

# Indigenous Ecological Knowledge and Wildlife Conservation: A Systematic Review of the Relevant Links



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## Abstract

While recent interest has been drawn to indigenous ecological knowledge (IEK), there remains a gap in its link to wildlife conservation. This link is important because it offers insight into how indigenous communities perceive, interact with, and manage their local ecosystems and wildlife. Furthermore, it helps understand the need to integrate IEK and Western Scientific Knowledge in wildlife conservation policies. This paper adopts a content analysis approach, following PRISMA guidelines, to systematically review the role of IEK in wildlife conservation, with a focus on its components, contributions, and collaboration opportunities. Emphasizing the profound role of IEK in community-based wildlife conservation, the review underscores its innovative solutions, arguing that IEK can complement Western scientific knowledge in wildlife conservation. The paper concludes that effective wildlife conservation requires cross-cultural knowledge exchange among indigenous ecological knowledge holders and conservative practitioners, as well as the bridging of the gap between IEK and Western Scientific Knowledge.

**Keywords:** Indigenous Ecological Knowledge; Wildlife conservation; Systematic Review; Western Scientific Knowledge

**Abbreviations:** IEK: Indigenous Ecological Knowledge; LEK: Local Ecological Knowledge; TEK: Traditional Ecological Knowledge; ITK: Indigenous Technical Knowledge; IUCN: International Union for Conservation of Nature; WCED: World Commission on Environment and Development; FAO: Food and Agriculture Organization; JSTOR : Journal Storage; RRSC: Ruby Range Sheep Steering Committee; NGO: non-governmental organizations; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

## Introduction

Wildlife was among the first natural resources that early societies often invented norms, taboos, and myths to conserve (Eagle et al. 2017). Indigenous communities worldwide have preserved wildlife and sustained their way of life for generations by relying on their indigenous ecological knowledge of the local environment. While traditional knowledge has thrived for millennia, its recognition as a valuable source of ecological information by the Western scientific community has only occurred in the last few decades Gilchrist [1]; Wilder et al. [2]. Such knowledge goes by various names, including local ecological knowledge (LEK), traditional ecological knowledge (TEK), ethno-ecology, traditional knowledge, folk ecology, indigenous technical knowledge (ITK), and indigenous ecological knowledge (hereafter IEK) Johnson [3]; Stevenson [4]; Kanak Pervez et al. [5]; Joa et al. [6]. While traditional ecological knowledge (TEK) is more often used in the literature given that it encompasses environmental wisdom from various communities, IEK is used in this study because it specifically pertains to the ecological wisdom

of indigenous peoples, deeply rooted in their unique cultural and historical contexts. The popularity of IEK can however be traced to documents such as those published by the International Union for Conservation of Nature and Natural Resources (IUCN) IUCN et al. [7] and 'Our Common Future' by the World Commission on Environment and Development (WCED) WCED [8]. These reports thoroughly discuss the imperative to directly incorporate the environmental knowledge of indigenous into the management of natural resources. Furthermore, the role of indigenous knowledge in sustainable development was recognized by the "International Workshop on Indigenous knowledge and community-based resource management" in 1991 Inglis [9], and ever since, the role of indigenous knowledge on health and environmental issues has given rise to a flourishing field of study and exploration.

The available literature indicates the absence of a single all-encompassing and universally agreed-upon definition of IEK. Despite this lack of a definitive definition, Berkes' interpretation has gained widespread usage over the past two decades. TEK,

which is oftentimes used interchangeably with IEK was defined as “a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment” Berkes [10]. This description aligns with the consensus among scholars, highlighting that IEK is characterized as dynamic, accumulative, continuously evolving, deeply rooted in specific geographical locations, and closely tied to local social institutions that govern through traditional rules, sanctions, and prohibitions Johnson [3]; Drew [11]; Fonseca et al. [12]; Cepeda et al. [13]. IEK also incorporates the worldviews of local communities, including biological, spiritual, physical, and social cultural systems, which significantly influence environmental perspectives, practices, and resource management systems Finn et al. [14]; Joa et al. [6]. These components are transmitted and absorbed through methods such as demonstrations, interactions with the surrounding environment, observations, imitations, and experiential learning Fongod et al. [15]; Reniko et al. [16].

Given the popularity of IEK, studies have explored its applications in diverse fields such as agriculture Grzywacz et al. [17]; Coté [18]; Aswani et al. [19], weather services and climate monitoring Chand et al. [20]; Nkomwa et al. [21]; Hosen et al. [22], disaster risk management Hiwasaki et al. [23]; Cuaton [24]; Oktari et al. [25], and biodiversity conservation Bofo et al. [26]; Joa et al. [3]; Das et al. [27]. This study, however, specifically examines IEK’s role in wildlife conservation. The aim of the study stems from the increased number of research studies emphasizing the importance of indigenous knowledge in conserving biodiversity in the last two decades. These studies tend to focus on generally preserving the variety of life within ecosystems, including species diversity Susanti [28]; Das et al. [27]. This trend is unsurprising as international organizations, including the World Bank Sobrevila [29] and Food and Agriculture Organization FAO [30], have recognized the significance of IEK in biodiversity conservation. The United Nations Convention on Biological Diversity, Article 8(j) mandates parties to “respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices” United Nations Sustainable Development [31]. With the acknowledgement of these organizations on IEK practices on biological diversity, it becomes to review specific IEK relevant to wildlife conservation Ramos [32].

