

Synthesizing the Characteristics and Applications of Indigenous Knowledge for Sustainable Development: A Systematic Review

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Abstract

This study systematically reviewed the literature to define the characteristics and relevance of Indigenous knowledge (IK), revealing it to be local, community-owned, intergenerational, holistic, and largely tacit. The research was guided by the Boolean search logic and the Population or Problem, Interest, and Context (PICo) tool in formulating and creating the search terms, retrieval, and research questions for this review. The findings highlight IK's significant contributions to the Sustainable Development Goals (SDGs). In agriculture and food security (SDGs 1, 2, 12), IK promotes agroecology, mixed cropping, and seed preservation, supporting resilience against poverty and hunger. In health and well-being (SDG 3), traditional medicine and community health systems provide accessible, culturally relevant care. IK also enhances education (SDG 4) by integrating local epistemologies and experiential learning into the curriculum. In terms of gender equality (SDG 5), IK based enterprises empower women through artisanal and entrepreneurial activities. It fosters climate action (SDG 13) and biodiversity conservation (SDGs 14, 15) through sacred ecological practices, early warning systems, and sustainable resource use. Further, IK underpins peaceful institutions and justice (SDG 16) through customary governance, consensus-building, and dispute resolution mechanisms. It supports partnership for development (SDG 17) by promoting inclusive, locally grounded collaborations. This study fills a knowledge gap by linking IK to the SDGs and calls for its integration into policy-making, education, development planning, and research. Ensuring indigenous communities lead in managing and transmitting their knowledge is vital for sustainable and equitable global development.

Keywords

indigenous people, indigenous knowledge, sustainable development, climate change, agriculture, natural resources

Introduction

There has been increasing interest in understanding the concept of IK and how to promote, process, and manage IK for sustainable development (Agyemang et al., 2020; Kumar, 2021). The rising interest is driven by several factors, such as the long-standing relationship between indigenous people and their local communities or societies with their environment (Hill et al., 2020), the comprehensive knowledge accumulated over the years to guide social-ecological systems (Nyahunda & Tirivangasi, 2022), and the resilience of these communities in facing crises and various changes like shifts in livelihoods, climate, ecosystems, and resource availability (Ghazali et al., 2021). IK is primarily possessed by indigenous

people. “Indigenous peoples have the right to determine their own identity or membership in accordance with their customs and traditions” (UNDRIP, Article 33).

Indigenous people possess a wealth of experience and knowledge, collectively referred to as IK (Dei et al., 2025; Dei, 2024). Reid et al. (2021) further posited that IK is a “cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down

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through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment.” IK represents a significant resource to the development and sustainability of the community, society, and the world as a whole.

With the adoption of the 2030 Agenda for Sustainable Development, the international community committed itself to addressing several challenges faced by member countries. This initiative led to the creation of the 17 Sustainable Development Goals (SDGs; Shafik, 2025). The attainment of these 17 SDGs largely depends on the recognition and empowerment of all disadvantaged, misrepresented, and marginalized social actors and indigenous people in the indigenous communities. These are based on programs, development policies, and legislation. These people or communities possess complex and diverse cultures, knowledge, traditions, and histories, which are essential to the development, implementation, and attainment of the 17 SDGs.

Many scholars have sought to examine how IK addresses SDGs from various perspectives and fields (Apraku et al., 2021; Dei & Asante, 2022; Kasilo & Wambebe, 2021; Makate, 2020). Although these studies focus on adapting IK to different areas of the SDGs, there is a lack of comprehensive and systematic reviews that thoroughly explore the characteristics of IK and its applications in achieving the SDGs. Conducting a systematic review of past studies is very important because it reduces reviewer bias, which is often present in traditional literature reviews. This study aims to fill the identified knowledge gap by systematically reviewing literature on the characteristics and functions of IK in promoting the SDGs. It seeks to clarify the definition, structure, and application of IK across various contexts. To accomplish this, the research proposes these questions.

1. What are the main traits that make up IK?
2. In what areas and fields does IK help with sustainable development?

This study is driven by the urgent need to systematically consolidate and analyze how IK is characterized and applied across development sectors, especially in the context of achieving the SDGs. It employs rigorous systematic review methodologies on recent literature (2019–2023) to reconcile fragmented academia, inform policy, and promote knowledge equity. In doing so, it supports the idea that IK is a vital, valid, and contextually relevant component of sustainable development and the SDGs.

Literature Review

IK has become a vital resource for achieving the SDGs. IK offers ecologically aware and context-sensitive

solutions to global development challenges, rooted in centuries of lived experience, cultural values, and adaptive behaviors. The significance of IK in localizing the SDGs is increasingly recognized by researchers and development experts (Gebara et al., 2023).

In agriculture, the use of IK is vital for reaching SDGs 1 and 2 (poverty reduction and zero hunger). Local farmers primarily employ methods such as mixed cropping, planting according to the lunar calendar, traditional pest control, and growing native, drought-tolerant crops (Echendu, 2023; Melash et al., 2023; Ogunyiola et al., 2022). These techniques not only promote climate-resilient farming but also support food sovereignty. However, their adoption is limited outside indigenous communities because they are often excluded from formal agronomic research and extension programs (Melash et al., 2023).

SDG 3, which seeks to promote good health and well-being, involves preserving and utilizing IK-based ethnomedicine and spiritual healing. Research shows that indigenous healing systems include holistic medicine, herbal pharmacology, and ecosystem-based remedies (Anywar et al., 2020; Brand et al., 2022; Fernández-Llamazares et al., 2021). However, the legitimacy and accessibility of traditional medicine are often diminished by national healthcare systems that frequently fail to properly incorporate or regulate it, despite the World Health Organization’s (Droney, 2022) recognition of its importance.

To achieve SDG 4 (Quality Education), IK promotes co-creating knowledge with elders, experiential learning, and multilingual education. Practice and observation form the basis of this interactive learning method, which enhances retention and relevance (Brand et al., 2022; Mbah, Ajaps, & Molthan-Hill, 2021). Indigenous and institutional knowledge systems remain disconnected because most formal education institutions fail to recognize these pedagogies.

Using traditional methods for water harvesting and conservation, IK supports SDG 6 (Clean Water and Sanitation). Indigenous societies manage limited resources through practices like contour bunds, earthen dams, and sacred ceremonies to protect water sources (Aklan et al., 2022; Quaghebeur et al., 2019). These systems are often overlooked in favor of manufactured solutions, despite their affordability and environmental suitability, leading to missed opportunities for hybrid approaches.

IK promotes sustainable energy practices that address SDG 7 (Affordable and Clean Energy), including solar drying, improved biomass cookstoves, and culturally rooted norms that limit excessive energy use (Congretel & Pinton, 2020; Tume et al., 2019). Although these methods align with clean energy transitions, they remain

mostly unnoticed within innovation ecosystems and energy planning.

Regarding catastrophe risk reduction, IK offers essential resources to help achieve SDGs 11 and 13 (Echendu, 2023; Hill et al., 2020; Phu & Tran, 2022). Communities anticipate and respond to floods, droughts, and storms through oral histories, natural signs, and sacred cosmologies. These local practices support early warning and mobilization, but are often overlooked in official disaster frameworks that prioritize technical solutions.

