Traditional Ecological Knowledge Repository in the Indian Himalayas: An Overview

P. Sahana Florence and Achyutananda Mishra

Abstract "Traditional ecological knowledge" (TEK) refers to a body of information that is also referred to as "local knowledge," "traditional knowledge," "native knowledge," and "indigenous technological knowledge." A number of studies show the role of traditional ecological knowledge in decision-making in social-ecological systems that support sustainability and resilience. International agencies have also highlighted and emphasised the importance of TEK practises in the preservation of biological variation. For instance, the UN Convention on Biodiversity, Article 8 (j), makes it very plain that "respect, maintain, and promote innovation and practises of indigenous and aboriginal populations connected with sustainable use of biological diversity" are essential. The benefits of TEK for sustainable forest management were acknowledged in the 2005 Millennium Ecosystem Assessment Report by the World Bank. As environmentalists, anthropologists, and arborists share interests in TEK for academic, social, or economic reasons, this highlights the significance of TEK in difficulties relating to biodiversity protection. Numerous components of TEK are seen favourably by experts in fields of forestry, irrigation, architecture, ethnobiology, irrigation, agriculture, medicine, sun and water conservation, conventional weather prediction, adaptation to climate change, and disaster risk reduction. Indian Himalayan Region (IHR) is predominantly populated by indigenous peoples and local societies, which are quite diverse in terms of socio-culture and race. The region has nearly 40% of all of India's indigenous tribes. This area is also special for its traditional ecological knowledge. Many of the TEK-based practices have supported local communities in earning a livelihood. The indigenous people's expertise and experiences are said to play a crucial part in preventing climate change, and they may give important information on the implications of climate change. Hence, sustaining biodiversity in the IHR is also a means of defending indigenous peoples' rights. By making the TEK the focal point of governance systems at the IHR, the variety of options for sustainable growth and even the co-production of the body of knowledge would be expanded. Therefore, it seems sensible to get knowledge from the TEK before it is lost to the onslaught of modernity. However, there are numerous

P. Sahana Florence (✉) · A. Mishra
School of Law, Christ (Deemed to be University), Bengaluru, India
e-mail: mssahana.florence@res.christuniversity.in

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problems or issues with traditional ecological knowledge in India, including ignorance in considering conservation policies by the Indian government and the lack of effective documentation of this priceless knowledge. To develop sustainable and culturally suitable management techniques, it is currently a challenge to combine indigenous knowledge standards and management methods with Western science. Realising the above, this chapter attempts to comprehend the concept of TEK and its application throughout a variety of resource management contexts throughout a variety of resource management scenarios. Further, it will explore various issues and challenges and examine the regulations thereof. Lastly, this chapter concludes by highlighting the strategies and suggestions for an effective repository of traditional ecological knowledge in the Indian Himalayan Region.

Keywords Biodiversity · Traditional ecological knowledge · Repository · Indigenous peoples · IHR

1 Introduction

Traditional ecological knowledge (TEK), which implies local knowledge, traditional knowledge, native knowledge, indigenous technological knowledge, etc., is widely acknowledged as an intellectual endeavour and is described as such by a variety of environmental, cultural, and social factors (Tynsong et al., 2020). A TEK is a crucial component in terms of the social values used in developing countries to generate food, improve health, and mould local views and perspectives on the world and people (Finn et al., 2017). Traditional ecological knowledge was transmitted from one generation to the next, and over time, it was enhanced and honed into a corpus of profound local knowledge and customs (Nautiyal & Goswami, 2022). Furthermore, in addition to providing ecosystem benefits, TEK and management strategies may help us understand systems for adaptive and socio-ecological management (Pandey, 2002). TEK is a crucial resource for addressing issues with socio-cultural practises, food security, the environment, and biodiversity (Rai & Mishra, n.d.). Unfortunately, when looking at natural resources in underdeveloped countries, TEK and its merits are generally overlooked. Regulations in India, such as the Biological Diversity Act of 2002, the Forest Rights Act of 2006, and intellectual property rights, have been developed to own TEK and share benefits with the local population (Pandey, 2002). TEK has been preserved, promoted, and documented with a lot of effort on both the national and international levels. However, there hasn't been any influence at ground level (Harisha et al., 2023). Traditional ecological knowledge encompasses multiple facets of climate change adaptation, medicine, weather forecasting, irrigation, agriculture, ethnobiology, and disaster risk reduction. If TEK were placed at the centre of environmental governance, the variety of opportunities for ecological sustainability and the co-production of a body of knowledge would indeed be enlarged (Traditional Knowledge System in the Himalayan Region: Key to Sustainable Development – Kalinga Institute of Indo-Pacific Studies, 2023). Therefore, it

makes sense to get knowledge from the TEK before it is lost to the forces of modernity (Rai and Mishra, n.d.). In light of the aforementioned, this chapter makes an effort to comprehend the idea of TEK and how it may be used in diverse resource management scenarios.