Indigenous communities around the world, deeply embedded in their environments for generations, possess a wealth of traditional knowledge that offers unique insights into

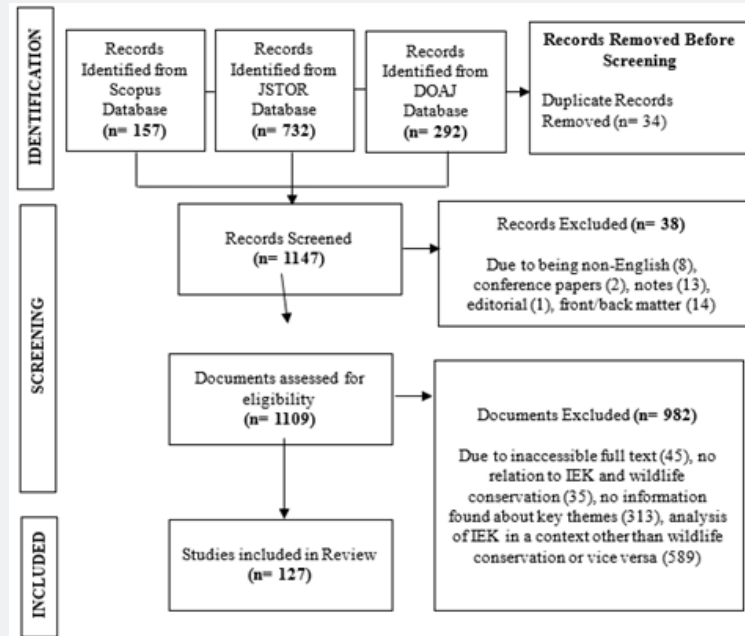
the natural world. In terms of wildlife conservation, a body of knowledge, spanning species identification, habitat management techniques, ecological indicators, and a profound understanding of the intricate relationships between humans and nature can be explored Parry [33]; Peñaherrera et al. [34]; Camino et al. [35]. Indigenous communities, often situated in ecologically diverse regions around the world, have maintained deep-rooted connections with the land, and rely on IEK not only for sustenance but also as a framework for holistic conservation practices. Despite the increased awareness on biodiversity conservation in general, documentation and synthesis of specific IEK relevant to wildlife conservation efforts is limited. This study aims to fill the gap as it reviews the diverse components of IEK, assesses its accuracy and explores, how indigenous communities perceive, interact with, and manage their local ecosystems and wildlife. The paper also discusses ways in which IEK can complement Western scientific knowledge in wildlife conservation.

## Methodology

A systematic examination of scholarly literature was undertaken based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines Parums [36] in order to investigate the contribution of IEK to wildlife conservation. The review involved a comprehensive peer-reviewed literature search encompassing IEK in wildlife conservation, utilizing Journal Storage (JSTOR), Directory of Open Access Journals (DOAJ), and Scopus databases in October 2023. The selected databases were due to their wide coverage of diverse journals spanning natural, social, and interdisciplinary sciences, ensuring transparency and replicability in the literature search. In addition, their journal articles are indexed and have been among the leading reliable and well-known databases Gusenbauer [37]. The search string included terms related to ecological knowledge and wildlife conservations. Synonyms and related expressions were cross-referenced with keywords employed in prior research to enhance these search terms. These combined keywords were then incorporated into the search query, employing truncation, Boolean operators (‘AND’ and ‘OR’), quotation marks, and asterisks for precision. Thus, the string “IEK,” OR “TEK,” OR “indigenous knowledge,” OR “local knowledge,” OR “local ecological knowledge,” AND “wildlife conservation” OR “wildlife management” was used for all the databases. Afterwards, the results were screened, and articles were inserted or eliminated based on the following criteria. First, duplicate articles were removed using the Mendeley software to compare the search results of the three databases. This review excluded publications such as conference proceedings, dissertations, early access materials, editorial content, letters, and notes to maintain consistency and relevance. Conference articles were excluded due to their tendency to contain preliminary and unverified results. Furthermore, unpublished technical reports were excluded because comprehensive national databases for systematic

retrieval were lacking. The criteria for inclusion stipulated articles written in English without any specific timeframe. The titles, abstracts, and full contents of chosen articles were thoroughly

examined to ensure their alignment with the study's aim (Figure 1).



**Figure 1:** The Study's Flow Diagram (adapted from PRISMA, 2023).

These articles were reviewed based on the previously established quality criteria in the protocol. Subsequently, the articles were carefully examined to evaluate their quality with regard to their ability to address the key research questions effectively. These are: a) What are the key components of IEK related to wildlife conservation, including species knowledge, habitat management techniques, and ecological indicators? b) How depth and accurate are indigenous observations? c) What aspects of IEK can contribute to wildlife conservation? and d) How can IEK complement Western Science in wildlife conservation? Following this, data extraction was conducted systematically to extract relevant information from selected studies. Study details such as the title, abstract, methodology, and key findings were read, and based on the research objectives, data was extracted. This ensured that findings of the studies answered the research questions. The data was then synthesized using a narrative approach, which summarizes key findings from each theme identified in the systematic review's objectives. While the review was not all-encompassing, it offered a representative overview of the literature's insights into the contribution of IEK to wildlife conservation.

