western science, viewing TEK as a bridging concept can foster meaningful dialogue and integration between diverse knowledge systems in research. We also observed that TEK is often more readily incorporated into Indigenous institutions and decision-making processes within Tribal Nations, while other forms of local knowledge may require significant 'translation' to function within governmental management systems. However, we noted

that some researchers (i.e., Bruegger et al. 2014; Bruyere et al. 2016; Castillo and Ladio 2017) may use TEK to refer to what might more accurately describe as local knowledge, particularly when Indigenous and local communities are engaged primarily as participants rather than research partnership. These distinctions address the unique role of TEK in bridging knowledge and conducting research with/by/as Indigenous communities.

Regarding the research protocols and methodologies, we found a lack of standardized approaches for bridging TEK in research partnerships with Indigenous communities. The majority of the literature still characterized Indigenous peoples as the research participants rather than collaborative research partners (Afentina et al. 2019; Chen and Cheng 2020; Abdul Aziz et al. 2020; Sebele et al. 2022). Few studies provided detailed guidance on establishing trust, obtaining consent, protecting sensitive information, and ensuring equitable knowledge sharing (Ban et al. 2008; Paniagua-Zambrana et al. 2014; Pyke et al. 2018; Holtgren and Auer 2022). Although the importance of incorporating Indigenous perspectives in research was acknowledged, we found a gap in integrating Indigenous voices and worldviews into the research process and interpretation of results (Bayrak and Marafa 2019). Most research findings were based on concepts, categories, and terminologies dominated by Western scientific logic, potentially leading to a bias and misrepresentation of non-Western viewpoints and knowledge systems (Marcinek and Hunt 2018). Furthermore, there were limited studies conducted as long-term partnerships with Indigenous communities, and Indigenous scholars' voices were still underrepresented in academic discourse.

Our review also revealed a notable underrepresentation of Latin American research in literature citing Berkes et al. (2000), which we consider a significant gap. This gap does not necessarily reflect a lack of TEK research in these regions, but rather points to important linguistic and academic factors influencing our results. Latin America has a rich tradition of TEK research, with many local scholars actively engaged in using and bridging TEK in scientific research. However, much of this valuable work is published in Spanish or Portuguese and less likely to cite Berkes et al. (2000). Readers should consider this aspect when interpreting our results. Future reviews could consider incorporating multilingual searches to provide a more comprehensive global picture of TEK research in these topics

To address limitations and gaps in TEK integration, we suggest future research on TEK and resilient livelihoods should prioritize the following areas:

(1) Conducting long-term research partnerships to establish relationships and understand the complexities and evolution of TEK on resilience strategies, considering environmental, social, and cultural factors. This includes emphasizing the involvement of Indigenous communities in the research process, including co-designing research objectives and methods and conducting participatory research.
(2) Following/developing standardized protocols for ethical research practices when working with Indigenous communities, including informed consent, data ownership and protection, and knowledge-sharing agreements that prioritize Indigenous data sovereignty principles (Carroll et al. 2019; Lovett et al. 2019; Carroll et al. 2021; Robinson et al. 2021).
(3) Exploring the implications of research results for policy and practice by actively engaging policymakers, practitioners, and community members in the research process.

(4) Supporting Indigenous-led research and knowledge production by providing resources (facilities, technologies and equipment, networking opportunities), funding, and platforms for Indigenous scholars to share their perspectives and contribute to academic discourse.
(5) Fully documenting the research partnership process in the methods section of studies to promote equitable and inclusive research collaboration with Indigenous communities.
(6) Conducting comparative studies across different geographic regions and Indigenous groups to identify common patterns and best practices for resilience strategies, incorporating TEK with government decisions and policies, and TEK revival practices.

For restoration research projects, allowing greater flexibility in project timelines and funding structures to accommodate the unique needs and practices of TEK-based approaches. This may involve rethinking traditional project management frameworks to align with the cyclical nature of TEK and Indigenous knowledge systems.

While our study focused on academic literature citing Berkes et al. (2000), it is important to acknowledge the significant influence of policy platforms, particularly the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), in promoting the bridging of TEK in both academic and policy in global biodiversity and ecosystem services discourse. Future review could benefit from exploring IPBES and its seminal report to provide insights into how TEK has developed and disseminated in environment management and conservation policy.

Our review has highlighted several key gaps in TEK research citing Berkes et al. (2000), particularly in the areas of resilience, forest ecosystem, and livelihood studies that collaborate with Indigenous communities. To better illustrate how these gaps can be addressed and to demonstrate the practical application of TEK as a bridging concept between Western science and Indigenous knowledges, we share our reflection on the Keweenaw Bay Indian Community's manoomin restoration efforts. This reflection not only illustrates the bridging of TEK in ecosystem restoration but we also hope to address the significance of establishing the long-term research partnership, which is built on mutual respect, trust, and acknowledgement of Indigenous rights and sovereignty. By examining this real-world application of TEK, we want to address a bridging approach that respects Indigenous perspectives, timelines, and cultural values.