2 Traditional Ecological Knowledge: A Conceptual Framework

2.1 Concept and Meaning of TEK: Meaning and Significance

Traditional ecological knowledge (TEK) is a notion that has many other names, including local knowledge, traditional knowledge, native knowledge, indigenous technical knowledge, etc. (Rai and Mishra, n.d.). It refers to indigenous and other traditional understandings of regional resources. The term "traditional" is a bit abstract in this notion. For some groups of people, the term "traditional" denotes a continuing adherence to outdated practices or a belief system rooted in superstition (Tynsong et al., 2020). While for many others, TEK means possessing or understanding information in various ways, it is distinct from the actual dimension of knowledge because it is formed in a manner that preserves the communities' traditions. TEK is adapted to the indigenous ecosystem and developed from the experiences gathered over the ages (Rai and Mishra, n.d.). Generally speaking, it has to do with understanding the composition and operation of nearby natural ecosystems and how to utilise them sustainably for human benefit (Tynsong et al., 2020).

TEK can be defined as the assimilation of knowledge acquisition and dissemination more straightforwardly. Any community, society, or culture's traditional indigenous knowledge is a special form of local knowledge (Jenkins, 2022). TEK is focused on how living things—including humans—interact with their surroundings and with the social groups that make up their traditional communities. Indigenous knowledge (local knowledge), though not a term that all communities use, refers to a set of information, traditions, or practices that have a strong place component (Usher, 2000). When few environmental baselines have been scientifically recorded, such information is used for managing natural resources to either replace or augment Western scientific approaches to ecological management (Jenkins, 2022). TEK can also be thought of as a self-management system, a very important source of environmental expertise that helps indigenous or other remote native cultures protect and maintain their way of life (Nautiyal & Goswami, 2022). It serves as the foundation for local decisions about social, economic, and political organisation, resource management, education, health, hunting, and agriculture. It is widely acknowledged that there is a connection that cannot be broken between biological and cultural variation (Nautiyal & Goswami, 2022). The biotic and abiotic environments, which vary depending on the types of society and culture, have an impact on the ongoing process of modification that resource users use to create TEK rather than specialists

(Rao et al., 2003). In a nutshell, it is a comprehensive corpus of knowledge, belief, and practise, growing from the TEK worldwide among indigenous and local people, and verbally transmitted from one generation to the next cultural values, beliefs, proverbs, folklore, and traditions, as well as regional laws, dialects, and agricultural practices (Tynsong et al., 2020) such as breeding changes in plants and animals, which are considered the community's intellectual property and intangible heritage (Nautiyal & Goswami, 2022).

2.2 Development of TEK

Traditional ecological knowledge (TEK), sometimes known as "traditional knowledge," is the specialised knowledge that societies that have traditionally lived near natural environments have amassed about those ecosystems and environmental resources (Kala, 2011). TEK serves as an example of the knowledge accumulated over centuries through direct human interaction with the environment. Although TEK has been used since the dawn of hunter-gatherer societies, tribal elders first used the phrase in the 1980s with a conceptual model to advance a deep understanding and raise awareness of TEK's significance (Kala, 2011). It was at this time that TEK began to get international attention for its potential use in sustainable development and resource management strategies. The World Commission on Environment and Development (WCED), established in 1983, released a report titled "Our Common Future" in 1987. The report was given the name "Brundtland Report" in honour of Commission Chairwoman Gro Harlem Brundtland (Commission on Environment, n.d.). It created the fundamental ideas of sustainable development as we know them today. The document noted how current trends increased ecological degradation "amidst diminishing resources and an ever-cleaner world" were brought on by the twentieth century's accomplishments (Commission on Environment, n.d.). But there was still hope for conventional ways of living. The study's findings indicated that indigenous peoples and cultures have ways of life that may teach modern nations how to manage resources in intricate forest, mountain, and dryland environments (Finn et al., 2017).

Since its origin, TEK as a natural substitute for knowledge systems in the environmental and biological health sciences has drawn increased attention from a variety of municipalities, governmental agencies, and academics (Kodirekkala, 2017). Scholarly experts and government organisations are beginning to see the importance (Kodirekkala, 2017) that such regional historical information can have for preserving biological processes, conservation areas, biodiversity, as well as other elements on indigenous territory (Bureau of Indian Affairs (BIA), 2016). The organisations that deal with indigenous people throughout the globe used components of TEK to valorise a body of knowledge made up of rich, historical data accumulated by decades of observers whose lives and cultures relied on this knowledge and its application (Finn et al., 2017).

