



Scoping the Need of Mainstreaming Indigenous Knowledge for Sustainable Use of Bioresources in the Indian Himalayan Region

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Abstract

Globally, Indigenous Knowledge Systems (IKSs), which have evolved through rigorously tested methods and practices, are a testimony of human intelligence and endurance. The diversity of goods such as food, beverages, herbs, etc., and its associated systems, which form an integral part of modern cuisine and healthcare systems, are deeply rooted in IKS and immensely contributing to overall well-being of mankind. The present study is an attempt to document and understand the contribution of indigenous and local knowledge to biodiversity conservation and management. Appreciation to the value of traditional and indigenous knowledge is globally recognized for their principles of coexistence and sustainable use practices. Past studies indicate a strong relationship between indigenous knowledge and sustainable development goals. This knowledge is valuable not only to dependent communities, but also to the modern world for ensuring food security and human well-being. The documentation of such valuable knowledge is therefore fundamentally essential for mainstreaming and strengthening the discourses on sustainable ecosystem management, and to address the preponderance of poverty among indigenous communities. Amid the changing scenario of consumption and the trend of revisiting nature-based solutions, the IKS hold a tremendous scope of engaging the community people in sustainable harvest and utilization of natural resources.

Keywords Indigenous and local knowledge · Indigenous community · Medicinal plants · Wild edible plants · Biodiversity management · Sustainable Development Goals (SDGs)

Introduction

Conservation of biodiversity faces multipronged challenges, which are increasing with climate change and growing list of threatened species. Environmental perturbations and anthropogenic disturbances call for increased attention to the conservation and sustainable use of bioresources. The Sustainable Development Goals (SDGs) of the UN Agenda 2030 and the agreement on the Aichi Biodiversity Targets (ABT) by the Parties of the Convention on Biological Diversity (CBD) are the encouraging global responses to promote biodiversity conservation (Navarro et al. 2017). Besides the governmental initiatives, there is a large group of people particularly residing in rural and remote areas, i.e.,

the indigenous and traditional communities, who have been managing and conserving the biodiversity and natural resources for centuries. It is reported that almost 20% of our planet is home to some 370 million indigenous people, described as ‘first’ or ‘original’ people, having a historic and cultural bond with their biodiversity (UNESCO 2016; Karki et al. 2017). Their diverse knowledge is deeply rooted within the environment and cultural cohesion, ensuring sustainable management of natural resources, and environment protection in the changing world (Magni 2017). CBD defines traditional knowledge as ‘the knowledge, innovations, and practices of indigenous and local communities around the world’; this knowledge is developed from experience gained over the centuries by trial and error (Gadgil et al. 1993). Furthermore, this knowledge symbolizes mutual relationships between them and their environments, and transferred through generations by cultural transmission (Berkes et al. 2000; Upadhaya et al. 2007). Traditional and indigenous knowledge systems related to biodiversity conservation are fundamental to human life, especially in rural and remote areas across the globe (Langton and Rhea 2005). Traditional knowledge systems

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are thus fundamental to the livelihoods of millions of people. Indigenous people are involved in the management of diverse ecosystem, natural resources, and conservation of biodiversity; a number of success stories on resource management have been reported globally (Langton et al. 2014; Negi and Maikhuri 2013). This knowledge has contributed to sustainable utilization and conservation of biodiversity, including the rare species (Colding et al. 2003; Bisht and Ghildiyal 2007; Gandile et al. 2017; Berkes et al. 2000; Irakiza et al. 2016; Upreti and Tewari 2020). The indigenous knowledge systems also play an important role in socioeconomic development of developing countries due to their higher dependency on bioresources and biodiversity (Langton et al. 2009). For example, documentation of traditional biodiversity-related knowledge on the status, uses, and management of biological resources constitutes the People's Biodiversity Registers (PBRs) in India (Langton and Rhea 2005). The documentation is therefore vital for appreciation and protection of this valuable knowledge.

Among the world's mountains, Asia has the largest, highest, and most populated mountain systems—the Himalaya. This region forms a diverse geographic and ecological entity endowed with overwhelming richness, representativeness, and uniqueness of biodiversity (Rawal et al. 2013). Undoubtedly, the Himalayan Biodiversity provides a resource base and ecosystem services that sustain life of millions of people in uplands and billions in down streams (Negi et al. 2019). Within the Himalaya, Indian Himalayan Region (IHR) contributes to a large proportion of the Himalayan biodiversity, and is attributed to the wide variety of bio-physical conditions. IHR comprises two biogeographical zones, i.e., Trans-Himalaya-Tibetan Plateau, and Himalaya. These two zones include seven biogeographical provinces (Rodgers et al. 2002) i.e., Ladakh Mountains (Jammu and Kashmir), Tibetan Plateau (Jammu and Kashmir, Himachal Pradesh, Uttarakhand), Sikkim (Northern Sikkim), North-West (Jammu and Kashmir and Himachal Pradesh), West (Uttarakhand), Central (Sikkim-Darjeeling Himalaya), and East (Arunachal Pradesh including north-east region). The rich biodiversity in the region is the outcome of conservation and management practices of the local inhabitants. IHR is well recognized for prevalence of Indigenous Knowledge Practices (IKP); these practices have helped them to ensure food security, and play an important role in biodiversity conservation and management (Farooque et al. 2004; Negi et al. 2010; Laishram et al. 2020).