4.2. Reflections on KBIC manoomin restoration efforts at Sand Point Sloughs

Manoomin (wildrice or *Zizania palustris*) holds a pivotal role in Ojibwa's cultural identity, tradition, and livelihood (Hosterman et al. 2023). This species embodies the Ojibwa historical migration and their profound relationship with the land (Barton 2018). Ecologically, manoomin provides food and habitat for over 17 wildlife species of conservation concern, maintains water quality, prevents erosion, and serves as an indicator of ecosystem health (Great Lakes Wetland Research Institute [GLWRI] 2020). On the livelihood aspect, manoomin is a dietary staple and important medicinal plant, which is deeply ingrained in Ojibwa ceremonies and sustenance (GLWRI 2020).

The Keweenaw Bay Indian Community (KBIC), the oldest federally-recognized Indian Tribe with the largest land base in Michigan, retained their treaty rights to harvest manoomin, hunt, fish, and gather on ceded lands through the Treaty of 1842 with the United States government (Great Lakes Indian Fish and Wildlife Commission [GLIFWC] 2022). The act of harvesting manoomin transcends mere practicality; it is a tradition that acknowledges Ojibwa sovereignty, binds communities together, preserves ancestral heritage, and fosters intergenerational connections (GLWRI 2020).

The Sand Point Sloughs, situated along Lake Superior's shores, hold immense cultural significance for KBIC and historically contained manoomin beds. However, the legacy of copper ore processing in the 1920s left behind mine tailings, leading to heavy metal contamination, while fluctuations in Lake Superior's water levels impacted manoomin abundance (GLWRI 2020). To mitigate these issues, KBIC has undertaken restoration efforts since 1991, including reintroducing manoomin and remediating the shoreline to revive 183 acres on Sand Point Sloughs. Between 1991 and 2018, KBIC seeded nearly 5,600 pounds of manoomin across the area (GLWRI 2020). However, only 8 acres were successfully revived during 1999 and 2002 (GLWRI 2020). Since 2002, the manoomin population has decreased, and restoration work has become increasingly challenging due to threats from hydrologic changes, pollution, land use impacts, invasive species, and climate change (GLWRI 2020). Despite these challenges, KBIC persists in annual seeding efforts at Sand Point Sloughs, conducting ceremonies and making offerings to the water in the hope that manoomin will one day return. The rice ceremony is also open to the public, reflecting the Community's commitment to keeping manoomin teachings and traditions vital (GLWRI 2020).

The first author of this paper participated in the KBIC manoomin camp in 2022 as a participant building relationships with community members. Listening to community members' perspectives on restoration work, we want to add two aspects that were not covered in our reviewed articles: (1) the importance of including TEK regarding the community's rights, sovereignty, tradition, and values in restoration work; and (2) the need for flexibility in the timescales of TEK-based collaborative restoration projects.

Holding a manoomin seed in her hand, a KBIC elder shared her thoughts on manoomin restoration:

> Manoomin restoration is for everyone. . .But for non-tribal people, this is our home. . .To do this work side by side is very important to myself and our community. And for you to hold that life in your hands, and to be able to put it back into the water where it needs to be. It is a reciprocal relationship. . .. Who knows, there might be a beautiful seed bank here, and then someday, when things come into alignment, how beautiful will that be. . .. So I get really emotional because this is the work I've been doing, and I see myself as a caregiver, to take care of the medicines. And that's our way of sustaining our way of living.

For the Ojibwa people, TEK involves caring for the landscape and plants like they are relatives living in close relation. Their perspective on restoration work stems from their cultural identity, responsibilities, and heartfelt desire to care for their relatives. Thus, restoration efforts that include TEK and partner with Indigenous people will also support Indigenous rights, to care for the land and other-than-human relatives (Whyte 2017). When conducted respectfully, restoration projects can greatly benefit from a community's

knowledge in answering questions like what plants should be included and how the restoration should be carried out. An elder in KBIC (Food Sovereignty Symposium 2022) said that:

> Manoomin is our medicine. . .. I sit with those plants, learn and receive their teachings. The plants are teachers. . .. They have rules and regulations, and we learned from them. . .. Science did not know about that, and they are just catching up to what we already know.

Indigenous people have built relationships with the landscape for generations, living and learning from plants, understanding native species, their abundance, growth patterns, and the conditions they require. Thus, their contribution is a key factor in shaping more effective and sustainable restoration approaches (Hosterman et al. 2023). A KBIC elder explained:

> We are losing manoomin as water levels rise. So as part of the manoomin restoration project, we did a water ceremony. We sing to the water. . . we must have our ceremonies. We must acknowledge those spirits and reconnect. . .. Water is our Mother Earth's blood. And when she is sick, our resources are starting to diminish.