The SDG 12 (responsible consumption and production) and SDG 15 (life on land) are also influenced by IK approach to managing natural resources. In many communities, the use of plants and animals is strictly governed by customs, taboos, and traditional norms that promote sustainable harvesting and shared responsibility for resources (Gebara et al., 2023; Mazzocchi, 2020). These practices not only protect biodiversity but also ensure that future generations have the same rights to manage natural resources. Intergenerational stewardship is encouraged, and biodiversity is conserved through this ingrained conservation mindset (Obiero et al., 2022). However, achieving fair benefit-sharing remains challenging when resources from IK are commercialized, leading to conflicts between market-driven exploitation and traditional custodianship.

A significant body of research highlights IK's role in enhancing ecological resilience and facilitating climate change adaptation (SDG 13). As shown by Phu and Tran (2022), Trogrlić et al. (2021), and Cacciotti et al. (2021), indigenous peoples rely on environmental cues to forecast seasonal changes, schedule planting, and prepare for extreme weather. These practices strengthen local resilience and adaptive capacity (Apraku et al., 2021; Bello-Bravo & Lutomia, 2022). A persistent policy gap exists because, despite extensive documentation, national climate programs often overlook indigenous forecasting methods (Makate, 2020). IK's role in sustainable land management (SDG 15) includes sacred groves, community-led boundaries, and rotational farming, which help preserve soil fertility and promote biodiversity (Benyei et al., 2020; Wang et al., 2021).

By preserving cultural history through rituals, storytelling, music, dance, and artisanal crafts like beadwork, IK also advances SDG 11 (Sustainable Cities and Communities; Agyemang et al., 2020; Guerrero-Gatica et al., 2020). Especially amid migration and industrialization, these expressions help sustain cultural continuity (Bello-Bravo & Lutomia, 2022). However, the sustainability and authenticity of IK are threatened by the commercialization of culture and the lack of legal protections for intellectual property rights.

Additionally, IK-based spiritual beliefs are crucial for promoting justice, peace, and strong institutions (SDG

16). Sacred forests, rituals, and moral codes support environmental ethics and social harmony (Gwervevendi & Mthombeni, 2023; Tomaselli & Xanthaki, 2021). Despite their effectiveness, these systems are often overlooked in mainstream governance and lack official legal recognition.

Through traditional governance systems that emphasize group decision-making, consensus, and accountability through chieftaincy and clan structures, IK supports SDGs 16 and 17 (Partnerships for the Goals; Chirisa et al., 2020; McLean et al., 2023). Although often overlooked in modern governance models, especially in centralized bureaucracies, these institutions strengthen the legitimacy of policies and align with community values.

Through community development driven by indigenous knowledge (IK), SDG 1 (No Poverty) is advanced. IK promotes independence and income generation by utilizing social capital, regional crafts, sustainable livelihoods, and natural resources (Hausknecht et al., 2021; Priyadarshini & Abhilash, 2019). However, the commercialization of IK could worsen existing inequalities and cause exploitation rather than reduce poverty if benefit-sharing arrangements or legal safeguards are not established (Hausknecht et al., 2021).

Methods

Firstly, a systematic review was performed to understand the current trends and literature on IK. A systematic review is one of the methods for reviewing and organizing literature more systematically. The systematic review enabled the researcher or review to organize, classify, and critically evaluate or appraise the previous studies to answer a set of formulated questions for this study. It enabled the researcher to develop a set of protocols, frameworks, guidelines, and specific plans before the review process. In this regard, the process and searching efforts of databases, selection criteria, inclusivity, and journal review were transparent. This study adhered to the systematic literature review methodology established by Denyer and Tranfield (2006).

The researcher was guided by the Population or Problem, Interest, and Context (PICO) tool in formulating and creating the research questions for this review. This PICO tool thus served as the foundation for the inclusion of three key terms for the review, namely indigenous people (population), IK and sustainable development (interest), and 2019 to 2023 (context).

Two principal databases were used to facilitate the systematic search and retrieval of literature for review. This was the Scopus. Google Scholar was also used to find articles for this review. However, the articles or items found in Google Scholar should be indexed in Scopus. Thus, only manuscripts or journal articles indexed in

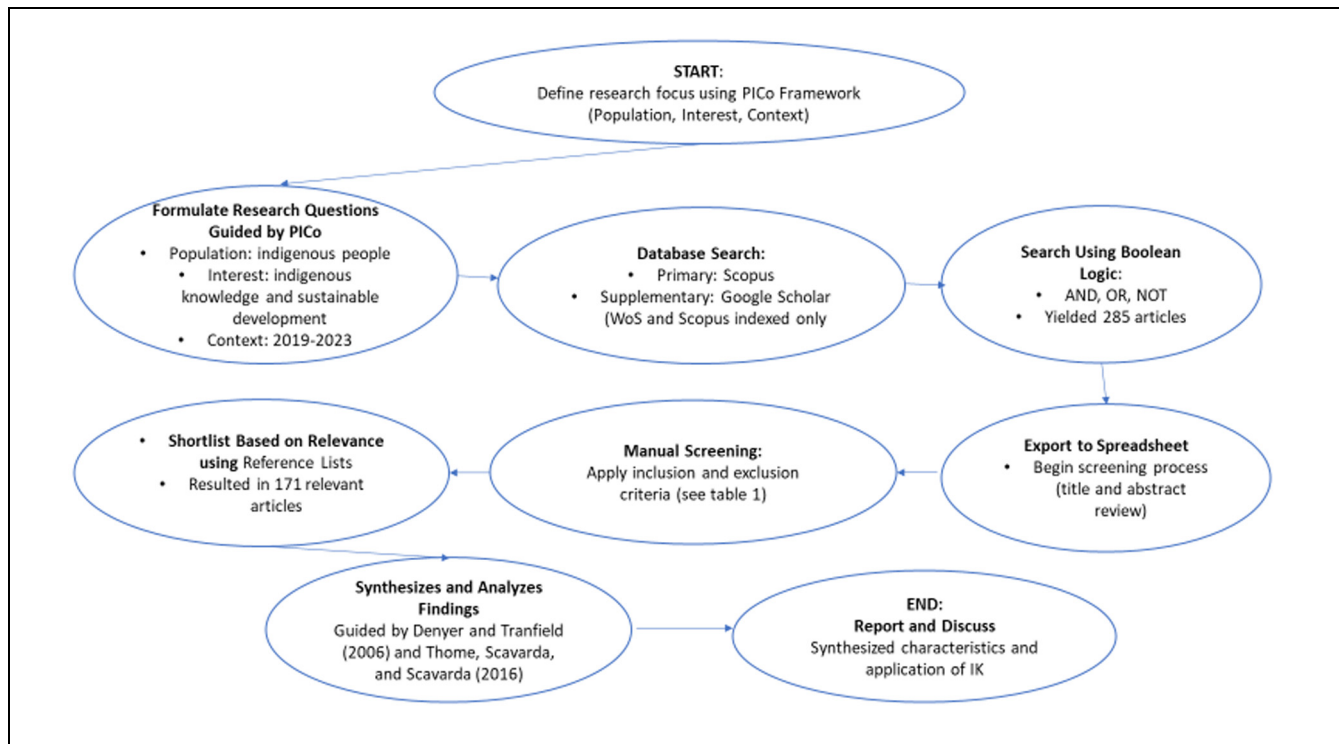


Figure 1. Flowchart of the method.