Several disciplines, such as agriculture, pharmacy, and ethnobotany, respect it since it currently indicates a seamless connection between ecosystems and people (Kala, 2011). Additionally, taking into account the current environmental problem, the destruction of organic habitats, and climatic alterations, TEK is regarded as a crucial instrument to mitigate the impact of shifting ecological and climatic conditions globally since it promotes the ideas of coexistence and sustainability (Kala, 2011). TEK assists in the creation of processes for local decision-making in several activities, including agriculture, pastoralism, food preparation, healthcare, and the management of natural resources (Lemi, 2019). It is a collection of particular local knowledge that has been refined over time. The concept of TEK was developed in an attempt to reassert the authority of regional groups whose voices and interests had been drowned out by the prevalent rhetoric of science-based modernization and development. Western scientists increasingly consider TEK in tribal research (Lemi, 2019). When Agenda 21 was established at the UN Conference on Environment and Development (UNCED), which was held in Rio de Janeiro in 1992, Traditional Ecological Knowledge Systems (TEKS) gained significance (Traditional Knowledge System in Himalayan Region: Key to Sustainable Development—Kalinga Institute of Indo-Pacific Studies, 2023). This was in response to new research and political acknowledgement of indigenous rights (Lemi, 2019). The Convention on Biological Diversity (CBD), which specifically addressed concerns regarding traditional knowledge, created international agreements that provide the sharing and protection of national biodiversity (Pandey, 2002). The UN Convention on Biological Diversity's Article 8(j) makes it very apparent that indigenous and aboriginal groups' innovations and practises related to the sustainable use of biological diversity must be respected, preserved, and supported. The Nagoya Protocols (2010) provide such a legal structure for effectively achieving the relevant CBD objectives (Traditional Knowledge System in Himalayan Region: Key to Sustainable Development—Kalinga Institute of Indo-Pacific Studies, 2023). The benefits of TEK for sustainable forest management were accepted by the World Bank and the Millennium Ecosystem Assessment Report, 2005 (Lemi, 2019). Support for indigenous wisdom, traditions, and customs is acknowledged in Article 31 of the United Nations Declaration on the Rights of Indigenous Peoples, 2007 (United Nations Declaration on the Rights of Indigenous Peoples United Nations, n.d.). As ecologists, anthropologists, as well as arborists (a tree surgeon) share a passion for TEK in academic, social, or commercial objectives, this highlights the significance of TEK in difficulties relating to biodiversity protection (Lemi, 2019).

2.3 Benefits of TEK

TEK has been used since the beginning of time. TEK contributes significantly to conservation efforts and, by saving time and money, helps pave the way for modern research and development (Benefits of TEK—Traditional Ecological Knowledge (U.S. National Park Service) 2023). A variety of TEK-related characteristics are

widely acknowledged by scientists in the fields of ethnobiology, conservation of soil, forestry, medicine, agriculture, irrigation, architecture, catastrophe risk reduction, climate change adaptation, water conservation, and forecasting (Gómez-Baggethun et al., 2013b). Application of TEK fosters cooperation with Indigenous peoples on environmental issues of shared interest offers transversal information for action planning connected to climate change and improves decision-making concerning species and ecosystems. The range of alternatives for sustainable development and knowledge base co-production would be increased if TEK were to be the focal point of environmental governance (Benefits of TEK: Traditional Ecological Knowledge (U.S. National Park Service), 2023). It promotes the ideas of cohabitation and sustainability. In light of the current environmental situation, the destruction of climatic change, and natural ecosystems, TEK is viewed as a crucial instrument to lessen the effects of altering global climatic and biological circumstances. The design of methods for decision-making at the local level in a range of disciplines, including livestock husbandry, food preparation, medical care, and resource development, is aided by TEK (Kala, 2011), which is a collection of specific local knowledge that has been refined over time (Garkoti & Semwal, 2015).

2.4 Aspects of TEK

Many writers have made an effort to compare the indigenous tribes' environmental information and that of the colonisers to better understand the two knowledge systems (Houde, 2007). A group's traditional ecological knowledge is made up of a variety of knowledge elements that have been categorised by some individuals (Usher, 2000). This research aims to comprehend how traditional ecological knowledge (TEK) may enhance environmental management or advance scientific knowledge. Houde lists the following six features or elements of conventional ecological knowledge (Rai and Mishra, n.d.). The elements of conventional ecological knowledge can be used and understood in a variety of ways. When attempting to combine two different methods of knowing and thinking. These are instructional illustrations of how it is applied from different angles and how they intersect, emphasising it even more. To more precisely pinpoint areas of convergence and divergence, collaborative management is used (Houde, 2007) (Fig. 1).