Researchers are encouraged to build relationships not only with Indigenous communities but also with the land itself. Being receptive to learning and attentively listening will assist in making restoration work more ethical and meaningful. Regarding the ethical aspect, TEK offers researchers a humble and positive outlook when dealing with difficulties, emphasizing observation and listening skills when faced with phenomena. A KBIC elder shared:

> When you sit with those medicines and sit on the landscape, the spirit will come and give you wonderful teachings. . ..I can run over a plant at Sand Point, making them lie down, and see how resilient they are. . .. The plants go back the next day when they're standing . . . . You can learn a lot from the medicines in that way with manoomin restoration.

To enhance the resilience of the manoomin restoration project, KBIC has been collaborating with different tribes and organizations, such as the Fond du Lac Band of Lake Superior Chippewa, Bois Forte, and the Great Lakes Indian Fish & Wildlife Commission (GLIFWC) to seed manoomin at various sites historically present with manoomin including the Net River Impoundment and Vermillac Lake (GLWRI 2020). At Sand Point Sloughs, seeding has been ongoing for four decades, with KBIC continuing the effort annually to this day. Reflecting on this effort, a KBIC elder said (KBIC Manoomin Camp, 2022):

> The manoomin revival is a beautiful way of showing you that when you have faith and do that work. . .and for all of you to participate on behalf of my community, to put your hands on that manoomin. . .. They are not doing too well right now. But maybe someday they will come back.

Restoration efforts that involve partnerships with Indigenous people and incorporate TEK often operate on a very different timescale compared to other projects with strict deadlines, timelines, and funding constraints. For example, KBIC's manoomin restoration focuses on the responsibility to care for and steward the species annually for annual progress, instead of a short-term project (GLWRI 2020). They are very careful when acknowledging and talking about manoomin or other-than-human beings with respect. When the Tribe conducts restoration projects, the process involves consulting elders, building kinship, giving thanks, acknowledging, and performing ceremonies. For restoration efforts related to invasive species, KBIC elders suggest careful observation and treating the new guest plants with

consideration and respect. A KBIC elder (Indigenous Day 2023) said, '*People have a tendency to want to fix everything immediately, but our elders always remind us to wait and listen.*' It also takes considerable time for researchers to initiate projects by building relationships and trust with the communities. Therefore, we suggest researchers and funding agencies should consider ways to allow temporal flexibility when conducting TEK-based restoration projects and building partnership with Indigenous communities.

While our review primarily focuses on epistemological aspects of TEK in bridging knowledges, it is crucial to acknowledge that the sociological barriers also exist. Formal academic credentials often act as a form of boundary work, limiting who can contribute to scientific knowledge in recognized ways (Schelly et al. 2024). As Björkvik et al. (2021) recorded Vendance fishers' sharing at the Swedish Baltic, '*We have not done research or anything, but we have 50 years of experience and have observed what is going on. So we can draw certain conclusions without having a thick CV*' (p.1). Credentialism can exclude valuable TEK from academic discourse, not because it is invalid, but because it does not conform to traditional academic norms or credentialing processes.

In our case study of the KBIC, we observed tribal members often saying they learn from the other-than-human beings, such as 'the plants are my teachers.' While this may not align with what academic research often perceives as valid, TEK have served their communities for generations, and as KBIC elder's statement '. . .[science] is just catching up to what we already know.' Thus, we also suggest that future studies should explore ways to overcome this limitation to bridge diverse forms of TEK into scientific discourse and decision-making processes.

5. Conclusions

In this paper, we examined documents citing Berkes et al. (2000) work on resilient forest ecosystems and livelihood during the last two decades. Our analysis covered 317 documents spanning 41 research areas, with the majority focusing on environmental science, ecology, and biodiversity. The most productive countries were the United States and Canada. There were 23 terms associated with TEK; however, they differed in their specific contexts, with some terms more closely tied to the cultural identities and worldviews of Indigenous people. Bibliometric mapping using VOSviewer was employed to analyze the co-occurrences of author keywords and visualize the relationship between research topics. We found that while research on resilience, conservation, and TEK dominated the field, topics such as ethnobotany, ecosystem restoration, governance, and Indigenous peoples received relatively limited attention.

To understand contemporary research on key themes and topics, we reviewed 64 articles and identified key themes and topics based on full reading, synthesizing, and categorizing them based on their objectives and findings. We identified four major themes, including social-ecological resilience, cultural preservation, conservation, climate change adaptation, and ecosystem restoration. We summarized each theme, its topics, and the method of bridging TEK with Western science in contemporary research in our results. Overall, despite the work advocating for bridging TEK in research and collaboration with Indigenous communities, we found a lack of standardized approaches for equitably integrating TEK into research partnerships with Indigenous communities. Indigenous voices and worldviews were underrepresented,

with findings dominated by Western scientific logic. To overcome these limitations, future research should prioritize long-term, participatory partnerships with Indigenous communities, co-designing objectives and methods. Developing ethical protocols, such as informed consent and Indigenous data sovereignty, is crucial.