Scopus were searched for and retrieved. These databases were chosen to perform this study because they have more significant and peer-reviewed indexed journals. The Boolean search logic “AND” and “OR.” The operator “AND” helped in retrieving only relevant articles with common terms while “OR” and “NOT” were used to identify synonymous terms or words such as: “indigenous OR local OR traditional OR community” AND “knowledge OR information” AND “knowledge NOT data” AND “indigenous AND knowledge” AND “indigenous AND knowledge AND management” AND “indigenous AND knowledge AND sustainable AND development” AND “sustainable AND development” OR “SDG.” This yielded 285 items. These items were exported into a spreadsheet to begin the screening process for inclusion and exclusion (Figure 1).

The retrieved materials were then put through a two-step screening procedure to see if they were relevant and useful for the review’s goals and questions. The second step involves the actual screening to determine the inclusion or exclusion of an article or item to the study. It was done by hand after the articles were found by reading the title and abstract of each one. We marked and pinned down the ones that had keywords that were used in the study and were related to it for further review. As a consequence, 285 things were left. We used the purposive technique to examine a reference list of these items,

which helped us narrow down the list to 171 items. The purposive technique involves deliberately selecting studies most relevant to research questions (Allen et al., 2025). The researcher considered these 171 articles more relevant to the study and met the research questions. See Table 1 for the inclusion and exclusion criteria for items or articles below.

Validity in the study was ensured by using only Scopus-indexed, peer-reviewed articles, applying clear inclusion and exclusion criteria, following established systematic review protocols, manually screening for relevance, and purposively selecting studies that met the research objectives and methodological rigor.

Findings

This part shows what the review found. It focused on the issues of definition and characteristics of IK and outlined the fields of application of IK.

Matters of Definition and Characteristics of Indigenous Knowledge

In assessing the characteristics of IK, the researcher reviewed the definitions of IK. The researcher then identified the thematic terms and words that describe IK, as shown in Table 2 below.

Table 1. Inclusion and Exclusion Criteria for Items or Articles.

Category name	Exclusion criteria	Inclusion criteria
Publication type, source validity, and peer review	Exclude articles that lacked validity or if the item or article is not in a peer-reviewed journal. This was catered for with the use of only articles indexed in Scopus	Include journal articles indexed in Scopus since the validity of the research is assured
Search term, and relevance to research focus	Exclude items outside the search terms and questions	Include journal articles with the keywords that are search terms used in the retrieval process
Accessibility of articles and source material	Exclude journal articles not available and accessible electronically and for download	Include journal articles that are available and accessible electronically and for download
Thematic alignment	Exclude if the journal article is not within the domain of IK and sustainable development	Include if the journal article is found within the domain of IK and sustainable development
Timeframe of publication	Articles published between 2019 and 2023 were included in the retrieval, as they are more current and contain up-to-date information and output	It excluded articles and research output published before 2019

Table 2. Characteristics of IK.

Characteristics of IK	Author(s)
It is local, generated within communities, evolves in the local environment, and is owned by the community	Cuatón and Su (2020), Hosen et al. (2020), Mavhura and Mushure (2019), Tume et al. (2019)
It is exclusive and unique to every culture, civilization, society, and environment; hence, it is societal and culturally specific	Congretel and Pinton (2020), Mazzocchi (2020), Sharma (2021)
It is intergenerational and built on lessons learned and experience that is passed on from one generation to the next generation	Hausknecht et al. (2021), Latulippe and Klenk (2020), Stagg and Robinson (2020)
It is human-centered and establishes a linkage between humans or people and nature or the environment	Ali et al. (2022), Hill et al. (2020), Mazzocchi (2020)
It is holistic and affects every aspect of life, spirituality, health and healing, economy, politics, social interaction, relationship with nature etc.	McIntosh et al. (2021)
It is mainly tacit and intangible, making it difficult to codify, while there exist explicit forms	Agyemang et al. (2020), Kumar (2021)
It is based on experiences relating to innovation, adaptation, and experimentation of the environment and culture	Agyemang et al. (2020), Fernández-Llamazares et al. (2021), Kumar (2021)
It is ancient and has developed from centuries of living in close proximity to nature	Gómez-Baggethun (2022), Turner et al. (2022)
It is embedded in culture and tradition	Hill et al. (2020)
It is scientific but empirically not viable	Chapman and Schott (2020), Sharma and Bajwa (2021)
It is bound by language, norms, behavior, farming activities, healthcare system	Fernández-Llamazares et al. (2021), Tume et al. (2019)
It uses local technology and systems that serve as the basis for agricultural practices, weather forecasting, weather casting, healthcare practices etc.	Dasgupta et al. (2023), Malapane et al. (2022)
Serves as the basis for making decisions	Drissi (2020), Flintan and Truebswasser (2019), Latulippe and Klenk (2020)
It is communicated orally, verbally, or using other forms such as gestures	Rai and Mishra (2023), Wheeler et al. (2020)

From this, we can see that IK is comprised of a collection of facts that are part of the broader set of ideas, beliefs, and perceptions people hold about the world

around them. This includes how people perceive and assess their environment, how they gather information, and how they verify new details. It describes how

knowledge is created, maintained, used, and shared with others. Indigenous peoples continuously seek to develop their knowledge systems over decades, and seek to improve them with information from their surroundings, long-term experiences, careful observations, lessons learned, and skills gained. Typically, people in the community do not discuss IK openly; instead, they pass it down through actions and oral traditions. It is difficult to access and share with others.

Based on this, it can be said that.

IK is knowledge that is local and based on the norms, behavior, and ecological or environmental systems of a particular group of people with extended interaction with nature, passed on from generation to generation using various forms of strategies, technologies, or communication tools.

What are the Fields and Applications of Indigenous Knowledge?

IK has traditionally played a crucial role in human existence. It serves as a valuable store of knowledge that scholars from different fields have documented. Today, IK is applied across many different domains. IK systems are not outdated; they are dynamic and continuously evolve through ongoing or recreated behaviors within various knowledge systems and changing environments. The fact that people have survived for generations is a compelling reason why this kind of knowledge cannot be easily undermined. Today, researchers are becoming increasingly involved in conducting scientific research and engaging more deeply in the various aspects of IK, including its application, relevance, and the insights it offers. The key fields and application of IK are shown in Table 3 below.

SDGs 1 and 2: IK for Poverty Eradication and Hunger Elimination

Through ecologically responsible farming, culturally based entrepreneurship, and community-led livelihoods, IK plays a vital role in reducing poverty (SDG 1) and combating hunger (SDG 2). By helping communities leverage their environment, skills, and social networks for sustainable food production and income, IK methods encourage self-reliance (Bello-Bravo & Lutomia, 2022; Mazzocchi, 2020; Priyadarshini & Abhilash, 2019). Traditional subsistence practices such as rain-fed agriculture, cattle herding, herbal medicine, and artisanal crafts are crucial to rural economies in many parts of Africa, Asia, and Latin America (Hausknecht et al., 2021;

Sharma, 2021). These knowledge systems are highly adaptable to local ecological conditions because they have been refined over thousands of years and are passed down orally. Besides producing food, communities also use this expertise to build informal support networks and microbusinesses, thereby reducing their reliance on external economic systems (Napogbong et al., 2021; Phu & Tran, 2022).

IK manages the entire farming process in agricultural settings, from choosing crops and land preparation to harvesting and pest control (Mbah, Ajaps, & Molthan-Hill, 2021; Ogunyiola et al., 2022). For example, planting schedules and rainfall forecasts are created using traditional meteorological signs, such as animal behavior, wind direction, or lunar phases (Saif & Sze, 2022; Ubisi et al., 2020). This approach reduces losses and boosts yields by aligning farming activities with natural ecological patterns.