I. **Factual Observation**

The list of precise observations which TEK bearers can produce is the first and most well-known component of TEK (Houde, 2007). Non-aboriginal researchers studied folk taxonomy, requiring TEK components to name, identify, and classify environmental components (Gagnon & Berteaux, 2009). It includes knowledge of facts about animals, information about the habitat and behaviour of animals, information about the anatomy of different species, and information that has been synthesised from various scientific discoveries. Monitoring ecosystem health indicators requires understanding species relationships, biophysical connections, spatial

Fig. 1 Aspects of traditional ecological knowledge.
Source The Authors

distributions, and historical trends in population and spatial patterns (Houde, 2007). Understanding ecosystem dynamics is crucial for environmental science advancement, database addition, and detecting changes in ecosystems. The management of endangered species and environmental impact assessments are seen as the contexts in which this is most helpful. Detecting unintended development implications helps First Nations (indigenous peoples) engage in decision-making processes (Houde, 2007). Factual TEK can be misinterpreted if it doesn't serve state or private interests, as First Nations lack control and participation in resource management decisions. Many Aboriginals have expressed grave concern about this lack of responsibility for TEK and its application (Kala, 2011).

II. **Management System**

In terms of management systems, the sustainable and ethical use of resources is the second component of TEK (Houde, 2007). Therefore, the TEK study's main emphasis is on the management of resource methods and how they have been modified for regional settings. The second TEK component involves measuring resource status and strategies for sustainable use, including pest control, conservation, and cropping patterns (Herrmann & Torri, 2009). This face acknowledges that TEK, which adapts to change by developing effective technology, is a "complex web of behaviours" (Houde, 2007) connected to an understanding of animals and their interactions.

III. **Current and Past Uses**

The temporal dimension of TEK, which is the third component, is concerned with environmental uses that have been verbally transmitted in the past and present, such as land usage, habitation, harvest, and settlement rates (Gagnon & Berteaux, 2009). Particularly important issues include historical sites and medicinal plants. This TEK component includes life tales that are handed through stories that foster a sense of family and community, tales are passed down through generations (Houde, 2007). In the course of land claim talks, Canadian First Nations frequently disclose this aspect of TEK. The Supreme Court of Canada, in Delgamuukw v. British Columbia [(1997) 3 SCR 1010], ("Delgamuukw v. British Columbia, SCC Cases," 2023) observed that oral history now has more legitimacy. First Nations identify toponyms, historical locations, and occupancy patterns using charts to demonstrate their native connection and regain lost terrain. First Nations compromised on TEK to increase integrity in the context of Western science, waiting for authority's recognition of their knowledge systems (Herrmann & Torri, 2009).

IV. **Ethics and Values**

The fourth aspect discusses the relationship between belief systems and facts, focusing on environmental ethics and values concerning human relationships and species' habitats (Janaki et al., 2021). Resource management struggles to effectively transfer TEK cultural rights as policy documents may not fully accommodate land ethics. First Nations assert their principles through position papers with minimal consequences. Examples of state and indigenous ethics that conflict but are rarely properly addressed include trophy hunting and catch-and-release fishing (Houde, 2007).

V. **Culture and Identity**

This fifth facet emphasises the significance of language and historical imagery in preserving culture. The culture that defines Aboriginals (original inhabitants) depends on the relationship between them and their surroundings (Finn et al., 2017). The notion is that indigenous civilizations are centred on the land and that if the land disappears, those cultures would perish or undergo far too much alteration, and civilizations also individuals would follow, it is essential to preserve these locations if aboriginal culture is to endure over the long term (Gagnon and Berteaux, 2009). Local histories, cultural practises, and social structures are all taken into account in this TEK component as they relate to the persistence, of indigenous cultures' and identities' expansion and regeneration. It highlights how cultural landscapes have healing qualities and may serve as sites for spiritual rebirth (Houde, 2007).

VI. **Cosmology**

The final recognisable facet of TEK is a cosmology with cultural roots that serves as the foundation for and is inextricably linked to the earlier faces. Cosmology is an idea that many cultures have about how the world functions. The laws that govern how people and animals interact with one another and how humans fit into the

greater scheme of things are laid forth in this worldview, which also outlines how everything is interrelated (Houde, 2007). Many anthropologists and cultural ecologists have studied this aspect of TEK to comprehend, for example, how "Cree" or "Inuit" peoples understand human-nonhuman animal relationships and how they affect managerial practices, social responsibility to others in the community, and social interactions. This dimension's resemblance to religion has been suggested. Others have refuted this assertion, claiming that TEK is more of a philosophy than an ideology and that the state's resource management was, in any case, founded on a particular philosophy that had a significant influence on the Christian worldview (Characteristics of the Six Faces of Traditional Ecological Knowledge (TEK) | Download Table, 2023).