## Results and Discussion

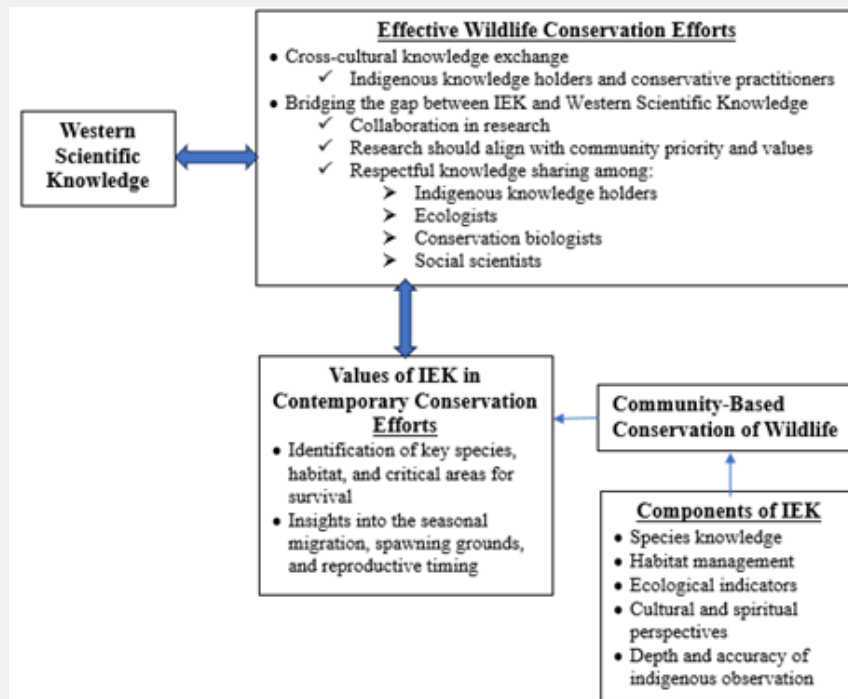
### Overview of Articles

Results showed that majority of the studies came from less-

developed countries, especially within Africa. This was followed by studies in Asia, Australia, North America and Europe. In terms of the publication years, the oldest paper was published in 1995. Thirty-nine (39) of the articles were published from 2000 to 2010, 69 were published from 2011 to 2020, and the remaining 19 from 2021 to 2023. Based on time series analysis of these publications, it becomes evident that the role of IEK or TEK in wildlife conservation has become more important in various fields. The components of IEK and how they contribute to wildlife conservation have been studied, and scholars have identified the various ways through which IEK could be documented and used along with western knowledge to conserve wildlife sustainably.

### Conceptual Framework for the Study

This framework sets out the context for this paper and points audience to the components that form IEK, and how these components inform community-based conservation of wildlife. It further informs the audience about how knowledge applied in community-based conservation of wildlife has contributed to contemporary conservation efforts in areas such as identification of species, habitat, and reproductive timing. Finally, how IEK in collaboration with western scientific knowledge would ensure an effective wildlife conservation is demonstrated by the framework (Figure 2).



**Figure 2:** IEK and Wildlife Conservation framework  
Source: Authors' construct

## Components of IEK and its relationship to Wildlife Conservation

Worldwide, scholars have categorized elements of IEK into specific groups or systems to enhance the effectiveness of wildlife conservation. Appiah-Opoku (2005) categorizes IEK into three systems; (a) Knowledge of biotic materials – detailed knowledge of the environment (b) Technical knowledge – technologies for primary resource utilization (c) Cultural knowledge - cultural practices and beliefs. This paper highlights the utilization of interconnected components of IEK in wildlife conservation, such as insights into species knowledge, habitat management methods, and ecological indicators. These components within traditional knowledge and management systems are founded on a framework that integrates knowledge, practices, and belief systems. This section elucidates the application of these IEK components in wildlife conservation across different ecological settings.

### Species Knowledge

The study revealed that IEK encompasses a rich tapestry of knowledge related to wildlife conservation. Indigenous communities possess a deep and intimate understanding of the wildlife in their ecosystems, and with that knowledge, may form various ways to protecting such wildlife Pimbert [38]. For instance, studies from South America Garcia [39]; Stein et al. [40]; Casi et al. [41] reported that indigenes are usually able to identify

the various species of wildlife. Similar reports have been found in Asia Steinmetz et al. [42]; Abbas et al. [43]; Matias et al. [44]; Allendorf et al. [45]; Zhang et al. [46], indigenes in Canada Henri et al. [47]; Marin et al. [48]; Tomaselli et al. [49], Oceania Lyver et al. [50]; Rasalato et al. [51], United States Beaudreau [52]; Naves et al. [53], and within Africa Goldman [54]; Angwafo [55]; Soliku [56]. Such species knowledge may extend from marine species Thornton [57]; Alexander et al. [58], birds Mallory et al. [59]; Gilchrist [60]; Ortega et al. [61]; Su et al. [62]; Herse et al. [63], and mammals like bears, lions, tigers, elephants, among others Henri et al. [47]; Gandiwa [64]; Angwafo [55]; Lokken et al. [65]; Schley et al. [66]. The studies reveal detailed insights IEK into the behavior, habits, life cycles, and ecological roles of the wildlife species. The insights encompass traditional ecological calendars, which highlight seasonal changes in wildlife behavior and resource availability Mallory et al. [59]; Partasasmita et al. [67]; Di Francesco et al. [68]; Woodward [69].

This is because persons who hold indigenous knowledge have often observed and interacted with wildlife over extended periods, resulting in a profound understanding of their environments Kanagavel et al. [70]; Paterson [71]; Schmidt et al. [72]. Indigenous communities have therefore developed their own classification systems and taxonomies for wildlife. Such knowledge can provide ethnobiological insights that complement Western scientific knowledge Drew [11], Gilchrist [60]; Shokirov



[73]. In South India, a jungle tribe known as Jenu Kurubas have been able to identify different bee types and learned about these bees in a way that allows them to benefit from the bees Demps et al. [74]. The authors report that from such observations, the people resort to division of labor, which considers the people's strengths and weaknesses to better harvest honey at the right time and in a manner that does not harm the bees. In the eastern Canadian arctic, indigenes (First Nations people) were able to provide accurate descriptions of killer whales, their historical use, and effects on other species Westdal et al. [75]. The authors recommended the use of such knowledge in wildlife conservation efforts as attitudes toward such species could bring out better management techniques. Knowledge of the various species and the systems through which indigenes may classify them may differ from Western scientific classifications, but they are no less accurate or insightful Naves et al. [53]; Matias et al. [44]; Tomaselli et al. [49]. They reflect the unique ways in which indigenous knowledge holders perceive and categorize wildlife based on ecological, cultural, and practical considerations. For instance, indigenous cultures classify species based on cultural or symbolic significance, which can have important implications for conservation practices Kuriyan [76]; Henri et al. [47].