In the IHR, indigenous knowledge and resource use practice has been passed on through generations. Various cultural and indigenous groups in the region have developed these unique practices, which are mostly a part of their culture. Moreover, biodiversity management and conservation are aggravated by beliefs and culture of these

communities; culture is strengthened by their relationship with biodiversity and environment (Negi 2010; Negi et al. 2017; Joa et al. 2018). Nature worship and management through promoting sacred landscape, forests, and groves are excellent examples of in-situ biodiversity conservation by local communities (Sharma and Devi 2014; Singh et al. 2014; Negi et al. 2017; Singh et al. 2019). This is an effective approach for sustainable management and utilization of biodiversity in climate change scenarios. Therefore, the present study is an attempt to document the indigenous knowledge of natural resource-based communities in the IHR for mainstreaming and strengthening the discourses on sustainable ecosystem management.

Materials and Methods

The present study is the synthesis of secondary information extracted from available literature related to indigenous knowledge and its arrays. Various research articles, reports, books, book chapters, and proceedings were explored using Google Scholar, ResearchGate, PubMed, Science Direct, and Springer Link. Various Keywords such as 'SDGs', 'traditional knowledge', 'indigenous knowledge', 'traditional knowledge system', 'indigenous knowledge system', 'indigenous and local knowledge' etc. were used for searching the literature. The literature pertaining to Indian Himalayan Region was further used for the synthesis and analysis. A total of 66 studies on the topic with respect to the Indian Himalayan were finally further reviewed for the synthesis of this document.

Results and Discussion

Role of IKS in Sustainable Forest Management

Management of biodiversity by indigenous communities is an age-old practice across the globe particularly in the developing countries. The knowledge of phyto-resource use significantly add to conservation of specific species, including the threatened species (Berkes 2007; Negi et al. 2018). Traditional knowledge system and practices are more common in the IHR due to their high dependency on the natural resources. The indigenous communities of the region have developed a symbiotic relationship with nature with a long history of spiritual and cultural heritage (Jaryan et al. 2010; Kala and Sharma 2010; Vidyarthi et al. 2013). Inhabitants of the region have lived in harmony with nature and thereby are protecting and managing the forests and forest resources, ensuring the flow of ecosystem services through traditional ecological knowledge. Indigenous practices of forest management and biodiversity

Table 1 Some important sacred natural sites in IHR and their characteristics

S. No.	Sacred site	State/UT	Area (hectare)	Dominant plant species
1	Shankaracharya	Jammu & Kashmir	138	<i>Platanusorientalis</i> , <i>Pinus helepansis</i> , <i>Ephedra gerardiana</i>
2	BakhuDevban	Himachal Pradesh	6.0	<i>Cedrus deodara</i> , <i>Quercus leucotrichophora</i>
3	Bhujani	Uttarakhand	12	<i>Betula utilis</i> , <i>Juniperus indica</i> , <i>Rhododendron campanulatum</i>
4	Sangfa Fu	Uttarakhand	20	<i>Juniperus communis</i> , <i>Rhododendron anthopogon</i>
5	Thal Kedar	Uttarakhand	15	<i>Quercus leucotrichophora</i> , <i>Q. floribunda</i> , <i>Myrica esculenta</i>
6	EncheyMonastery	Sikkim	1.61	<i>Cryptomeria japonica</i> , <i>Cupressus torulosa</i> , <i>Toona spp.</i>
7	Langsomepi	Assam	65	<i>Areca catechu</i> , <i>Bauhinia scandens</i> , <i>Phyllanthus emblica</i>
8	HeingangMarjing	Manipur	7.08	<i>Pinus kesiya</i> , <i>Albizia lucida</i> , <i>Albizia stipulate</i> , <i>Eugenia praecox</i>
9	Khloo Paiu Ram Pyrthai	Meghalaya	9.0	<i>Betula alnoides</i> , <i>Fraxinus Floribunda</i> , <i>Elaeocarpusfloribundus</i>
10	Akashi Ganga	Arunachal Pradesh	8.0	<i>Altingia excelsa</i> , <i>Artocarpus lakoocha</i> , <i>Artocarpus heterophyllus</i> , <i>Ficus palmata</i> , <i>Pterosepermum acerifolium</i>

Sources: Jamir and Pandey 2003; Khumbongmayum et al. 2005; Negi and Nautiyal 2005; Vasan and Kumar 2006; Anonymous 2010; Agoramoorthy and Kumar 2011; Gokhale and Pala 2011; Negi et al. 2012; Murtem and Chaudhry 2014

conservation involve delineation of sacred forests, sacred groves, and devoted forest patches. This is one of the important practices of conserving forest patches; dedicating forest or forest patch to the local deity automatically conserves the biodiversity in the region (Gadgil and Vartak 1976; Negi and Maikhuri 2013). These are mostly associated with temples and are also culturally important. These sites serve as a refuge to diverse group of floral and faunal biodiversity elements, and hence are important means for conservation and management.