3 Western Science and TEK: A Comparison

> Traditional Ecological Knowledge is complementary to Western science, not a replacement for it—David Suzuki

Many academics have recently been interested in the vast group of knowledge named "traditional knowledge" (TK), "indigenous knowledge" (IK), or "traditional ecological knowledge" (TEK), with other titles (Finn et al., 2017). These systems of multigenerational knowledge are founded on individual and group worldviews and experiences that have been approved by seniors. They also draw on oral traditions, various kinds of record-keeping, and directed and transmitted experiential learning. The TEK's more encompassing components include a wide and deeper knowledge of how people interact with various aspects of the physical, social, and spiritual environment, beyond conventional conceptions like actual assertion and co-management standards (Houde, 2007). On the other hand, when it is found that TEK conflicts with scientific results, its usefulness is called into doubt or it is written off as a myth. In popular culture, science is depicted as being impartial, quantitative, and the basis for advancement and assessment of "real" information, whereas TEK might be seen as hearsay, incorrect, or written unusually (Finn et al., 2017). Fulvio Mazzocchi of the Institute of Atmospheric Pollution of the Italian National Research Council contrasts TEK and Western scientific knowledge as follows: The interconnection of humans and nature has become a central theme in traditional ecological knowledge's development of an understanding of the environment. It provides a strategy for regional growth that takes account of ecosystem density and co-evolution with the surroundings (Mazzocchi, 2006). It may be useful for environmental evaluation, development planning, and natural resource management. It may also aid in conservation education (Arruda & Krutkowski, 2017). In addition to the usual advantages for individuals who rely on this information, it may provide mankind with a whole set of new ecological and biological insights. In comparison to Western science, which is scientific and materialistic, traditional knowledge is eternal and does not differentiate between the sacred and the secular. Traditional knowledge is mostly qualitative

and intuitive, as opposed to Western science, which is scientific and quantifiable (Mazzocchi, 2006). The elders often verbally pass on traditional knowledge from one generation to the next. whereas Western science was founded on the exchange of intellectual and literary information (Finn et al., 2017). While Western science uses reductionist techniques and a linear cause-and-effect mechanism, TEK considers the issues affecting the overall biological community. The human brain is used in TEK to gather, filter, and evaluate observational data (Kodirekkala, 2017). In terms of its demands for consistency and proof, traditional ecological knowledge (TEK) differs from Western science. It is dispersed and produced differently from Western science and is frequently viewed as folklore. Modern tradition holds that Western science alone possesses the truth, frequently as a result of the tension between science and conventional wisdom. In other cases, Western scientific knowledge and TEK are not fundamentally different; both ultimately come from scientific findings regarding the surroundings and the methodical process of establishing order and stability out of a survival necessity (Arruda & Krutkowski, 2017). TEK's cultural and religious environmental ideas are essential to understanding and safeguarding the environment, even though some of them may be illogical in terms of modern science. As a result, it is hard to discern between scientific and conventional knowledge with precision based on method, epistemology, context, or content (Stephens, 2000). Consequently, to disprove the notion that such a Westernised knowledge structure is the sole workable solution to the global environmental crisis, globalisation should be utilised effectively to have or ingrain indigenous expertise into the globalised world (Gagnon & Berteaux, 2009). Although epistemology is the study of universal knowledge, different types of information might be acquired based on the sociocultural circumstances in which knowledge claims are established and made explicit. There is a need to close the epistemic gap that emerges from not understanding how local or indigenous knowledge is acquired when people with different worldviews work together on the same subject (Stephens, 2000).

3.1 Integration of TEK & Western Science

The ability of traditional ecological knowledge, which represents centuries of experience, to manage complex systems is widely accepted. A TEK approach for understanding the complex relationships between ecosystems, together with correctly collected longitudinal data and insightful information, can substantially help scientific research (Lemi, 2019). TEK may also be included in Western scientific studies as a component or as an additional tool for quantitative Western methodologies. Unlike scientific knowledge, which relies on separating traditional knowledge, which is founded on connection, knowing from the known (Lemi, 2019) Academic scholars have recently started to investigate, assess, and, in some instances, seek to integrate indigenous knowledge systems into modern scientific theories and institutional frameworks. These academics are conversant with the ideas and practices of TEK (Finn et al., 2017).

According to research conducted in the Arctic, there are five areas where TEK and Western science can integrate. The area of focus includes local scale expertise; sources of historical climate data; hypotheses and research questions; effects and community adaptation; and neighbourhood-based surveillance (Lemi, 2019).

TEK can be highly helpful in deciding on adaptation measures for climate change as well as in analysing its effects (Lemi, 2019). Traditional knowledge may support scientific knowledge by allowing people to gain practical experience navigating ecosystems and adjusting to change. For example, India's advancement in science has benefited from the ancient wisdom and knowledge that have been developed in several fields, including management of natural resources, mathematics, metallurgy, surgery, and medicine (Pandey, 2002). Traditional knowledge, local skills, and rural craftsmanship all have a wide range of applications in India. We must take into account both science and verified local knowledge in developing a strong sustainability science because "knowledge cannot be split." (Pandey, 2002). Local knowledge systems can assist with problems like forest management, sustainable water management, biodiversity preservation, and climate change mitigation because they are still commonly employed in India. We must make use of all available knowledge in order to create effective mitigation strategies for the ecological repercussions of climate change (Pandey, 2002). The potential advantages of TEK for resource management are growing in popularity. Governmental and non-governmental organisations are beginning to include TEK in planning, policies, teaching, and research pertaining to climate change throughout the world. The TEK project has been funded by the National Science Foundation so that it may be used in the study of climate change (Traditional Knowledge Holders Formalize a Network for Community to Community Exchange—Institute for the Advanced Study of Sustainability, n.d.). By establishing the Traditional Knowledge Initiative, the Convention on Biodiversity Conservation, the United Nations University (an academic division of the UN), and other affiliated organisations have also recognised the significance of TEK (Traditional Knowledge Holders Formalize a Network for Community to Community Exchange—Institute for the Advanced Study of Sustainability, n.d.). TEK is essential for understanding and promoting its ethical use in international initiatives (Lemi, 2019).