### Habitat Management

Indigenous communities have, for centuries, also managed and enhanced wildlife habitats using traditional ecological knowledge Bhattacharyya [77]. This knowledge includes practices such as controlled burning, as found in Western Arnhem Land in Australia where wallaroos often eat crops that appear after burning Telfer [78]. Rotational grazing allows wildlife access to food year-round. For instance, in Tanzania, it has been found that wild animals that inhabit the Tarangire National Park migrate across villages to graze with domestic animals every rainy season Goldman [54]. In these instances, locals are able to regenerate and maintain habitats for specific wildlife species. This practice does not only support wildlife populations, but also promotes the growth of vegetation Polfus et al. [79].

### Ecological Indicators

The study revealed that indigenous communities often rely on specific ecological indicators to assess their ecosystems. These indicators may include the presence of particular species Partasasmita et al. [67]; Heisel et al. [80], the health and behavior of wildlife Paterson et al. [71]; Miard et al. [81]; Straka et al. [82]; Huntington et al. [83], and other changes in the physical environment Lingard et al. [84]; Gadamus et al. [85]. These changes observed could be associated with migration patterns, intensity of harvest, and land use changes Lemelin et al. [86]; Jessen et al. [87]. When discussing the reasons for the decline in the abundance of wildlife in Kenya, Heisel et al. [80] notes that animal migration had been the leading cause of reduction in wildlife. In such cases, the observed reduction in wildlife sightings could lead to conservation efforts put in place to reduce further

declines. Similar reports are shown when looking at the intensity of harvest. A study among the Cree hunters in Northern Ontario showed that after observations of risks associated with hunts of Polar Bears, in terms of damage to other animals, humans and property, they refrained from hunting the bears Lemelin et al. [86]. Indigenous ecological indicators thus valuable tools for assessing the impact of environmental changes and for guiding conservation efforts.

### Cultural and Spiritual Perspectives on Wildlife Conservation

The relationship between indigenous communities and wildlife goes far beyond ecological or practical considerations. For instance, participants may strongly connect their personal and cultural identities to the wildlife, viewing them as relatives, individuals, or neighbors within their family group Menzies [88]; Angwafo [55]; Bhattacharyya [77]. This relationship is deeply interwoven with cultural and spiritual dimensions that shape unique approaches to conservation. About 20% of the reviewed document discussed the various ways through which indigenes view wildlife culturally, and how these shape their attitudes toward wildlife conservation. In many indigenous cultures, wildlife holds profound cultural significance. These societies often have creation stories, myths, and legends that feature wildlife as central characters. Wildlife species are integrated into traditional narratives and art forms, reflecting the cultural heritage of these communities. On IEK and cultural significance of Kāhuli, a study looked at its metaphorical role, poetic use, and importance to hula, as well as its ecological aspects Sato [89]. This indigenous knowledge offers valuable contributions to the conservation of endangered and rare species. The authors then noted that such knowledge comes from centuries-old observations found in songs, chants, and stories have gained global recognition as a resource that can be integrated into conservation efforts for endangered species Sato [89]. In the case of the endemic land snails, Kāhuli, in the Hawaiian archipelago, a significant cultural presence has been preserved in oral tradition and written records, particularly in 19<sup>th</sup> and early 20<sup>th</sup> century Hawaiian language newspapers. In some situations, IEK can be transmitted via hands-on activities. These experiences help young individuals develop skills, values, and establish meaningful relationships with adults and elders Demps et al. [74]; Gadamus [85].

Some species are considered iconic and serve as symbols of identity, resilience, or strength for indigenous communities Rasalato et al. [51]. Traditionally, the utilization of wildlife by the Sundanese people in West Java is greatly influenced by their local knowledge (corpus) and belief systems (cosmos), and thus wildlife serves a range of socio-cultural and economic functions including being a source of household meat, pets, pest control, and aiding in seed dispersal. This unique combination has allowed them to create a sustainable system for wildlife conservation Partasasmita et al. [67]. Learning about wildlife may take many forms, one of which is the folk classification employed by the

Karangwangi community in which categories of wildlife is based on attributes such as color, habitat, voice, and part within the ecosystem Partasasmita et al. [67]. Additionally, myths tend to guide how wildlife is viewed and conserved. For instance, the Sunda slow loris holds a mythic significance associated with bad luck. It is strictly forbidden for the blood of this animal to touch the ground, as it is believed that any land affected by the blood of a Sunda slow loris will suffer from drought. Consequently, the blood of the Sunda slow loris is regarded with great fear. Those who kill this animal are believed to bring serious illness to the people living near the site of the slaughter, affecting up to 40 households. Furthermore, the direction in which the animal is slaughtered also plays a role in determining where misfortune will strike; for instance, if the animal faces east during slaughter, people to the west will be affected by bad luck, and vice versa Partasasmita et al. [67]; Miard et al. [81].

Spirituality and wildlife conservation are intertwined in indigenous communities. Many indigenous belief systems view the natural world, including wildlife, as sacred Westdal et al. [75]; Su et al. [62]. This spiritual connection often leads to profound reverence for wildlife and a strong commitment to its protection. Among the common eider and the polar bear in Hudson Bay region, throughout centuries, polar bears have held a special place, being both admired and feared while commanding respect Henri et al. [47]. They have been integral to the subsistence practices of the Inuit and Cree communities, serving as a source of sustenance, clothing, tools, and currency. The polar bear's importance is deeply ingrained in oral tradition. Throughout much of Inuit and Cree history, the utilization and hunting of polar bears were subject to a set of taboos, rituals, and ethical codes of conduct designed to maintain the appropriate attitudes necessary for successful animal capture Henri et al. [47]. The tiger, often regarded as the Guardian of the jungle, also holds a deep and longstanding reverence in India, with its roots tracing back to pre-Aryan traditions. The fierce goddess Durga, representing the battle against darkness and chaos, is consistently depicted riding a lion or a tiger. Villagers of Bhaonta- Kolyala therefore tend to have a strong affinity for the presence of carnivores Torri [90].