Our reflections on the Keweenaw Bay Indian Community's manoomin restoration efforts highlighted the importance of respecting Indigenous rights, sovereignty, traditions, and values in TEK-based projects. This case study underscored the need for flexible timelines and funding structures to accommodate TEK's unique practices and value systems. Further, a key lesson from our work is that while the science of engagement focuses on building relationships with people, TEK emphasizes the importance of also building relationships with a place and the other-than-human beings residing in it as a part of building a foundation for meaningful partnerships with Indigenous communities.

Note

1. It is interesting to note that Australia and Canada are particularly well-represented in the literature citing Berkes et al. (2000). While our study does not explore the reason behind this geographic distribution, future research would benefit from investigating potential factors influencing this trend. Such a study could provide insights into the drivers of academic interest in TEK across different regions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the USDA National Institute of Food and Agriculture, McIntire-Stennis [Award # MICZ 10012022], and the National Science Foundation [Award #1934346].

References

Abdul Aziz M, Ullah Z, Pieroni A. 2020. Wild food plant gathering among Kalasha, Yidgha, Nuristani and Khowar speakers in Chitral, NW Pakistan. Sustainability. 12(21):9176. doi: 10.3390/su12219176.

Aburto JA, Stotz W, Cundill G, Tapia C. 2021. Toward understanding the long-term persistence of a local governance system among artisanal fishers in Chile. Ecol Soc. 26(3). doi: 10.5751/es-12479-260305.

Afentina, McShane P, Wright W. 2019. Ethnobotany, rattan agroforestry, and conservation of ecosystem services in Central Kalimantan, Indonesia. Agrofor Syst. 94(2):639–650. doi: 10.1007/s10457-019-00428-x.

Aswani S, Lemahieu A, Sauer WHH. 2018. Global trends of local ecological knowledge and future implications. Viña A, editor. PLOS ONE. 13(4):e0195440. doi: 10.1371/journal.pone.0195440.

Ban NC, Picard C, Vincent ACJ. 2008. Moving toward spatial solutions in marine conservation with indigenous communities. Ecol Soc. 13(1). doi: 10.5751/ES-02473-130132.

Barnhill-Dilling SK, Delborne JA. 2019. The genetically engineered American chestnut tree as opportunity for reciprocal restoration in Haudenosaunee communities. Biol Conserv. 232:1–7. doi: 10.1016/j.biocon.2019.01.018.

Barton BJ. 2018. Manoomin. East Lansing (MI): Michigan State University Press.

Bayrak MM, Marafa LM. 2019. Are Vietnamese farmers able to combat global climate change? A case study on perceptions and attitudes towards sustainable forest management and REDD+ in central Vietnam. J Sustain For. 39(3):242–258. doi: 10.1080/10549811.2019.1634593.
Benyei P, Arreola G, Reyes-García V. 2019. Storing and sharing: a review of indigenous and local knowledge conservation initiatives. Ambio. 49(1):218–230. doi: 10.1007/s13280-019-01153-6.
Berkes F. 1993. Traditional ecological knowledge in perspective. In: Inglis J, editor. Traditional ecological knowledge: concepts and cases. Ottawa (ON): International Program on Traditional Ecological Knowledge and International Development Research Centre; p. 1–9.
Berkes F. 2004. Rethinking community-based conservation. Conserv Biol. 18(3):621–630. doi: 10.1111/j.1523-1739.2004.00077.x.
Berkes F, Colding J, Folke C. 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecol Appl. 10(5):1251–1262. doi: 10.1890/1051-0761(2000)010[1251:roteka]2.0.co;2.
Björkvik E, Boonstra WJ, Telemo V. 2021. Going on and off the map: lessons from Swedish fisher knowledge about spawning areas in the Baltic Sea. Ocean Coast Manage. 211:105762. doi: 10.1016/j.ocecoaman.2021.105762.
Bohensky EL, Maru Y. 2011. Indigenous knowledge, science, and resilience: what have we learned from a decade of international literature on "integration"? Ecol Soc. 16(4). doi: 10.5751/ES-04342-160406.
Bruegger RA, Jigjsuren O, Fernández-Giménez ME 2014. Herder observations of rangeland change in Mongolia: indicators, causes, and application to community-based management. Rangeland Ecol Manag. 67(2):119–131. doi: 10.2111/rem-d-13-00124.1.
Bruyere BL, Trimarco J, Lemungesi S. 2016. A comparison of traditional plant knowledge between students and herders in northern Kenya. J Ethnobiol and Ethnomed. 12(1). doi: 10.1186/s13002-016-0121-z.
Caballero-Serrano V, McLaren B, Carrasco JC, Alday JG, Fiallos L, Amigo J, Onaindia M. 2019. Traditional ecological knowledge and medicinal plant diversity in Ecuadorian Amazon home gardens. Glob Ecol Conserv. 17:e00524. doi: 10.1016/j.gecco.2019.e00524.
Caillon S, Cullman G, Verschuuren B, Sterling EJ. 2017. Moving beyond the human-nature dichotomy through biocultural approaches: including ecological well-being in resilience indicators. Ecol Soc. 22(4). doi: 10.5751/ES-09746-220427.
Cámara-Leret R, Dennehy Z. 2019. Information gaps in indigenous and local knowledge for science-policy assessments. Nat Sustain. 2(8):736–741. doi: 10.1038/s41893-019-0324-0.
Carroll SR, Garba I, Figueroa-Rodríguez OL, Holbrook J, Lovett R, Materechera S, Parsons M, Raseroka K, Rodriguez-Lonebear D, Rowe R, et al. 2021. The CARE principles for indigenous data governance. Data Sci J. 19:43. doi: 10.5334/dsj-2020-043.
Carroll SR, Rodriguez-Lonebear D, Martinez A. 2019. Indigenous data governance: strategies from United States native nations. Data Sci J. 18(1):31. doi: 10.5334/dsj-2019-031.
Castillo L, Ladio A 2017. Mammals and birds as ethno-indicators of change: their importance to livestock farmers in arid Patagonia (Argentina). Environ Dev Sustain. 20(5):2161–2179. doi: 10.1007/s10668-017-9983-z.
Cervellini M, Fiorini S, Cavicchi A, Campetella G, Simonetti E, Chelli S, Canullo R, Gimona A. 2017. Relationships between understory specialist species and local management practices in coppiced forests – evidence from the Italian apennines. For Ecol Manage. 385:35–45. doi: 10.1016/j.foreco.2016.11.027.
Charnley S, Fischer AP, Jones ET. 2007. Integrating traditional and local ecological knowledge into forest biodiversity conservation in the Pacific Northwest. For Ecol Manage. 246(1):14–28. doi: 10.1016/j.foreco.2007.03.047.
Chen TL, Cheng HW. 2020. Applying traditional knowledge to resilience in coastal rural villages. Int J Disaster Risk Reduct. 47:101564. doi: 10.1016/j.ijdrr.2020.101564.
Colding J, Folke C. 2001. Social taboos: "invisible" systems of local resource management and biological conservation. Ecol Appl. 11(2):584–600. doi: 10.1890/1051-0761(2001)011[0584:stisol]2.0.co;2.