In this context, the merging of formal and traditional sciences is urgently needed. The following factors could be helpful in this respect (Pandey, 2002):

1. The development of numerous approaches allowing locals and formal scientists to study together.
2. In order to apply indigenous practices in forest development and management initiatives, institutional structure in the community and ethical forestry must receive full attention in forest development regulations and forest management procedures.
3. The application of traditional knowledge and practises might be advantageous for developing village micro plans for sustainable, cooperative forest protection, and rural development. Both governmental and conventional community borders should be considered in the planning.

4. Restoration of water management practice techniques which have long supported civilisation but are now in danger.
5. In order to implement adaptive techniques for natural resource management, it is obvious that traditional and formal sciences must be integrated.

TEK has become more widely used in conservation planning and resource evaluation because of its effectiveness, additionality, and community engagement. Information gathering with TEK might be more successful when there is a strong correlation between TEK and scientific data (Finn et al., 2017). Although such systems of knowledge take a long time to establish and require a significant investment from experts in social science, rigorous experimentation and observation approaches may frequently be able to obtain some of this knowledge more quickly and inexpensively than via conventional ecological study (Pandey, 2002).

4 TEK and Resource Management

In recent years, study into traditional ecological knowledge and wisdom has given birth to a new language and point of reference in the management of natural resources (Chettri & Sharma, 2022). The role that TEK plays in decision-making in social-ecological systems that support resilience and sustainability is being highlighted by an increasing number of studies. Academics are becoming increasingly interested in TEK, and development organisations concur that the concept and its use in managing natural resources are essential (Chettri & Sharma, 2022). Due to the widespread decrease in quality and ecological services that affect human well-being, more attention is being paid to indigenous communities' TEK rules and processes for ensuring sustainable natural resource management and use. In recent years, TEK has come to be recognised as an essential beginning point for the development of effective environmental management and preservation programmes (Rai and Mishra, n.d.). TEK was originally mocked as being unscientific, but today it is viewed as being more productive and environmentally responsible, and it is frequently necessary for the development of successful sustainable development initiatives (Rai and Mishra, n.d.). The practise of TEK predates the hunter-gatherer cultures themselves, even if the name didn't start to be used often until the 1980s. In various disciplines, including environmental sciences, studying traditional knowledge is crucial. In Our Common Future (Commission on Environment, n.d.), it is stated:

> The way of life of tribal and indigenous peoples can teach modern cultures a lot about how to manage resources in the complicated forest, mountain, and dry land ecosystems.

Indigenous and tribal populations will need particular consideration whenever the strains of economic growth disrupt their traditional ways of existence. These people have a lot to teach contemporary cultures about resource management in difficult forest, mountain, and dryland settings (Negi et al., 2018). Some people are practically in danger of extinction due to irresponsible development that they

have no control over. They should have a major say in establishing how resource development in their areas will be controlled, and their customary rights should be upheld. These organisations act as repositories for a vast collection of conventional knowledge and wisdom that trace humanity back to its origins in prehistory. Their passing is a loss for contemporary society, which would greatly benefit from their traditional understanding of how to sustainably manage enormously complex natural systems (Negi et al., 2018). The IUCN Programme on Traditional Knowledge for Conservation claims that much of the traditional ecological knowledge is still relevant for managing natural resources today, particularly in places like wetlands. Traditional ecological knowledge (TEK), despite having helped to preserve nature and natural resources for millennia, is disappearing as a consequence of cultural homogeneity and globalization (Kala, 2011). Applying scientific research with local knowledge enhances environmental sustainability as well as equity, prosperity, stability, and the empowerment of locals. Local knowledge is helpful for the gathering of information, strategic planning, creation of flexible learning and acceptance procedures, scenario evaluation, and support mechanisms for implementing policies (Negi et al., 2018).

5 The Indian Himalayan Region's Traditional Ecological Knowledge for Climate Change Adaptation

5.1 Indian Himalayan Region

The Indian Himalayan (IHR) area is home to over 51 million people, many of whom practise hill farming in delicate and diverse settings, including species-dense forests (NMSHE: National Mission For Sustaining The Himalayan Ecosystem, 2023). Numerous perennial rivers in the region that rely on the survival of glaciers for water supply and power generation have tremendous hydropower potential in the region (Dimri et al., 2019). The IHR is home to about 40% of India's indigenous communities and tribes, giving the entire nation a notable socio-cultural and ethnic diversity (Government of India, 2013). The biodiversity of the Himalayas is primarily caused by several biophysical elements, notably IHR.