Additionally, IK promotes the use of organic pest control methods, natural fertilizers, and drought-resistant native crops (Makate, 2020; Saif & Sze, 2022). These approaches enhance food security for indigenous communities while supporting environmental sustainability. To maintain soil fertility, conserve moisture, and diversify food sources, techniques like mixed cropping, crop rotation, agroforestry, and intercropping are often employed (Echendu, 2023; Ubisi et al., 2020).

Indigenous pastoralists rely on their in-depth knowledge of regional ecosystems to manage water supplies, regulate grazing patterns, and respond effectively to droughts that impact livestock production. For example, herders anticipate dry seasons and adjust their movement plans based on cues like insect chirping or plant flowering (Napogbong et al., 2021). During dry periods, they enhance feed diversity by adding tree branches, grass sprouts, and crop leftovers (Mbah, Johnson, & Chipindi, 2021).

These ancient practices support food sovereignty. IK maintains biodiversity, reduces environmental harm, and supports local food producers by employing locally adapted methods rather than industrial agriculture (Galappaththi & Schlingmann, 2023; Melash et al., 2023). Additionally, indigenous entrepreneurs enhance household incomes and rural economies by establishing businesses in food processing, seed banking, and herbal products, leveraging their expertise in agriculture (Stagg & Robinson, 2020).

Integrating IK into food security and poverty reduction ultimately reflects community values, builds resilience, and promotes sustainable livelihoods. To achieve SDGs 1 and 2, it offers affordable, inclusive, and

Table 3. Field and Application of IK.

SDGs	Field and application of IK	Author(s)	Key highlights of IK application and role
SDG 1: No poverty	Eliminating poverty through agriculture, entrepreneurship, and community development	Bello-Bravo and Lutomia (2022), Galappaththi and Schlingmann (2023), Mazzocchi (2020), Phu and Tran (2022), Priyadarshini and Abhilash (2019), Sharma (2021), Stagg and Robinson (2020), Tume et al. (2019)	• Makes use of traditional means of subsistence (such as farming, herbalism, and crafts) to generate revenue • Increases resilience by utilizing collective knowledge and community-based resources • Boosts local economies through entrepreneurship that is ingrained in the culture • Encourages independence through informal networks and traditional support systems • Encourages the production of locally grown, drought-resistant crops, and incorporates conventional pest management techniques • Utilizes seasonal and lunar calendars for planting • Employs agroecology (agronomy, agribusiness, agriculture) and mixed cropping methods • Promotes sustainability and food sovereignty
SDG 2: Zero hunger	Eliminating hunger through IK agriculture	Apraku et al. (2021), Echendu (2023), Galappaththi and Schlingmann (2023), Makate (2020), Mbah, Ajaps, and Moltan-Hill (2021), Melash et al. (2023), Napogbong et al. (2021), Ogunyiola et al. (2022), Phu and Tran (2022), Saif and Sze (2022), Tume et al. (2019) Ubi et al. (2020)	• Offers easily accessible primary healthcare via spiritual and natural remedies • Conserves ethnobotanical knowledge for the prevention and treatment of illness • Encourages culturally-based holistic well-being activities • Uses dependable conventional methods to support the health of mothers and children • Uses healer networks to bolster community health systems
SDG 3: Good health and well-being	Promoting good health and well-being through IK healthcare and medicine	Akinsete and Ajala (2022), Anywar et al. (2020), Asare (2022), Velanovich (2023), Birjees et al. (2022), Brand et al. (2022), Fernández-Llamazares et al. (2021), Fuller (2022), Gutema and Mengstie (2023), Hong and Henrich (2021), Jimenez-Fernandez et al. (2023), Kahnet al. (2023), Kasilo and Wambebe (2021), Masola and Sigida (2021), McIntosh et al. (2021), Öztürk et al. (2022), Pham et al. (2021), Priyadarshini and Abhilash (2019), Redvers et al. (2020), Reid et al. (2019), Subu et al. (2022), World Health Organization (2022)	• Promotes respect for traditional epistemologies • Supports bilingual and indigenous language education • Facilitates knowledge co-production with elders • Integrates local knowledge into curricula • Encourages learning via participation and observation • Empowering women through entrepreneurship (strengthens community ties and identity) • Preserves indigenous artistic techniques and meanings • Supports the local economy through artisanal skills
SDG 4: Quality education	Research and education	Archibald Q'um Q'um Xiem (2022), Balogun and Kalusopa (2021), Brand et al. (2022), Hopkins (2020), Neeganagwedgin (2022), Prempeh (2021), Restoule (2022), Stein et al. (2023)	
SDG 5: Gender equality	Promoting gender equality through economic inclusion and community development	Agyemang et al. (2020), Bello-Bravo and Lutomia (2022), Mazzocchi (2020), Priyadarshini and Abhilash (2019), Sharma (2021), Stagg and Robinson (2020)	

(continued)

Table 3. (continued)

SDGs	Field and application of IK	Author(s)	Key highlights of IK application and role
SDG 6: Clean water and sanitation	IK for water harvesting and conservation	Akter et al. (2020), Basu and DasGupta (2023), Dubey et al. (2020), French (2022), Fu et al. (2023), Gashure and Wana (2023), Nandi and Gonela (2022), Obiero et al. (2022), Quaghebeur et al. (2019), Raghavan and Eslamian (2021), Sadeghi and Eslamian (2021), Saha et al. (2023), Sivakumar et al. (2021), Tamagnone et al. (2020), Tilahun and Desta (2021) Congretel and Pinton (2020), Mavhura and Mushure (2019), Tume et al. (2019)	• Uses conventional methods for storing rainwater • Utilizes earthen dams, contouring, and stone bunds to safeguard water sources through religious rituals in times of scarcity • It promotes water sharing and adjusts to local rainfall and topography
SDG 7: Affordable and clean energy	Use of IK for biomass, energy generation and solar drying		• Effectively uses conventional biomass (such as upgraded cookstoves) and uses solar drying for crops and food • Cultural norms are used to encourage energy-saving behaviors • IK-based local textile, agricultural, fishing, herbal medicine, and craft industries can generate employment
SDG 8: Decent work and economic growth	IK-based enterprises and traditional economies	Bello-Bravo and Lutomia (2022), Hausknecht et al. (2021), Mazzocchi (2020), Priyadarshini and Abhilash (2019), Sharma (2021), Staggs and Robinson (2020), Tume et al. (2019), Ubisi et al. (2020)	• IK can support rural entrepreneurship and the productivity of the unorganized sector • Encourages local value chains and sustainable lives • Vernacular architecture, such as structures that can withstand climate change
SDG 9: Industry, innovation, and infrastructure	Integration of IK in sustainable innovation and infrastructure	Akhan et al. (2022), Arkhurst et al. (2022), Congretel and Pinton (2020), Mavhura and Mushure (2019), Quaghebeur et al. (2019), Tume et al. (2019), Wang et al. (2021)	• Terracing and conventional irrigation systems • Bio-innovation employing regional resources and methods • Decentralized rural infrastructure, such as small dams based on IK
SDG 10: Reduced inequality	IKs role in cultural inclusion and equity	Agyemang et al. (2020), Chirisa et al. (2020), Latulippe and Klenk (2020), Neeganagwedgin (2022), Stein et al. (2023)	• Encourages inclusion in development and policy; acknowledges indigenous cultures and marginalized groups • Promotes fair access to resources according to land rights and customary laws • Contests Western-system-privileged knowledge hierarchies