Sacred groves and forests are rich with many rare, endemic, and threatened plant species along with important fauna in the Indian Himalayan Region (Negi and Nautiyal 2005; Rai 2007; Singh et al. 2010; Anthwal et al. 2010; O'Neill et al. 2017; Upadhyay et al. 2019). In IHR more than 5800 sacred groves have been reported, with Himachal Pradesh alone having 5000 sacred groves (Sharma and Kumar 2020; CPREEC ENVIS 2020). In a study from Uttarakhand, Negi et al. (2018) reported unique threatened and endemic species of medicinal plants (MPs) in the sacred groves/forests. One of the best examples of sacred forest is the Tarkeshwar Sacred forest in Uttarakhand, representing 343 plant species of which at least 50 are medicinal plant species (Bisht and Ghildiyal 2007). Hariyali Devi SG is one of the oldest sacred grove in Uttarakhand, well known for rich floral and faunal diversity; around 80 species of plants in 44 families reported having high economic values (Singh et al. 2017). This grove also represent 9 mammals; *Capri-cornis sumatraensis*, *Cervus unicolor*, and *Felis bengalensis* are some common mammalian species. Tungnath sacred grove is known to harbor threatened MPs like *Picrorhiza kurroa* and *Nardostachys jatamansi*. Some endangered animals like musk deer, and Himalayan black bear are also reported from the grove. In Eastern and Northeast region of the IHR, many sacred groves are well known for contributing toward biodiversity conservation

attributed to the nature worship tradition of the communities (Khumbongmayum et al. 2005). The sacred groves in five states of north-east India i.e., Arunachal Pradesh, Assam, Manipur, Meghalaya, and Sikkim, covers >40,000 hectares of natural forest area (Upadhyay et al. 2019). In Jaintia hills of Meghalaya, there are many sacred groves, however, three sacred groves namely Khloo Paiu Ram Pyrthai, Urkhla, and Khloo Langdoh are of great significance as the species recorded from these groves are 12% of the flora of the state and 26% of the flora of Jaintia hills (Jamir and Pandey 2003). In Sikkim, traditional and community knowledge strengthens conservation policies and has paved the way for its adaptive capacity (O'Neill et al. 2017), thus ensuring sustainable forest and biodiversity management. The details of some of the important sacred forest/groves of IHR are presented in Table 1.

Resource use in terms of lopping, felling of trees is strictly prohibited in sacred forests; dead wood or twigs may however be harvested only for the purposes of religious rituals during specific occasions (Negi et al. 2018). Religious sanction of the resources for use purpose from the forest granted in times or in need of people. Thus, sustainable management of forest in Uttarakhand by sacred forests/groves is an important means of conservation and sustainable use of biological diversity; also addressing fundamental objectives of the CBD (Convention on Biological Diversity 2021). Another forest management practice that shows the significant role of IKS, is community forest. Community Forests (Van Panchayat) are the important means of poverty reduction, biodiversity conservation, and ecological sustainability (Agrawal 2007; Newton et al. 2015; Germain et al. 2018; Pandey et al. 2017). Community-based forest management is widely popular in the developing countries indicated by the fact that 31% of the total forests are being managed by the community themselves in several countries (Wangchuk

et al. 2018; Maraseni et al. 2019; Gatiso 2019). Most of the earlier studies on community forests at global level (Hayes and Persha 2010; Persha et al. 2011; Porter-Bolland et al. 2012) and regional level (Somanathan 1991; Agarwal 2007; Somanathan et al. 2009; Negi et al. 2012; Thapliyal 2013), suggest that community forestry performs better in management of forests and also maintain sustainable supply of goods to the dependent inhabitant. By formulating a set of rules, indigenous community ensures that the forest under their management fulfill their needs and the community in return helps toward conservation of the forest. Studies have reported that over half a billion people depend on the community-managed forests (Agrawal 2007; Niraula and Pokharel 2016). Traditional practice of managing forest resources in the IHR are most common and vital mean of sustainable resource utilization and conservation. Among other, Uttarakhand is often cited for good management of forests through institutions like Van Panchayat (Agrawal 2007; Negi et al. 2012). The VPs in Uttarakhand are one of the oldest examples of co-management of forest resources by the community themselves. State forest department is managing most of the forests in the state, however, 15% of the forest is under the control of village community, commonly known as Van Panchayat (VP) or Forest Council (UFS 2018). The example of few well-managed Van Panchayat in Uttarakhand is presented in Table 2.