Ens EJ, Pert P, Clarke PA, Budden M, Clubb L, Doran B, Douras C, Gaikwad J, Gott B, Leonard S, et al. 2015. Indigenous biocultural knowledge in ecosystem science and management: review and insight from Australia. Biol Conserv. 181:133–149. doi: 10.1016/j.biocon.2014.11.008.

Ferrari R. 2015. Writing narrative style literature reviews. Med Writ. 24(4):230–235. doi: 10.1179/2047480615Z.000000000329.

Folch A, Planas J. 2019. Cooperation, fair trade, and the development of organic coffee growing in Chiapas (1980–2015). Sustainability. 11(2):357. doi: 10.3390/su11020357.

Food Sovereignty Symposium. 2022 Dec 3. Food sovereignty symposium festival. [accessed 2024 Apr 19]. https://food-sovereignty.com/schedule/.

Ford JD, King N, Galappaththi EK, Pearce T, McDowell G, Harper SL. 2020. The resilience of indigenous peoples to environmental change. One Earth. 2(6):532–543. doi: 10.1016/j.oneear.2020.05.014.

Friday C, Scasta JD. 2020. Eastern Shoshone and Northern Arapaho traditional ecological knowledge (TEK) and ethnobotany for wind river reservation rangelands. Ethnobiol Lett. 11(1):14–24. doi: 10.14237/ebl.11.1.2020.1654.

Gagnon VS. 2016. Ojibwe Gichigami ("Ojibwa's great sea"): an intersecting history of treaty rights, tribal fish harvesting, and toxic risk in Keweenaw Bay, United States. Water Hist. 8(4):365–384. doi: 10.1007/s12685-016-0185-7.

García-Jácome LG, García-Frapolli E, Bonilla-Moheno M, Rangel-Rivera CE, Benítez M, Ramos-Fernández G. 2020. Multiple resource use strategies and resilience of a socio-ecosystem in a natural protected area in the Yucatan Peninsula, Mexico. Front Sustain Food Syst. 4:4. doi: 10.3389/fsufs.2020.522657.

Great Lakes Indian Fish and Wildlife Commission [GLIFWC]. 2022. Ojibwe treaty rights. Odanah (WI): Great Lakes Indian Fish and Wildlife Commission.

Great Lakes Wetland Research Institute [GLWRI]. 2020. Lake superior manoomin cultural and ecosystem characterization study. Duluth (MN): Great Lakes Wetland Research Institute.

Green BN, Johnson CD, Adams A. 2006. Writing narrative literature reviews for peer-reviewed journals: secrets of the trade. J Chiropr Med. 5(3):101–117. doi: 10.1016/s0899-3467(07)60142-6.