(continued)

Table 3. (continued)

SDGs	Field and application of IK	Author(s)	Key highlights of IK application and role
SDG 11: Sustainable cities and communities	Culture and heritage for planning, decision making, and disaster management	Agyemang et al. (2020), Arkhurst et al. (2022), Bello-Bravo and Lutomia (2022), Chapman and Schott (2020), Cuaton and Su (2020), Gebara et al. (2023), Guerrero-Gatica et al. (2020), Hill et al. (2020), Latulippe and Klenk (2020), Mavhura and Mushure (2019), Öztürk et al. (2022), Phu and Tran (2022), Reihana et al. (2023), Sharma et al. (2022), Tume et al. (2019)	• Preserves native languages and storytelling • Encourages communal rituals and symbols • Fosters intergenerational identification and cultural pride • Protects intangible heritage in media and education • Celebrates indigenous festivals, songs, and dance • Integrates community values and priorities • Enhances sustainability and decision-making ownership • Aligns contemporary solutions with local wisdom • Catastrophe memory is preserved through storytelling • Settlement locations are guided away from hazards • Early community mobilization and reaction are supported
SDG 12: Responsible consumption and production	IK in agro-business, farming, and agriculture	Arkhurst et al. (2022), Galappaththi and Schlingmann (2023), Mazzocchi (2020), Melash et al. (2023), Napogbong et al. (2021), Nelson et al. (2019), Phu and Tran (2022), Son et al. (2019), Tume et al. (2019), Ubisi et al. (2020)	• Use of local resources • Production of locally grown, drought-resistant crops, and incorporates conventional pest management techniques • Utilizes seasonal and lunar calendars for planting • Employs agroecology (agronomy, agribusiness, agriculture) and mixed cropping methods • Promotes sustainability and food sovereignty • Provide early warning signs through environmental cues
SDG 13: Climate change	Climate adaptation, early warning, climate change and migration	Adanu et al. (2021), Ankrah et al. (2022), Arkhurst et al. (2022), Bello-Bravo and Lutomia (2022), Cacciottiet al. (2021), Cuaton and Su (2020), Kakiso (2023), Kohnsaka and Rogel (2021), León-Pérez (2019), Loch and Riechers (2021), Makate (2020), Phu and Tran (2022), Trogrlić et al. (2021), Volpato and Ellena (2023), Vushe (2021)	• Enhances community resilience to climate variability • Guides seasonal farming and harvesting cycles • Promotes biodiversity and ecosystem preservation • Integrates traditional forecasting with modern systems • Seasonal knowledge helps determine when to migrate • It aids in the adaptation of customs in new areas • Resource-sharing and settlement patterns are shaped
SDG 14: Life below water	IK and decision on fishing and coastal protection, religion, and spirituality	Apraku et al. (2021), Obiero et al. (2022)	• Seasonal bans, sacred marine zones, and IK protect aquatic ecosystems • Preserves sacred water bodies • Spiritual and religious rites for water bodies

(continued)

Table 3. (continued)

SDGs	Field and application of IK	Author(s)	Key highlights of IK application and role
SDG 15: Life on land	Land use, natural resources and forest conservation	Ananyev and Poyker (2021), Arkhurst et al. (2022), Bello-Bravo and Lutomia (2022), Benyei et al. (2020), Berkes (2020), Cămară—Leret and Dennehy (2019), Cuaton and Su (2020), Das et al. (2021), Galappaththi and Schlingmann (2023), Gebara et al. (2023), Ghorbani et al. (2021), Gupta et al. (2020), Gwervevande and Mthombeni (2023), Mazzocchi (2020), Park et al. (2020), Paul Victor and Treschuk (2020), Pivello et al. (2021), Tomaselli and Xanthaki (2021)	• Encourages rotational and intergenerational land use • Protects soil fertility through following and mulching • Utilizes local land demarcation and tenure systems • Preserves ecological balance through sacred sites • Promotes sustainable agroforestry and land rehabilitation • Respects taboo species and sacred woods • Enforces seasonal restrictions on resource use • Promotes community replanting • Upholds ecosystems via cultural values • Use is controlled by taboos and customary laws • Sustainable plant and animal harvesting is ensured • Community resource custodianship is encouraged • Overexploitation is prevented by cultural sanctions • Conservation is integrated with subsistence activities
SDG 16: Peace, justice, and strong institutions	Chieftaincy, politics, governance, religion, and spirituality	Chapman and Schott (2020), Chirisa et al. (2020), Congretel and Pinton (2020), Hosen et al. (2020), Latulippe and Klenk (2020)	• Instills stewardship principles in customs and beliefs • Upholds moral standards and harmony with nature • Decentralized leadership and governance are provided • Customary law and dispute resolution are upheld • Traditional authorities linked to the usage of local resources • Indigenous administrative systems are preserved • Integrates traditional leaders into contemporary governance • Promotes inclusive decision-making through consensus • Social justice is ensured through customary standards
SDG 17: Partnership and goals	Partnership for sustainable development	Ali et al. (2022), Chirisa et al. (2020), Loch and Riechers (2021), McMillen et al. (2020), Phu and Tran (2022), Son et al. (2021), Wheeler et al. (2020), Zidny et al. (2020), Zurba and Papadopoulos (2023)	• Projects are rooted in local knowledge and culture, and IK encourages sustainability • Enhances community engagement and social capital • Harmonizes development objectives with customs • Lessens reliance on outside models • Support collaboration between IK holders and institutions

environmentally responsible solutions by integrating ecological knowledge with cultural identity (Bello-Bravo & Lutomia, 2022).

SDG 3: Indigenous Knowledge in Health and Medicine

SDG 3 is significantly supported by IK, which offers preventive, comprehensive, and culturally sensitive healthcare to complement formal systems (Birjees et al., 2022; Reid et al., 2019). Traditional medicine remains the primary source of healthcare in many indigenous communities, meeting the needs of over 80% of the population (Reid, Cormack, & Paine, 2019). Traditional medicine is used by 40% to 70% of individuals, even in developed countries (Kasilo & Wambebe, 2021; Öztürk et al., 2022).

The utilization of local plants, spiritual activities, and community-based networks is a fundamental component of IK-based therapies. These methods include bathing rituals, ceremonies, laying of hands, storytelling, divination (Hong & Henrich, 2021), herbal medicine (Rana et al., 2021), and ceremonies (Akinsete & Ajala, 2022; Masola & Sigida, 2021). Dreams, vision quests, and guidance from experienced healers are among the ways people learn about healing (Pham et al., 2021). Using incantations, music, prayer, therapy, and food, these traditions support mental and spiritual well-being in addition to physical health (Anywar et al., 2020; Fuller, 2022; Kahnet al., 2023). To treat ailments and promote the health of mothers and children, IK preserves ethnobotanical knowledge (Brand et al., 2022).

Additionally, IK promotes SDG 9 by developing AI-enhanced drugs based on traditional remedies and ethnopharmacology (Moalosi et al., 2023; Pirintsos et al., 2022). Global health solutions that are equitable and sustainable need that IK be protected, integrated, and modernized in national healthcare systems (Abas et al., 2022; Redvers et al., 2020).