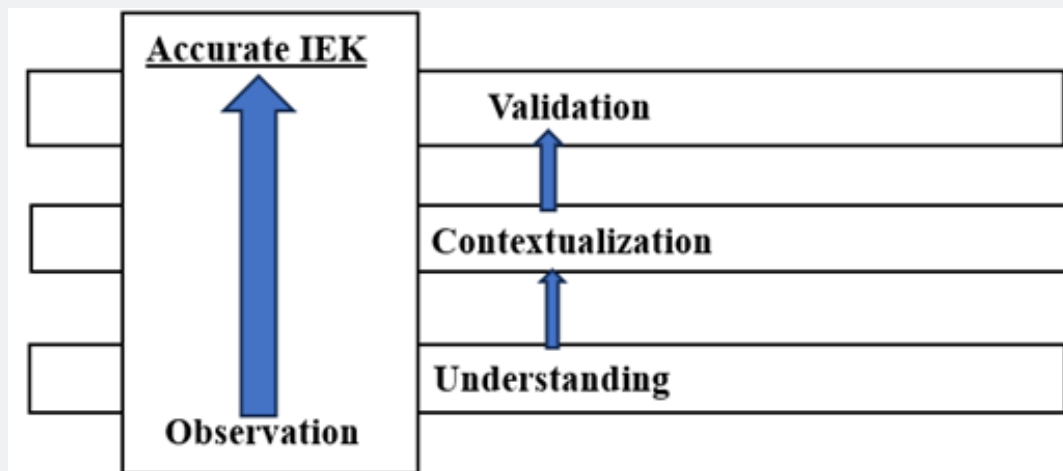
These spiritual connection with wildlife instills a strong ethical framework that guides conservation efforts Casi et al. [41]; Borish et al. [91]. Killing or harming wildlife may be seen as a violation of these ethical principles. In traditional Ghanaian culture, there is a deep-rooted belief that certain animals possess special spirits, and harming or killing these animals can bring significant harm to the person responsible. As a result, these animals like the antelope are typically not removed or eliminated, as they are considered sacred and are treated with great respect Awuah [92]. The hunting of sacred species necessitates the observance of traditional rituals. In this context, causing harm or injury to a sacred animal is seen as a serious transgression of a customary rule, and it may result in severe penalties. Taboos have arisen as means to enforce and uphold the connection between humans and nature Kideghesho [93]. Since many of these taboos are

designed to safeguard species and their habitats from harm, and they are typically followed without question or challenge, their impact on the conservation of nature has often been beneficial. Cultural practices and rituals play a pivotal role in promoting respect and protection for wildlife. Through storytelling, songs, and oral traditions, knowledge about wildlife is shared and preserved Kanagavel et al. [70]. These practices are often passed down through generations and help maintain the delicate balance between indigenous communities and their environments Clark [94]. Understanding the cultural and spiritual perspectives on wildlife conservation within indigenous societies is therefore crucial for fostering culturally sensitive conservation strategies Uprety et al. [95]; Shokirov [73].

### Depth and Accuracy of Indigenous Observations

One of the strengths of IEK is the precision and reliability of indigenous observations Mclean [96]. Among the Inuit and Cree in Canada, authors found that IEK is often based on meticulous, long-term observations of the environment and wildlife Henri et al. [47]; Lemelin et al. [86]. These observations are informed by direct experience and the authors found that indigenes were able to accurately estimate the population size and trends, perceptions on the effects of climatic changes on wildlife, as well as even animal behavior and health Henri et al. [47]; Lemelin et al. [86]. A study by Appiah-Opoku (1999) found that indigenous observations are remarkably accurate, especially when it comes to detecting subtle changes in the environment or animal behavior. From Figure 3, It is noteworthy to mention that IEK employs a three-step transformational process to generate knowledge. This starts with understanding of observed data, followed by contextualization, and finally validation, which strengthens the accuracy of IEK Gratani et al. [97].

For instance, polar bear behaviors in northern Ontario among the Cree revealed that Cree knowledge supports previously published information on polar bears, and also adds further contextual findings on longer distance travels by male bears than previously recorded and known Lemelin et al. [86]. Similar studies have found highly accurate depictions of species knowledge. For instance, mountain goat sightings corroborated aerial survey findings Jessen et al. [87] as did animal population trends Telfer [78]; Jones et al. [98]; Gandiwa [64]; Hallwass et al. [99]; Ziembicki et al. [100]. These studies prove that IEK as a beacon of wisdom is increasingly recognized for its invaluable contributions to contemporary wildlife conservation efforts. Such knowledge is thus being harnessed in practical ways to address current challenges in wildlife conservation as indigenous communities and conservation practitioners are actively leveraging this knowledge to protect and sustainably manage ecosystems and species Hallwass et al. [99]. It should however be noted that not all IEK may be accurate. Studies in coastal ecosystems Turvey et al. [101]; Beaudreau [52] and scavenging ecosystems Morales R et al. [102] note that accuracy may differ in terms of age groups where older persons knowledge has been found to be higher.