Guerrero-Gatica M, Mujica MI, Barceló M, Vio-Garay MF, Gelcich S, Armesto JJ. 2020. Traditional and local knowledge in Chile: review of experiences and insights for management and sustainability. Sustainability. 12(5):1767. doi: 10.3390/su12051767.

Hamlin CC, Salick J. 2003. Yanesha agriculture in the upper Peruvian Amazon: persistence and change fifteen years down the "road". Econ Bot. 57(2):163–180. doi: 10.1663/0013-0001(2003)057[0163:YAITUP]2.0.CO;2.

Holtgren JM, Auer NA. 2022. Forging a new path for multi-cultural fishery management. J Great Lakes Res. 49(1):S116–S127. doi: 10.1016/j.jglr.2022.09.001.

Hosterman H, Ritter K, Schuldt N, Vogt D, Erickson DL, Griot O, Johnston EF, Schmidt K, Ravindran E, LaBine R, et al. 2023. Lake superior manoomin cultural and ecosystem characterization study. Ecol Soc. 28(3). doi: 10.5751/es-13763-280317.

Immanuel RR, Imayavaramban V, Elizabeth LL, Kannan T, Murugan G. 2010. Traditional farming knowledge on agroecosystem conservation in northeast coastal Tamil Nadu. Indian J Tradit Know. 9(2):366–374.

Indigenous Day. 2023 Sep 28. Gathering presentation honoring indigenous peoples' day. [accessed 2024 Apr 19]. https://blogs.mtu.edu/computing-advisor/2023/09/28/gathering-presentation-honoring-indigenous-peoples-day/ .

Intergovernmental Panel on Climate Change [IPCC]. 2018, Oct 8. Summary for policymakers of IPCC special report on global warming of 1.5°C approved by governments. [accessed 2024 Apr 19]. https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/.

Irakiza R, Vedaste M, Elias B, Nyirambangutse B, Nyirambangutse JS, Marc N. 2016. Assessment of traditional ecological knowledge and beliefs in the utilisation of important plant species: the case of Buhanga sacred forest, Rwanda. Koedoe. 58(1). doi: 10.4102/koedoe.v58i1.1348.

Jackley J, Gardner L, Djunaedi AF, Salomon AK. 2016. Ancient clam gardens, traditional management portfolios, and the resilience of coupled human-ocean systems. Ecol Soc. 21(4). doi: 10.5751/ES-08747-210420.

Jurjonas M, Seekamp E, Rivers L, Cutts B. 2020. Uncovering climate (in)justice with an adaptive capacity assessment: a multiple case study in rural coastal North Carolina. Land Use Policy. 94 (C):104547. doi: 10.1016/j.landusepol.2020.104547.

Khakurel D, Uprety Y, Ł Łuczaj, Rajbhandary S. 2021. Foods from the wild: Local knowledge, use pattern and distribution in Western Nepal. PLoS One. 16(10):e0258905. doi:10.1371/journal.pone.0258905

Kurashima N, Jeremiah J, Whitehead A, Tulchin J, Browning M, Duarte T. 2018. ʻĀina Kaumaha: the maintenance of ancestral principles for 21st century indigenous resource management. Sustainability. 10(11):3975. doi: 10.3390/su10113975.

LaRochelle S, Berkes F. 2003. Traditional ecological knowledge and practice for edible wild plants: biodiversity use by the Rarámuri, in the Sirerra Tarahumara, Mexico. Int J Sustain Dev World Ecol. 10(4):361–375. doi: 10.1080/13504500309470112.

Li A, Ford J. 2019. Understanding socio-ecological vulnerability to climatic change through a trajectories of change approach: a case study from an indigenous community in Panama. Weather Clim Soc. 11(3):577–593. doi: 10.1175/wcas-d-18-0093.1.

Loch TK, Riechers M. 2021. Integrating indigenous and local knowledge in management and research on coastal ecosystems in the global south: a literature review. Ocean Coast Manage. 212:105821. doi: 10.1016/j.ocecoaman.2021.105821.

Lovett R, Lee V, Kukutai T, Cormack D, Rainie S, Walker J. 2019. Good data practices for indigenous data sovereignty and governance. In: Daly A, Devitt S Mann M, editors. Good data. Amsterdam: Institute of Network Cultures; p. 26–36.

Luna-José A, Aguilar B. 2012. Traditional knowledge among Zapotecs of Sierra Madre Del Sur, Oaxaca. Does it represent a base for plant resources management and conservation? J Ethnobiol Ethnomed. 8(1):24. doi: 10.1186/1746-4269-8-24.

Lyver POB, Timoti P, Richardson SJ, Gormley AM. 2021. Alignment of ordinal and quantitative species abundance and size indices for the detection of shifting baseline syndrome. Ecol Appl. 31 (4). doi: 10.1002/eap.2301.

Macnight NN, Saito O, Sato A, Agyeman Boafo Y, Jasaw G. 2018. Traditional and local knowledge practices for disaster risk reduction in northern Ghana. Sustainability. 10(3):825. doi: 10.3390/su10030825.