SDG 4: Research and Quality Education

IK aids the achievement of SDG 4 (quality education) through the integration of local epistemologies and values into formal education systems. Mbah, Johnson, and Chipindi (2021), Brand et al. (2022), and Neeganagwedgin (2022) posit that SDG 4 encourages inclusive, egalitarian, and lifelong learning through culturally responsive teaching that acknowledges indigenous methods of knowing. Strengthening linguistic and cultural identity, incorporating IK into school curricula promotes multilingual and indigenous language instruction (Hausknecht et al., 2021; Kumar, 2021; Masenya, 2022).

Programs like Amiskwaciy Academy (Manasc, 2020) and frameworks by Restoule (2022) and Archibald Q'um Q'um

Xiiem (2022) promote learning through storytelling, observation, oral traditions, and engaging with elders. These approaches emphasize participation over memorization. They foster intergenerational knowledge sharing by blending modern teaching methods with traditional wisdom (Balogun & Kalusopa, 2021; Hopkins, 2020).

Additionally, IK promotes critical thinking and sustainable development by helping students tackle community-relevant problems (Ali et al., 2022; Guerrero-Gatica et al., 2020). Education becomes more meaningful, accessible, and transformative when local knowledge systems are included, especially for marginalized communities (Prempeh, 2021; Stein et al., 2023).

SDG 5: Promoting Gender Equality Through IK and Community Engagement

By acknowledging and strengthening the historic responsibilities of women in knowledge transfer, entrepreneurship, and sustainable livelihoods, IK systems significantly contribute to the advancement of SDG 5: Gender Equality. From artisanal crafts, food preservation, herbal medicine, and seed saving to water management and community healing rituals, women are the guardians of important IK practices in many indigenous communities (Agyemang et al., 2020; Bello-Bravo & Lutomia, 2022). These customs support intergenerational identity, conserve cultural legacy, and maintain household economies.

Women's involvement in IK-based activities promotes community resilience and economic inclusion, particularly in artisanal production, agro-processing, and local trading. While protecting endangered cultural traditions and artistic abilities, encouraging women's indigenous entrepreneurship boosts local economies (Priyadarshini & Abhilash, 2019; Sharma, 2021). Women develop social capital in their communities, enhance household security, and achieve financial independence through these endeavors (Hausknecht et al., 2021; Mazzocchi, 2020).

IK-based community development strategies inherently prioritize respect for gendered roles in environmental stewardship, equitable knowledge sharing, and communal well-being (Stagg & Robinson, 2020). By utilizing these frameworks to empower women, inclusive growth and sustainable rural development can be promoted, while addressing cultural marginalization and structural inequality (Arkhurst et al., 2022).

Additionally, IK ensures that indigenous women are not only knowledge holders but also decision-makers in social governance, conservation, and climate action, by providing a culturally appropriate foundation for gender-responsive education, skill development, and leadership development. Development initiatives must strengthen the voices of indigenous women, defend their

rights to resources and land, and incorporate IK into gender equality plans that value local creativity and cultural uniqueness in order to achieve SDG 5.

SDGs 6 and 7: Clean Water and Affordable Energy

IK, which offers proven and environmentally friendly methods for water collection and conservation tailored to local environmental conditions, is essential for achieving SDG 6 (Clean Water and Sanitation). Communities have developed various indigenous techniques to store and manage water sustainably, including contour bunding, stone terraces, clay dams, and rooftop rainwater harvesting (Aklan et al., 2022; Quaghebeur et al., 2019; Saha et al., 2023). These systems are especially critical in areas where water is scarce and rainfall is irregular due to climate change (Gashure & Wana, 2023; Sharma et al., 2023). Additionally, cultural beliefs and rituals that emphasize the sacredness of water sources and promote conservation are closely linked to IK-based practices (Dubey et al., 2020; Obiero et al., 2022).

Adaptability to seasonal rainfall, spiritual taboos around pollution, and water sharing practices make these systems highly resilient and community-centered (French, 2022; Tilahun & Desta, 2021). IK also addresses the social and technical dimensions of water governance, promoting long-term sustainability and participation (Basu & DasGupta, 2023).

IK provides practical energy solutions through traditional biomass and solar applications, supporting SDG 7. To lower emissions and meet household energy needs, communities have long used biomass, such as wood and crop residues, in improved cookstoves (Tume et al., 2019). Based on traditional post-harvest methods, solar drying techniques also enhance food preservation and decrease reliance on grid electricity (Mavhura & Mushure, 2019). Furthermore, energy-saving habits are often promoted by indigenous cultural norms, which reinforce sustainable consumption practices (Congretel & Pinton, 2020).

SDGs 8, 9, and 10: IK for Decent Work, Innovation, and Equity

Innovation, inclusive development, and sustainable economic growth are all made possible through IK. By promoting IK-based industries and traditional economies such as regional textiles, agriculture, herbal medicine, and crafts, it plays a vital role in achieving SDG 8 (Bello-Bravo & Lutomia, 2022; Mazzocchi, 2020; Priyadarshini & Abhilash, 2019; Sharma, 2021). Especially in underserved areas, these knowledge systems support livelihoods, empower rural entrepreneurs, and generate jobs (Hausknecht et al., 2021; Stagg & Robinson, 2020; Ubisi

et al., 2020). They make significant contributions to the informal economy, boost productivity in the unorganized sector, and support circular economies and local value chains (Mazzocchi, 2020; Sharma, 2021; Stagg & Robinson, 2020).

As part of SDG 9 (Industry, Innovation, and Infrastructure), IK promotes decentralized, climate-resilient, and sustainable innovation. In addition to being climate-adaptable, traditional architectural methods such as vernacular building styles made of bamboo, thatch, and mud are also environmentally sustainable (Aklan et al., 2022; Tume et al., 2019; Wang et al., 2021). These methods help preserve cultural assets while reducing environmental impact. Production and ecological stability are further enhanced through terracing and traditional irrigation systems based on IK (Congretel & Pinton, 2020; Mavhura & Mushure, 2019). IK-based bio-innovation demonstrates how traditional systems can support low-carbon, place-based development. Examples include using indigenous materials for tools and infrastructure, organic fertilizers, and local herbs for medicine (Arkhurst et al., 2022; Quaghebeur et al., 2019).

IK is crucial for achieving SDG 10 (Reduced Inequalities) because it encourages inclusive governance and cultural respect. It questions the dominance of Western-centric knowledge in development planning and policy-making while promoting alternative ways of knowing (Latulippe & Klenk, 2020; Stein et al., 2023). IK helps ensure fair access to land, water, and biodiversity for marginalized groups by respecting indigenous land tenure systems and resource management frameworks (Agyemang et al., 2020; Brand et al., 2022; Guerrero-Gatica et al., 2020).

SDG 11: IK and Sustainable Cities and Communities

IK strengthens the social, cultural, and spiritual foundations necessary to create resilient communities and sustainable cities, which significantly advances SDG 11. Through storytelling, songs, festivals, oral traditions, group rituals, and native languages, IK preserves intangible cultural heritage (Guerrero-Gatica et al., 2020; Reihana et al., 2023). These methods guide urban design and disaster risk reduction techniques while fostering identity, intergenerational learning, and cultural pride (Arkhurst et al., 2022; Wang et al., 2021).

Land-use decisions, settlement placement, and conservation practices are influenced by religious beliefs and spirituality, which are fundamental to indigenous worldviews and perceive landscapes as sacred and alive (Milgin et al., 2020; Wang et al., 2022). By coordinating local knowledge with policy, promoting early community mobilization during disasters, and preserving memory

through disaster narratives, IK promotes sustainable urban governance (Chapman & Schott, 2020; Cuaton & Su, 2020).