**Figure 3:** A three-step transformational process of knowledge production framework  
Source: Adapted from Gratani et al., (2011)

A lack of intergenerational communication can lead to a “shifting baseline syndrome,” where younger generations become less informed about the historical ecological conditions, resulting in decreased awareness of local species diversity and abundance in the recent past Turvey et al. [101]. In addition, information from persons with lower levels of formal education and those living in high vegetation-covered areas may better corroborate scientific findings in accuracy, as found when studying giant honey bees Matias et al. [44]. Although these could change the depth of accuracy, it is still important to note that IEK often provides essential insights into the status of ecosystems and knowledge holders may play a critical role in conducting biodiversity surveys, as they possess the ability to identify and locate species with exceptional accuracy. For instance, among 82 fishers in Dominican Republic, IEK and scientific knowledge overlapped for most of the species studied Mclean [96]. The authors reported that due to the fishers making routine quantitative assessments of body size and maturity, it does suggest potential for future collaboration in monitoring efforts to generate estimates that can be used by scientists and fishers Mclean [96]. IEK is usually formed by observations, and thus may change which may make IEK seem outdated McPherson et al. [103], calling for higher accuracy studies Gilchrist et al. [104]; Service et al. [105]. Only then can indigenous knowledge accurately guide efforts to manage wildlife and ecosystems Mallory et al. [106]; Ulicsni et al. [107].

### Community-based Conservation of Wildlife and IEK

Indigenous communities are increasingly recognized as vital partners in wildlife conservation efforts Dau [108]; Jackson et al. [109]. Their profound connection with the land and ecosystems, coupled with their rich IEK, positions them at the forefront of community-based conservation initiatives. In Southeast Asia, village woodsmen engaged in ranking exercises to create a detailed representation of 20-year trends in the population of

31 mammal species Steinmetz et al. [42]. They also analyzed the specific reasons for declines in each species. A crucial outcome of this exercise was the development of a common understanding of the problem, which opened the door to collaborative efforts. Consequently, there has been enhanced communication between local residents and sanctuary managers. They have launched joint monitoring and patrolling initiatives and set up wildlife recovery zones Steinmetz et al. [42]. Other collaborative efforts in integrating IEK and Western scientific methods offer the potential to improve decision-making in resource management, as has been found when studying the effects of collaborations on indigenous-based habitat suitability index models in northern British Columbia Polfus et al. [79]. Added to this, collaborative efforts boast of valuable insights into wildlife distribution within a human-altered landscape through a cost-effective, speedy, and non-invasive approach Pédarros et al. [110].

Such successes have been found in the Näättämö co-management project for Finland and Norway, where this project is recognized as a model of best practice in Arctic environmental governance Brattland [111]. Notably, the project has shown success when third parties, such as scientific organizations, have established direct bilateral collaborations with the Sámi people under the United Nations (UN) framework. This approach has been instrumental in the success of the Näättämö co-management project Brattland [111]. Another success is the co-management partnership established between the Wiyot Tribe, a Native American Tribe, and California Polytechnic State University Erickson et al. [112]. Outcomes from the partnership show a strong interest in managing wildlife, and promoting forest health and resilience. Additionally, participants expressed a keen interest in integrating training and education for youth in the tribe so that they are able to manage IEK. Other successful community-based conservation projects have been found in Tanzania Goldman et

al. [54], Botswana Phuthago et al. [113], Ghana Attuquayefio et al. [114]; Soliku et al. [56], among Maasai Warriors Dolrenry et al. [115], Canada Moller et al. [116]; Lokken et al. [65]; Popp et al. [117]; Hessami et al. [118], Australia Butler et al. [119], Nepal Allendorf et al. [45], Newfoundland Davis et al. [120], Peace-Athabasca Delta Straka et al. [82], United States Schley et al. [66], and Mexico Ortega et al. [61].

The successes of these collaborative efforts confirm that indigenous communities can indeed play pivotal roles in the design and implementation of wildlife conservation initiatives Peacock et al. [121]. Their involvement extends far beyond being passive stakeholders; they are active contributors and leaders in these efforts. Additionally, indigenous communities often serve as the primary stewards of their ancestral lands and territories, where wildlife conservation is intrinsically tied to their way of life. Indigenous knowledge holders are therefore critical in sharing their IEK with conservation practitioners and researchers, ensuring that it is respectfully incorporated into conservation strategies. While community-based conservation initiatives that integrate IEK have achieved significant successes, there are also unique challenges and complexities that demand careful consideration. In the Ruby Range Sheep Steering Committee (RRSSC) case which serves as a co-management entity in southwest Yukon and has been considered a successful model by some, an interesting dynamic emerges Nadasdy [122]. Over a span of three years, RRSSC members gathered a wealth of information about Dall sheep from various sources and effectively translated it into formats compatible with scientific wildlife management practices. However, despite these efforts, RRSSC members struggled to fully integrate their collective knowledge about sheep, with just one exception.

While there were certainly technical and methodological challenges that hindered knowledge integration, the ultimate reasons for this shortfall were found to be rooted in political factors Nadasdy [122]. Co-management, which was originally envisioned as a means to enhance resource management and empower Aboriginal communities, may therefore face challenges stemming from a shortage of technical expertise and the influence of self-serving political interests Nadasdy [123]. There may also be the challenge of conceptualizing relationships between humans and animals, as well as the integration of scientific research and management practices. Without adequately recognizing and accommodating IEK and Western scientific knowledge, co-management projects would not succeed Dowsley [124]. Community-based conservation initiatives therefore offer the potential for sustainable, culturally sensitive, and effective wildlife conservation. By acknowledging the roles of indigenous communities and the challenges they face, conservation practitioners can work together to create mutually beneficial and respectful partnerships.