Malapane OL, Musakwa W, Chanza N, Radinger-Peer V 2022. Bibliometric analysis and systematic review of indigenous knowledge from a Comparative African Perspective: 1990–2020. Land. 11 (8):1167. doi: 10.3390/land11081167.

Marcinek AA, Hunt CA. 2019. Tourism and cultural commons in the Ecuadorian Amazon. J Tour Cult Change. 17(4):449–466. doi: 10.1080/14766825.2019.1591711.

Marcinek AA, Hunt CA 2019. Tourism and cultural commons in the Ecuadorian Amazon. J Tour Cult Change. 17(4):449–466. doi: 10.1080/14766825.2019.1591711.

Mariel J, Carrière SM, Penot E, Danthu P, Rafidison VM, Labeyrie V. 2021. Exploring farmers' agrobiodiversity management practices and knowledge in clove agroforests of Madagascar. People Nat. 3(4):914–928. doi: 10.1002/pan3.10238.

Martínez-Torres HL, Castillo A, Ramírez MI, Pérez-Salicrup DR. 2016. The importance of the traditional fire knowledge system in a subtropical montane socio-ecosystem in a protected natural area. Int J Wildland Fire. 25(9):911. doi: 10.1071/wf15181.

Milestad R. 2003. Building farm resilience: challenges and prospects for organic farming [dissertation]. Uppsala (Sweden): Swedish University of Agricultural Sciences.

Moller H, Kitson JC, Downs TM. 2009. Knowing by doing: learning for sustainable muttonbird harvesting. N Z J Zool. 36(3):243–258. doi: 10.1080/03014220909510153.

Moyo BHZ, Moyo DZ. 2014. Indigenous knowledge perceptions and development practice in northern Malawi. Geogr J. 180(4):392–401. doi: 10.1111/geoj.12056.

Mulki S, Ormsby AA. 2021. Breaking green ceilings: podcasting for environmental and social change. J Environ Stud Sci. 12(1):18–27. doi: 10.1007/s13412-021-00723-z.

Nguyen T, Ross A. 2017. Barriers and opportunities for the involvement of indigenous knowledge in water resources management in the Gam River Basin in North-East Vietnam. Water Altern. 10 (1):134–159.

O'Gorman CJ, Bentley LP, McKay C, Purser M, Everly KM. 2022. Examining abiotic and biotic factors influencing specimen black oaks (Quercus kelloggii) in northern California to reimplement traditional ecological knowledge and promote ecosystem resilience post-wildfire. Ecol Soc. 27(2). doi: 10.5751/es-13187-270219.

Olivero J. 2016. Using indigenous knowledge to link land cover mapping with land use in the Venezuelan Amazon. Rev Biol Trop. 64(4):1661–1682. doi: 10.15517/rbt.v64i4.21886.

Paniagua-Zambrana NY, Camara-Lerét R, Bussmann RW, Macía MJ. 2014. The influence of socio-economic factors on traditional knowledge: a cross scale comparison of palm use in northwestern South America. Ecol Soc. 19(4). doi: 10.5751/ES-06934-190409.

Pyke ML, Toussaint S, Close PG, Dobbs RJ, Davey I, George KJ, Oades D, Sibosado D, McCarthy P, Tigan C, et al. 2018. Wetlands need people: a framework for understanding and promoting Australian indigenous wetland management. Ecol Soc. 23(3). doi: 10.5751/es-10283-230343.

Ray LA, Kolden CA, Chapin FS. 2012. A case for developing place-based fire management strategies from traditional ecological knowledge. Ecol Soc. 17(3). doi: 10.5751/ES-05070-170337.

Riedlinger D, Berkes F. 2001. Contributions of traditional knowledge to understanding climate change in the Canadian Arctic. Polar Rec. 37(203):315–328. doi: 10.1017/s0032247400017058.

Robinson CJ, Kong T, Coates R, Watson I, Stokes C, Pert P, McConnell A, Chen C. 2021. Aug. Caring for indigenous data to evaluate the benefits of indigenous environmental programs. Environ Manage. 68(2):160–169. doi: 10.1007/s00267-021-01485-8.

Rustomjee C. 2016. Indigenous knowledge as a driver of resilience. London (UK): Commonwealth Foundation.

Schelly C, Gagnon V, Brosemer K, Arola K. 2024. Engagement for Life's Sake: reflections on partnering and partnership with rural tribal nations. Rural Sociol. doi: 10.1111/ruso.12519.

Schipper J, Chanson JS, Chiozza F, Cox NA, Hoffmann M, Katariya V, Lamoreux J, Rodrigues ASL, Stuart SN, Temple HJ, et al. 2008. The status of the world's land and marine mammals: diversity, threat, and knowledge. Science. 322(5899):225–230. doi: 10.1126/science.1165115.