However, their contributions are lessened when indigenous groups are excluded from decision-making. Indigenous peoples have the right to participate in governance processes that affect their physical and spiritual environments, as outlined in the UNDRIP (Cambou, 2019; Tomaselli & Xanthaki, 2021). Therefore, recognizing and integrating IK into city design improves the sustainability, equity, and resilience of urban environments.

SDG 12: IK for Responsible Consumption and Production

To achieve SDG 12, IK is essential, as it promotes crop diversity, resource efficiency, sustainable agriculture, and waste reduction. Using traditional land-use systems, tenancy customs, and planting methods as a reference, it supports farming operations such as crop cultivation, fish farming, and cow breeding (Ogunyiola et al., 2022). Farmers utilize IK to choose native crop types, manage soil and water, predict rainfall using celestial signals, and apply preservation and pest control methods (Saif & Sze, 2022; Ubisi et al., 2020).

IK is used to understand climate variability before planting seasons, guiding decisions on crop spacing, rotation, calendar adjustments, soil preparation, and seed selection (Mbah, Johnson, & Chipindi, 2021; Nelson et al., 2019). To enhance food security and sovereignty, farmers adopt mixed cropping and agroecological techniques (Van Huynh et al., 2020). Reducing waste and conserving biodiversity are additional benefits of intercropping, shifting cultivation, and traditional storage (Son et al., 2019).

Using mobile herding strategies, a variety of feed sources such as grass sprouts and tree branches, and water conservation techniques, livestock managers utilize IK to adapt to climate stress (Napogbong et al., 2021). Sub-herding is used to manage cattle based on their location, health, and pregnancy status, with herd composition adjusted as needed (Mbah, Johnson, & Chipindi, 2021). Therefore, IK in agro-business helps protect local knowledge systems and livelihoods while promoting resilience, environmental sustainability, and responsible production (Arkhurst et al., 2022; Mazzocchi, 2020; Phu & Tran, 2022).

SDG 13: Indigenous Knowledge in Natural Resources Management and Climate Change

IK is vital for achieving SDG 13 because it enhances environmental management, improves early warning systems, and facilitates climate adaptation. Ecological

signals such as insect sounds, plant movements, wind patterns, and animal behaviors are used by communities to predict seasonal changes and weather (Adanu et al., 2021; Cuaton & Su, 2020; Kohsaka & Rogel, 2021; León-Pérez, 2019; Loch & Riechers, 2021; Makate, 2020; Volpato & Ellena, 2023; Vushe, 2021). According to Phu and Tran (2022), these signals help guide migration, agricultural cycles, and disaster preparedness efforts.

Agroforestry, holy land protection, and traditional irrigation are among the methods that IK uses to support biodiversity preservation, forest fire management, and water conservation (Bello-Bravo & Lutomia, 2022; Gupta et al., 2020). Conservation is also supported by religious beliefs, such as the veneration of rivers, woods, and totemic animals (Apraku et al., 2021; Karalekas & Openshaw, 2022).

Much IK remains unrecorded, risking its survival despite its significance (Cámara-Leret & Dennehy, 2019). To unlock its potential and protect it, legal safeguards and inclusion in national policies are necessary (Benyei et al., 2020; Makate, 2020). Combining IK with scientific methods encourages sustainable environmental management and boosts community-led climate solutions (Loch & Riechers, 2021; Vushe, 2021).

SDG 14 and 15: IK for Aquatic and Terrestrial Sustainability

IK supports SDGs 14 and 15 by significantly contributing to aquatic and terrestrial ecosystems. IK systems regulate fishing activities in coastal and marine environments through seasonal bans, designated marine areas, and religious or spiritual ceremonies that honor water bodies (Apraku et al., 2021; Obiero et al., 2022). By controlling fishing hours, ensuring the regeneration of aquatic species, and maintaining biodiversity in lakes, rivers, and coastal waterways, these methods function as traditional conservation techniques.

Sacred water bodies are protected and honored in many indigenous cultures due to their spiritual significance; these traditions are often governed by community laws and local taboos. Water spirit rituals encourage stewardship within the community by preventing pollution and overuse. These spiritual frameworks foster environmental ethics and a sense of social ownership, which support official conservation efforts.

IK's land-based conservation methods contribute to achieving SDG 15. To protect biodiversity, halt deforestation, and maintain healthy soil, practices such as sacred groves, intergenerational land rights, and rotational land use are employed (Lawal et al., 2022; Tomaselli & Xanthaki, 2021). Ecological balance is preserved, and pressure on resources is reduced through local enforcement of seasonal rules, community resource

guardianship, and spiritual taboos against harvesting certain species (Pivello et al., 2021).

IK also employs culturally ingrained techniques to support mulching, sustainable agroforestry, and ecosystem restoration. Overharvesting is prevented, and ecosystem use remains within sustainable limits thanks to taboos and customary regulations (Benyei et al., 2020; Cámara-Leret & Dennehy, 2019). These systems effectively blend conservation with daily subsistence activities because they are rooted in spirituality and oral traditions. Additionally, IK links ecological preservation with spiritual beliefs by identifying and safeguarding sacred forests and culturally significant landscapes (Qu, 2021; Wang et al., 2022). As a result, it provides a comprehensive, locally driven framework for environmental governance that conserves biodiversity, maintains cultural identity, and preserves natural resources for future generations.

SDG 16: Indigenous Knowledge for Peace, Justice, and Strong Institutions Through Chieftaincy, Governance, Culture, and Heritage

In line with SDG 16, IK is essential to advancing justice, peace, and inclusive institutions. Native American governance structures, which are based on spiritual authority, customary law, and chieftaincy, promote moral principles, foster stewardship, and preserve balance with the environment (Chirisa et al., 2020; Hosen et al., 2020). Traditional leaders are included into modern political and administrative institutions through inclusive governance offered by these decentralized, consensus-driven systems (Chapman & Schott, 2020; Congretel & Pinton, 2020). Using elders and customary courts to settle disputes fosters social cohesion and accessible justice (Latulippe & Klenk, 2020).

Indigenous identity and governance are heavily reliant on cultural legacy. It preserves values that direct behavior and political interaction and is passed down through festivals, rituals, oral history, and community-centered activities (Otero, 2022; Ruhanen & Whitford, 2019). While intangible forms, such as naming rituals and rites of passage, preserve communal memory, tangible heritage—comprising symbols, clothing, artifacts, and sculptures—serves as a source of knowledge (Agyemang et al., 2020; Yeh et al., 2020).

Indigenous rights to self-governance, cultural expression, spiritual practices, and the return of stolen cultural property are all upheld under UNDRIP (Frogner, 2022; Lixinski, 2019). These rights guarantee the preservation, legal recognition, and integration of IK and traditional government systems. Frameworks such as Nonaka's SECI model facilitate the collection, processing, and dissemination of indigenous governance systems, thereby

preserving this knowledge (Asiedu et al., 2022; De-Graft, 2019). Maintaining indigenous authority over the dissemination of law and culture fosters enduring institutions and advances justice, peace, and solid social underpinnings (Byron, 2022; Hill et al., 2020).