## Value of IEK in Contemporary Conservation Efforts

The ecological knowledge of indigenous communities have a long history of managing and enhancing wildlife habitats Bruckmeier [125]; Huntington et al. [83]. IEK can identify key species, habitats and critical areas that are essential for the survival of wildlife species Danielsen et al. [126]; Tomaselli et al. [49]; Zhang et al. [46]. For instance, in northern Quebec's Iuvivik region, hunters witnessed a significant occurrence of common eider ducks succumbing to a disease within nesting colonies situated in the northern Hudson Bay and western Hudson Strait Henri et al. [47]. Subsequent laboratory examinations of the eider carcasses verified that avian cholera was the cause of their demise. Since that initial observation, avian cholera has continued to be detected every summer among eider colonies along Quebec's northern shores, as well as at the East Bay colony on Nunavut's Southampton Island Henri et al. [47]. Additionally, IEK has been able to offer insights into the seasonal migrations, spawning grounds, and reproductive timing of lake trout, which were hitherto not covered in scientific studies Marin et al. [48]. Such knowledge helps in wildlife survival and future conservation efforts Huntzinger et al. [127]. IEK thus unveils not just variations within species that are pertinent to natural resource management and taxonomy but also shed light on the degree of such population distinctions Marin et al. [48]. Another pathway through which IEK becomes valuable in contemporary efforts is through the provision of low-cost knowledge. IEK was found to be 100 times cheaper than data obtained through linear-transect surveys Anadón et al. [128]. Coupled with its ability to provide crucial information, it has become a key route to understanding and enhancing conservation efforts worldwide Attum et al. [129]. Additionally, indigenous practices are also often based on principles of sustainability. These practices can therefore help ensure the continued availability of resources for both wildlife and indigenous communities Jessen et al. [87].

The synergy between IEK and Western scientific approaches is also increasingly recognized as a powerful force in conservation Kideghesho [93]; Ziembicki et al. [100]. When combined, these two knowledge systems offer a more comprehensive and holistic understanding of ecosystems and wildlife. Information from local experts on the biology of the King Vulture (*Sarcoramphus papa*) in communities near the Calakmul Biosphere Reserve and a workshop aimed at educating farmers on how to monitor endangered species, including the King Vulture revealed that the preservation of this knowledge would not have been possible without traditional knowledge Haenn et al. [130]. IEK can thus serve as a valuable supplementary data source, and it may be particularly advantageous when managing wildlife populations found in remote areas inhabited by indigenous communities, Gilchrist et al. [104]; Henri et al. [47]; Gandiwa [64]; Shokirov [73]. Efforts to combine IEK with scientific knowledge can achieve this by assisting researchers in establishing trust and fostering



effective communication within these remote or aboriginal communities Fraser et al. [131]. Enhancing collaboration between scientists and fishermen will then hold the potential to enhance the accuracy of survey estimates and stock assessments Nordlund et al. [132]; Paterson [71].

IEK often emphasizes holistic and interconnected views of nature, which can complement reductionist approaches in Western science. This holistic perspective acknowledges the intricate relationships between all elements of an ecosystem Drew [11]; Service et al. [105]; Bhattacharyya [77]; Buchholtz et al. [133]. The studies also show that the incorporation of IEK into conservation strategies allows for adaptive management approaches that are responsive to changing conditions and informed by the wisdom of indigenous communities. The combination of scientific and traditional monitoring methods not only fosters partnerships and community consensus but, more importantly, empowers indigenous wildlife users to critically assess scientific predictions according to their own criteria and assess sustainability using their forms of adaptive management Berkes et al. [134]; Moller et al. [116]; Murray et al. [135]; Ortega et al. [61]; Naves et al. [53]. Given that indigenous knowledge is deeply rooted in local contexts and specific environments, when integrated with Western scientific data, it provides essential context and fine-grained insights into ecosystem dynamics that contribute to recovery planning Upreti et al. [95]; Polfus et al. [79]; Miard et al. [81]. The value of Indigenous Ecological Knowledge in contemporary wildlife conservation therefore extends far beyond its role as an adjunct to Western scientific methodologies. It is a dynamic and essential resource that has the potential to shape more effective and culturally sensitive conservation practices Dawe [136]; Huntington et al. [83].

## Conclusion and Research Implications

### Effective Wildlife Conservation Efforts

The synthesis of findings from each of the explored themes highlights the multifaceted nature of IEK and its profound impact on wildlife conservation. Indigenous knowledge about wildlife species, habitat management techniques, ecological indicators, and the reliability of indigenous observations collectively form a comprehensive and accurate understanding of ecosystems. IEK contributes practically to wildlife conservation by offering insights into monitoring, biodiversity surveys, and invasive species control. It also plays a crucial role in habitat preservation and restoration while complementing Western scientific approaches. The cultural and spiritual dimensions of IEK emphasize the cultural significance of wildlife, spiritual connections, and the role of cultural practices and rituals. These dimensions influence ethical considerations and traditional belief systems related to conservation. Indigenous communities actively participate in community-based conservation initiatives, serving

as stewards of the land and guardians of IEK. Collaborative projects result in successes and overcome challenges through respectful partnerships. Opportunities for collaboration between indigenous knowledge holders and conservation practitioners are abundant. Strategies to bridge the knowledge gap include interdisciplinary collaboration, respectful knowledge sharing, and capacity building within indigenous communities.

The synthesis of these themes underscores the profound impact of IEK on wildlife conservation. Indigenous knowledge serves as a repository of wisdom, honed through generations of direct interaction with ecosystems. Its practical applications, cultural significance, and spiritual connections reveal a holistic worldview that recognizes the interconnectedness of all life forms. IEK complements and enriches Western scientific approaches, offering innovative solutions for conservation challenges. The value of IEK extends beyond the realm of conservation biology; it embodies a broader ethic of respect for nature and cultural diversity. The insights derived from this review have significant implications for policy and practice in wildlife conservation. Policies must recognize the value of IEK and respect the rights of indigenous communities. Conservation practices should incorporate IEK in ways that respect cultural and spiritual dimensions. Conservation practices should be inclusive, involving indigenous communities as active partners and decision-makers. Policies should also ensure that indigenous voices are heard and that benefits are equitably shared. Supporting the transmission of IEK to future generations and facilitating active participation in conservation initiatives is vital.