Sebele L, Mundy P, Fritz H, Guerbois C. 2022. Perceptions on barn owls and their use in rodent control: a case study of Hwange district. Trop Conserv Sci. 15:194008292211201. doi: 10.1177/19400829221120175.

Siddaway AP, Wood AM, Hedges LV. 2019. How to do a systematic review: a best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. Annu Rev Psychol. 70(1):747–770. doi: 10.1146/annurev-psych-010418-102803.

Singh RK, Turner NJ, Pandey CB. 2011. "Tinni" Rice (Oryza rufipogon Griff.) production: an integrated sociocultural agroecosystem in Eastern Uttar Pradesh of India. Environ Manage. 49 (1):26–43. doi: 10.1007/s00267-011-9755-8.

Sobrevila C. 2008. The role of indigenous peoples in biodiversity conservation. Washington (DC): The World Bank.

Stevens ML. 2020. Eco-cultural restoration of riparian wetlands in California: case study of white root (Carex barbarae Dewey; Cyperaceae). Wetlands. 40(6):2461–2475. doi: 10.1007/s13157-020-01323-3.

Tagliari MM, Levis C, Flores BM, Blanco GD, Tavares C, Bogoni JA, Vieilledent G, Peroni N. 2021. Collaborative management as a way to enhance Araucaria forest resilience. Perspect Ecol Conserv. 19(2):131–142. doi: 10.1016/j.pecon.2021.03.002.

Teaiwa K. 2014. Reframing Oceania: lessons from pacific studies. In: Karriem A, Ramutsindela M Toerien F, editors. Dialogues in human geography. Cape Town (South Africa): University of Cape Town; p. 40–52.

Thornton SA, Setiana E, Yoyo K, Dudin Y, Harrison ME, Page SE, Upton C. 2020. Towards biocultural approaches to peatland conservation: the case for fish and livelihoods in Indonesia. Environ Sci Policy. 114:341–351. doi: 10.1016/j.envsci.2020.08.018.

[UNWCED] World Commission on Environment and Development. 1987. Report of the world commission on environment and development. Our Common Future [Internet]. [place unknown]:

United Nations. https://www.are.admin.ch/are/en/home/media/publications/sustainable-development/brundtland-report.html
U.S. 2022. White house releases first-of-a-kind indigenous knowledge guidance for federal agencies | CEQ. The White House [Internet]. https://www.whitehouse.gov/ceq/news-updates/2022/12/01/white-house-releases-first-of-a-kind-indigenous-knowledge-guidance-for-federal-agencies/.
van Deelen G. 2022 May 16. The spirit in the science: wild rice conservation through tribal-university partnerships in Minnesota. [accessed 2024 Apr 19]. https://cmsw.mit.edu/the-spirit-in-the-science-wild-rice-conservation-through-tribal-university-partnerships-in-minnesota/.
Van Eck NJ, Waltman L. 2018. Vosviewer manual manual for VOSviewer version 1.6.8. Leiden (Netherlands): Leiden University.
Velázquez A, Bocco G, Torres A, López AA, Gómez FA. 2015. Indigenous community of Nuevo San Juan Parangaricutiro, Michoacán, Mexico. In: Balderas Torres A, editor. Integrated land-use planning for sustainable agriculture and rural development. Amsterdam: Elsevier; p. 169–175.
Watson A, Alessa L, Glaspell B. 2003. The relationship between traditional ecological knowledge, evolving cultures, and wilderness protection in the circumpolar north. Conserv Ecol. 8(1). doi: 10.5751/es-00589-080102.
Whyte K. 2017. What do indigenous knowledges do for indigenous peoples? In: Nelson M Shilling D, editors. Traditional ecological knowledge: learning from indigenous practices for environmental sustainability. Cambridge (UK): Cambridge University Press; p. 57–82.
Whyte KP 2013. On the role of traditional ecological knowledge as a collaborative concept: a philosophical study. Ecol Process. 2(1). doi: 10.1186/2192-1709-2-7.
Yacoub H. 2018. Knowledge and community resilience in rangelands recovery: the case of Wadi Allaqi biosphere reserve, Southeastern desert. Egypt Restor Ecol. 26(S1):S37–S43. doi: 10.1111/rec.12667.
Yazzie JO, Fulé PZ, Kim YS, Sánchez Meador A. 2019. Diné kinship as a framework for conserving native tree species in climate change. Ecol Appl. 29(6):1331–1343. doi: 10.1002/eap.1944.
Zhang L, Chai Z, Zhang Y, Geng Y, Wang Y. 2016. Ethnobotanical study of traditional edible plants used by the Naxi people during droughts. J Ethnobiol Ethnomed. 12(1). doi: 10.1186/s13002-016-0113-z.
Zhang L, Guan Z, Fei H, Yan L, Turvey ST, Fan P. 2020. Influence of traditional ecological knowledge on conservation of the Skywalker hoolock gibbon (Hoolock tianxing) outside nature reserves. Biol Conserv. 241:108267. doi: 10.1016/j.biocon.2019.108267.