SDG 17: Partnership for the Goal

IK is a key component of sustainable development and a strategic instrument for achieving SDG 17, which calls for inclusive partnerships based on respect and shared values (Ali et al., 2022; Zurba & Papadopoulos, 2023). IK systems, which have their roots in local contexts, encourage integrated and participatory development models that promote long-term sustainability, community ownership, and trust.

By ensuring that development policies are socially inclusive and culturally aligned, IK improves cooperation between indigenous communities and national or international agencies. It promotes collaborative decision-making, knowledge co-production, and creativity based on the wisdom of ancestors and the environment (McMillen et al., 2020). According to Loch and Riechers (2021), this strategy enhances community engagement, resilience, and adaptive capacity while reducing reliance on externally imposed solutions.

In education, integrating IK into curriculum design enhances global academic fields such as archaeology, history, ecology, and medicine, while also making learning more relevant and accessible for indigenous populations (Zidny et al., 2020). Through ethnobotany and traditional healing methods, IK contributes to more than 40% of contemporary medical products. Nearly 80% of individuals in developing countries and a sizable fraction of people in industrialized countries receive primary health care via indigenous systems, according to WHO data (Öztürk et al., 2022).

Additionally, IK fosters values such as reciprocity, information transfer between generations, and a spiritual bond with nature, all of which contribute to societal cohesiveness. By aligning development initiatives with regional traditions and beliefs, this holistic perspective enhances the legitimacy and effectiveness of policy implementation (Chapman & Schott, 2020; Wheeler & Root-Bernstein, 2020).

Governments, international organizations, and development actors must formalize collaborations with IK holders and incorporate indigenous viewpoints into cross-sectoral initiatives, international negotiations, and national planning in order to fully realize the potential of IK. Acknowledging IK not only protects cultural heritage but also opens up creative, locally relevant, and globally significant sustainable development solutions.

Implications and Recommendations

The review yields several critical implications for policy, practice, research, and community empowerment across various sectors and development agendas.

1. Recognition and integration into national policies: The unique, holistic, and localized nature of IK highlights the importance of formal recognition in national sustainable development policies, particularly in climate change adaptation, land management and use, agriculture, and healthcare planning.
2. Implications for Culture: Language, spirituality, rites, rituals, and art are all deeply intertwined with IK. IK-supported cultural preservation enhances identity, resilience, and social cohesion. Protecting intangible cultural heritage requires community recording projects, museums, formal education, and storytelling.
3. Protection and intellectual property rights: Since IK is often shared communally and transmitted orally, policymakers need to create frameworks to safeguard indigenous intellectual property from exploitation and misappropriation, especially in biotechnology, pharmacology, and commercial uses.
4. Contextualized development approaches: development interventions should be tailored to the specific context, culturally respectful, and centered around IK systems, ensuring community values and traditional ecological knowledge are incorporated into project plans.
5. Fields like agriculture, crafts, and traditional medicine rooted in IK can be used to promote inclusive economic growth, generate jobs, and support rural livelihoods through micro-enterprises and local value chains.
6. The tacit, oral, and often intangible nature of IK creates difficulties for preservation. This requires organized efforts to document, digitize, and safeguard IK while honoring its sacred and community significance.
7. Curriculum reform and integration: Educational systems at all levels should incorporate IK into the curriculum to value local knowledge and empower future generations to appreciate, preserve, and innovate within Indigenous frameworks.
8. Theoretical implications: By validating holistic, experiential, and intergenerational knowledge, IK challenges dominant epistemological hierarchies and expands the scope of theory in knowledge systems. It encourages scholars to adopt a decolonial perspective that values the different worldviews and ontologies found in IK systems.

9. Implications for research: Researchers should use respectful, culturally aware, and participative methodologies. IK needs to be recognized as a source of innovation and actively explored, especially in public health, food security, and climate adaptation. Priority should be given to collaboration between academic institutions and indigenous communities to co-produce knowledge.
10. Implications for community empowerment: IK provides a foundation for community autonomy, self-determination, and participatory governance. By empowering women, youth, and elders to serve as knowledge keepers, important customs are maintained and intergenerational connections are strengthened. Increasing IK fosters pride, economic resilience, and locally driven responses to global issues.

Limitations and Implications for Future Studies

This systematic review offers significant insights into the attributes and applications of IK for sustainable development; however, the researchers have identified certain limitations:

- Database selection: The research primarily utilized Scopus-indexed journal articles, with Google Scholar serving as a supplementary resource. This does not include grey literature, community reports, and unpublished studies that might be useful and often show rich, localized IK practices.
- Timeframe limitation: By focusing on publications from 2019 to 2023, earlier foundational works on IK and sustainability may have been overlooked, which could limit historical perspectives.
- Selection and screening bias: Although the researchers followed systematic protocols, the purposive selection process may have introduced subjective bias in deciding which articles to include or exclude.

Future research should expand data sources to include grey literature, community archives, and oral histories to achieve a more comprehensive understanding of IK. Extending the timeframe would facilitate the documentation of the evolution of IK in sustainable development. To ethically document tacit knowledge, it is essential to work with indigenous communities. Comparative regional analyses can illuminate the context-specific applications of IK. At the same time, a more profound examination of its integration with contemporary

scientific and policy frameworks can bolster evidence regarding IK's significance in climate adaptation, agriculture, health, and sustainable development initiatives.

Conclusion

This study has systematically analyzed the characteristics of IK based on the definitions propounded by scholars and literature. It was able to synchronize all the definitions and extract the key features and characteristics highlighted in the literature. Through this process, a comprehensive definition was developed, taking into account the major features identified in the existing definitions. It was discovered that IK is mainly local, generated within communities, evolves in the local environment, and is owned by the community; exclusive and unique to every culture, civilization, society, and environment; hence it is societal and culturally specific; intergenerational and built on lessons learned and experience that is passed on from one generation to the next generation; human-centered and establishes a linkage between humans or people and nature or the environment; holistic and affects every aspect of life spirituality, health and healing, economy, politics, social interaction, relationship with nature; mainly tacit and intangible making it difficult to codify while there exist explicit forms; based on experiences relating to innovation, adaptation, and experimentation of the environment and culture; ancient and developed from centuries of living in close proximity to nature; embedded in culture and tradition; scientific but empirically not viable; bound by language, norms, behavior, farming activities, healthcare system; uses local technology and systems that serve as the basis for agricultural practices, weather forecasting, weather casting, healthcare practices, and communicated orally, verbally, or using other forms such as gestures.

The study further systematically reviewed articles and empirical studies in the various fields and applications of IK. Existing empirical studies provide fragmented insight into IK. The fragmented articles and studies were synchronized in this study. The review disclosed that the applications generally help in the effective management of the ecosystem, effective agricultural practices, management of natural resources, effective land management, management of water resources, river bodies, forest conservation, disaster management, fire management, rainwater harvesting, preservation of cultural heritage and history, preservation of customs and tradition, basis for economic and political decision, and aiding indigenization of education. These ultimately help sustain the environment and ecosystem, thereby contributing to achieving sustainable development.

IK plays a vital role in the development of the socio-economic lives of indigenous people, communities, the environment, and the global ecosystem. It should be factored into all policy formation and implementation in all spheres of knowledge or fields of study. Furthermore, indigenous people should be involved in decisions that pertain to the development and growth of their local community and ecosystem, as IK is unique and culturally specific. Findings from this study can be used by policymakers and development actors to gain a broader understanding of the general role and application of IK. Future studies should seek to compare the impact or role of IK in various fields of study.

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