The extensive biodiversity in the area is a result of the people's conservation and management practices (Negi et al., 2018). Due to the IHR's great ecological and socio-cultural diversity, it has been named one of 34 "biological hotspots." (i.e., an area of the natural world with such biodiversity that is home to a significant number of endangered indigenous species) (Sharma et al., 2022) Traditional knowledge-based businesses have helped local communities in the area generate money (Dimri et al., 2019). Indigenous peoples of IHR are expected to play a significant role in the fight against climate change since they possess crucial knowledge about its consequences. In the IHR, indigenous traditional knowledge and resource-use techniques have been passed down through the years. Local communities preserve biodiversity by adoring nature and caring for sacred landscapes (Negi, 2021). Indigenous peoples of the IHR

have an intimate grasp of and connection to their natural environments. Due to their culture's symbiotic interaction with the environment and their awareness of the clear connection between biodiversity and changing climatic circumstances, a wealth of traditional ecological knowledge has emerged (General/Latest News: Envis Centre, Ministry of Environment & Forest, Govt. of India, 2023).

Natural catastrophes, biodiversity loss, climate change, and food security issues threaten Indian Himalayan ecosystems (General/Latest News: Envis Centre, Ministry of Environment & Forest, Govt. of India, 2023). The Indian Himalaya area is divided into 12 states (IHR). According to a risk analysis conducted by the Department of Science and Technology (DST), Mizoram and Assam are the two states most sensitive to climate change's consequences. Of the eight missions, included in the National Action Plan on Climate Change, the Indian Government formed the NMSHE (National Mission on Sustaining Himalayan Ecosystem).after realising that IHR is an extremely susceptible and fragile ecosystem (General/Latest News: Envis Centre, Ministry of Environment & Forest, Govt. of India, 2023). To create adaptation plans and manage the area's ecosystems, it is crucial to understand how vulnerable the Himalayan region is to climate change, The Indian Institutes for Technology in Guwahati, Mandi, and Bengaluru conducted a collaborative study entitled "Climate Vulnerability Assessment for the Indian Himalayan Region Using a Common Framework". This study outlined the four primary factors that define vulnerability: the socio-economic, demographic, and health conditions of the populace; the susceptibility of agricultural output; living standards dependent on the forest; and data access and infrastructure services (Climate Vulnerability Assessment for the Indian Himalayan Region Using a Common Framework, n.d.). This project also offered a wonderful opportunity to collect and share locally relevant knowledge, for developing innovative responses to climate change's consequences on mountain communities, and for raising awareness of the issues worldwide (The Himalayas and Climate Change WCS-India, 2023).

5.2 The Impact of TEK in Adapting to Climate Change

Indigenous peoples are the first to detect environmental changes since they depend on natural resources and biodiversity. Indigenous peoples have been dealing with regional changes in the climate for millennia (Lemi, 2019). The implication is that conventional ecological knowledge may be used to build protracted datasets obtained via years of trial and error. Indigenous peoples are employing a range of strategies to cope with the loss of biodiversity and adapt to climate change, such as land reclamation, migration, irrigation, water-saving methods, and modifying plant cultivation's schedule, location, and altitude, to mention a few. Thus, using their customs and traditional ecological knowledge, indigenous people have created a variety of techniques to create societal structures that are tailored to deal with the damaging effects of natural disasters (Ingty & Bawa, n.d.). Indigenous peoples' views as well as experiences are essential for scientists to test hypotheses on preventing climate change

and gearing up for it. Additionally, they are crucial for adaptation because they are the ones who experience most of climate change's consequences (Ingty, 2017).

The evident connections between indigenous knowledge as well as climate change adaptation need public attention (Gómez-Baggethun et al., 2013b). Indigenous societies could adapt or assist themselves, as seen in previous parts of this chapter for tribes that have recently adapted both to the effects of climate change and to a variety of pressures that have existed for generations (Gómez-Baggethun et al., 2013a). It has been demonstrated via research on indigenous people's perceptions of changing climatic conditions throughout the world that the primary sources of information for climate sciences are traditional knowledge, local observations, and personal experience (Gómez-Baggethun et al., 2013a). Indigenous people might be a significant asset because of their wealth of ecological knowledge in completing scientific investigations in a location like the IHR where there is a dearth of research on climate change's consequences (Gupta & Gupta, 2008). Women are heavily involved in IHR's management of interrelated subsystems, such as agriculture and management of natural forests, farming, and other aspects of the local subsistence sector (Traditional Knowledge System in Himalayan Region: Key to Sustainable Development—Kalinga Institute of Indo-Pacific Studies, 2023). Recent policy, institutional, and technological developments bring to light the IHR's biophysical and social weaknesses, including the fusion of the local subsistence economy, acculturation, dialect disappearance, lifestyle changes, and youth migration (Gupta & Gupta, 2008). Even though there are currently few studies on how indigenous people's TEK contributes to research on climate change, it is acknowledged for its applicability in environmental and social evaluations as well as its contributions to interpreting ecosystem processes. The TEK should therefore be studied before they are lost to the forces of modernity (Traditional Knowledge System in Himalayan Region: Key to Sustainable Development—Kalinga Institute of Indo-Pacific Studies, 2023).