### Cross-Cultural Knowledge Exchange

Cross-cultural knowledge exchange represents a dynamic and transformative pathway for conservation efforts. It entails the collaboration and mutual learning between indigenous knowledge holders and conservation practitioners from diverse backgrounds Weiss et al. [137]. Through collaboration, individuals can unite to pursue a shared objective. While navigating colonial governance and institutional structures that perpetuate unequal power dynamics can pose a challenge Ball 2008; Reed et al. 2021, individual accountability plays a crucial role in making a significant impact. Similar to the principles of building relationships, effective collaboration hinges on people prioritizing their shared humanity—a readiness to engage in ethical dialogue (Ermine, 2007) regardless of discomfort or busyness (Styres & Zinga, 2013). Only within this collaborative space can open and free communication occur, fostering opportunities for the emergence of new ideas and personal growth. The synergy between indigenous knowledge holders and conservation practitioners presents numerous opportunities to enhance the effectiveness of wildlife conservation. These opportunities can be identified in various aspects of conservation initiatives. For instance, traditional hunters have widely embraced a community-

based conservation approach, primarily because it aligned with their subsistence hunting traditions Shokirov [73]. Additionally, the fusion of traditional hunter knowledge with a community-based conservation approaches facilitated knowledge sharing, enhanced the accuracy of scientific surveys, and fostered stronger collaboration among conservancies and other conservation non-governmental organizations (NGOs). Most importantly, these approaches lead locals to assume responsibility for wildlife management Tschirhart et al. [138]; Shokirov [73].

Indigenous knowledge holders also offer unparalleled expertise in local ecosystems, which can inform and enrich conservation strategies. Mapped depictions and the narratives that accompany them portray the collective wisdom of indigenous hunters and these offer distinct and valuable contributions to management practices Kendrick [139]. The intergenerational knowledge held by indigenous communities, coupled with the chance to explore a wide range of interpretations of environmental observations, is essential for the integration of indigenous learning systems into contemporary wildlife management efforts Mallory et al. [106]. It is not solely the data derived from indigenous hunters that holds relevance for resource management; rather, it's the opportunities for social learning and for resource managers to grasp how indigenous persons acquire knowledge about the environment that directly informs decision-making in resource management Kendrick [139]. Indigenous communities can provide valuable insights into cultural and ethical considerations that guide conservation actions. IEK institutions and systems can provide valuable entry points for promoting sustainable natural resource management and use Phuthego [113]; Stacey et al. [140]. This can be accomplished by examining the cultural practices of indigenes and incorporating relevant elements into modern natural resource management practices Phuthego [113]; Mclean [96]. Collaborative projects can alternatively involve indigenous communities in decision-making, fostering a sense of ownership and responsibility for conservation outcomes. An instance can be found in Fiji, where a reconfiguration of the marine protected areas network was undertaken to enhance both resilience and compliance Weeks [141]. This endeavor was shaped by several contributing factors including clearly defined resource-access rights, which facilitated effective management; local communities showing support for a customary system of governance; an ongoing commitment and consistent presence of co-management partners; a supportive policy environment for co-management efforts; a blend of traditional management approaches with systematic monitoring techniques and; the coordination across districts offering a broader spatial context for making adaptive management decisions Weeks [141].

### **Bridging the gap between IEK and Western Scientific Knowledge**

While cross-cultural knowledge exchange holds great promise, it is essential to address the knowledge gap between

IEK and Western scientific knowledge. One of the key ways is to encourage collaboration and respect between indigenous knowledge holders, ecologists, conservation biologists, and social scientists Weiss et al. [137]; Harrison et al. [142]; Zarazúa et al. [143]. Establishing mechanisms for respectful knowledge sharing will prioritize indigenous voices and perspectives and enable Western scientific paradigms to acknowledge the validity of IEK Pimbert [38]; Thornton [57]; Alexander et al. [58]. Additionally, indigenous communities could be more involved in the design and implementation of research projects, ensuring that research aligns with community priorities and values Rutina et al. [144]; Ramos [32]. This could be achieved when initiatives actively engage indigenous communities in ways that enable them to participate more effectively in conservation efforts and research Gauvreau et al. [145]; Ramos [146]; Saturno et al. [147]. In so doing, Ramos [146] indicates the need to understand indigenous community's distinct needs, priorities, and values. IEK and Western scientific knowledge must collaborate to devise innovative, mutually beneficial approaches for wildlife stewardship. Given the challenges of climate change and declining biodiversity, IEK and Western scientific knowledge share a collective responsibility-both to wildlife and to each other-to advocate for and implement transformative changes for a more sustainable future. The time is right to move beyond discussions about uplifting Indigenous-land relations and translate our words and ideas into collective action. Another way to bridge the gap is to foster long-term partnerships built on trust and mutual respect, acknowledging that effective cross-cultural knowledge exchange takes time to develop Low et al. [148]; Heisel et al. [80].

With the right frameworks being developed to guide cross-cultural collaborations, knowledge sharing would be ensured in a way that respects indigenous rights Berkes [149]; Sidorova [150]. It is always important to note that cross-cultural knowledge exchange has the potential to generate innovative conservation solutions that draw on the strengths of both indigenous knowledge and Western scientific approaches. Only by recognizing and respecting the diverse ways in which knowledge is generated and applied, conservation can become more inclusive, holistic, and culturally sensitive McPherson et al. [103]. To conclude, IEK worldwide has long been involved in both scientific endeavors and ecosystem stewardship. However, it is only in recent times that indigenous-led conservation with Western scientists have gained mainstream recognition, attracting increased funding and collaboration opportunities. While this presents new avenues for wildlife research and monitoring, it also raises the risk of Western scientists entering into collaborative research with Indigenous partners without sufficient understanding of local histories and customs (Wong et al., 2020). There is a pressing need for reconciliation, both broadly and within conservation. Importantly, any reconciliation must occur on the terms defined by Indigenous Peoples and communities themselves. Genuine collaboration requires a shift away from perceiving Indigenous Nations as

'marginalized' to treating them as full and active guiding partners (Styres & Zinga, 2013). Reconciliation cannot happen within colonial assumptions about the needs of Indigenous Peoples Berkes [151].

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