6 Issues and Challenges of Change in Traditional Ecological Knowledge

In light of current world concerns, TEK has become a valuable tool. Particularly about biodiversity loss and accomplishing sustainable development goals (Traditional Ecological Knowledge, 2023). As part of their tens of thousands-year-old way of life, the people of the Indian Himalayan Region had long lived in peace with nature and created a variety of traditional systems. However, due to causes including the expanding human population, and the fragile alpine environment's low productivity, these old knowledge systems are presently vanishing more quickly due to the rising usage of contemporary and/or irresponsible practices (Traditional Ecological Knowledge, 2023).

The IHR is being developed in a way that will preserve ecosystems at the level of biodiversity, organisms, and genetic variation. The IHR is a rich reservoir of

biodiversity and culture (NMSHE: National Mission For Sustaining The Himalayan Ecosystem, 2023). According to an analysis of TEK in India, it covers a variety of subjects, including sustainable forest management, preservation of biodiversity by use of precious groves, sacred settings, sacred plant species, agricultural, farm, and animal management, as well as the healing effects of Ayurveda (Traditional Knowledge, 2023). However, the growth of economic interests in forests and biodiversity resulted in a lack of respect for indigenous philosophy and practises, particularly the religious strategy employed by the local inhabitants to maintain biodiversity (Sharma et al., 2009). This caused several inconsistencies and issues with the management and conservation of natural resources (Traditional Ecological Knowledge, 2023). The practicality of TEK faces major challenges despite the promise of increased knowledge:

- When TEK and Western Science are compared, one of the main issues is that TEK loses its significance when applied in a Western scientific atmosphere and taken out of its original context.
- The TEK's close linkages to indigenous languages and culture present another challenge. Oral traditions provide a lot of knowledge that is pertinent to Western scientific investigation, but since it is not comprehended, this information is typically ignored or misunderstood.
- The question of whether or not indigenous peoples still own ownership rights on traditional knowledge systems and need to get authorization before using them is up for dispute. This scenario is particularly complicated by the fact that TEK is often transmitted verbally and could not have any objectively validated evidence.
- The TEK which was able to preserve long-term sustainability has been marginalised by the commodification of environmental assets. These organisations frequently play no active role in the current legal and legislative frameworks for TEK conservation.
- The importance of TEK in climate change adaptation is beyond dispute, although some locals and those outside the scientific community are still unaware of its importance.

In India, particularly in the IHR, no particular legislative framework recognises TEK's importance.

7 Conclusion/Strategies and Suggestions for an Effective Repository of TEK

Many indigenous peoples around the world view TEK as a positive and powerful component of their indigenous identity that is distinctive to their culture and location. For them, the application of TEK in environmental assessment as well as maintenance is a rejection of such a long tradition of undervaluing this kind of knowledge, experience, and talent as well as a validation of the accuracy and applicability of their

own. To safeguard the Himalayan ecosystems and the well-being of humanity, these extensive TEK systems must be fully comprehended and adequately documented. For the Indian Himalayan region's sustainable development, formal decision-support systems can benefit from a platform for indigenous knowledge systems. It is important to recognise, accept, and mainstream some of these advantages of TEK practises to protect the sustainability of ecological services and biodiversity in the IHR's fragile mountains. Despite certain obvious limitations, TEK substantially aids in adapting to climate change. However, many people, including indigenous people and researchers, have expressed scepticism about the application of TEK in this circumstance. Major concerns have been made about the identification, preservation, and documenting of TEK in the literature and the now available data, and these worries are valid. Following are a few suggestions to strengthen the TEK**:**

- To integrate TEK systems and referencing technologies into the social settings of the nation, strategic knowledge systems should solicit input from a variety of stakeholders, including representatives of indigenous tribes.
- Respect for indigenous knowledge, voices, and experiences can be seen through digital storytelling. It can convey important messages and aid in the preservation of traditional languages.
- Understanding TEK could serve as a basis for effective co-management methods between Tribes and the government.
- It is essential to scale up TEK to manage resources and decrease climate change's impacts. Empowering neighbourhood groups to use TEK to prepare for climate change.
- To recognise the intellectual property of tribes, policy frameworks are necessary. The TEK and IK should be used to guide and illuminate strategic decisions to fight against natural disasters.
- Tribal-based programmes that are rooted in culture and geography must include TEK.

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