Role of IKS in Non-timber Forest Products Management

Global and national markets for Non-timber Forest Products (NTFPs) have been growing rapidly, and significant economic gains are being realized. The natural resource-based communities have strong relationship with forests in the IHR, as forests play an important role in the economy and ecology of the region (Negi et al. 2018). In recent decades, particular attention has been paid to mainstream local biodiversity for food and nutrition security by several UNGA resolutions including World Health Assembly (WHO 2015). It is reported that forest products contribute to the livelihood of millions of people across the globe (Mamo et al. 2007). Reports indicate that wild edibles are used as sources of food in many developing countries, and provide an adequate level of nutrition to human beings (Maikhuri et al. 2004; Murphy et al. 2005). The wide use of non-timber forest products (NTFPs) particularly in the rural/remote areas totally depends on the indigenous knowledge system. Among other, conservation and sustainable use of medicinal plants (MPs) and wild edibles is receiving increased attention due to their significant role in global healthcare system and nutritional security (Shahidullah and Haque 2015, Chen et al. 2016). The collection of MPs and wild edibles also form a critical source of income in many

Table 2 Some of well-managed community forests in Pithoragarh district of Uttarakhand

S. No.	Van Panchayat	Block	Year of establishment	Area (hectare)	Dominant plant species
1	Hat-Tharp	Didihat	1975	121	<i>Quercus glauca</i> , <i>Myrica esculenta</i> , <i>Q. leucotrichophora</i> , <i>Randia tetrasperma</i> , <i>Pyracantha crenulata</i> , <i>Origanum vulgare</i> , <i>Bidens pilosa</i>
2	Jwal	Gangolihat	1948	16.05	<i>Quercus leucotrichophora</i> , <i>Pinus roxburghii</i> , <i>Lantana camara</i> , <i>Rhus parviflora</i> , <i>Ageratina adenophora</i> , <i>Reinwardtia indica</i>
3	Topradhar	Didihat	2004	37.94	<i>Quercus leucotrichophora</i> , <i>Q. glauca</i> , <i>Pyracantha crenulata</i> , <i>Rubus ellipticus</i> , <i>Leucas lanata</i> , <i>Thymus linearis</i>
4	Balatadi	Gangolihat	1933	44.56	<i>Pinus roxburghii</i> , <i>Myrica esculenta</i> , <i>Inula cappa</i> , <i>Rubus ellipticus</i> , <i>Reinwardtia indica</i> , <i>Ageratina adenophora</i>
5	Papri	Munsiyari	2003	125.2	<i>Alnus nepalensis</i> , <i>Cupressus torulosa</i> , <i>Pyracantha crenulata</i> , <i>Principia utilis</i> , <i>Origanum vulgare</i> , <i>Anaphalis contorta</i>
6	Sarmauli	Munsiyari	1955	112	<i>Quercus floribunda</i> , <i>Alnus nepalensis</i> , <i>Berberis chitrea</i> , <i>Pyracantha crenulata</i> , <i>Araesema tortuosum</i> , <i>Anaphalis contorta</i>
7	Sirdang	Dharchula	1962	112.4	<i>Pinus wallichiana</i> , <i>Betula alnoides</i> , <i>Taxus wallichiana</i> , <i>Berberis jeshkiana</i> , <i>Viola pilosa</i> , <i>Canum carvi</i>
8	Ghorpata	Munsiyari	1997	15.06	<i>Quercus floribunda</i> , <i>Aesculus indica</i> , <i>Ilex diplyrena</i> , <i>Berberis chitrea</i> , <i>Berberis indica</i> , <i>Viola biflora</i>
9	Sosa	Dharchula	1963	319	<i>Abies spectabilis</i> , <i>Rhododendron arboreum</i> , <i>Berberis jeshkiana</i> , <i>Rosa macrophylla</i> , <i>Anaphalis contorta</i> , <i>Roscea procera</i>
10	Rawal gaon	Gangolihat	2000	4.55	<i>Quercus glauca</i> , <i>Q. leucotrichophora</i> , <i>Rubus ellipticus</i> , <i>Ageratina adenophora</i> , <i>Reinwardtia indica</i>

rural and remote areas in the Himalayan region (Maikhuri et al. 2007; Negi et al. 2011; Singh et al. 2021). The indigenous communities have inherited knowledge related to the use of MPs and wild edibles in traditional system of herbal medicine through generations; this has played a key role in the healthcare system and formulation of new drugs across the globe (Nautiyal et al. 2008; Bhatia et al. 2015; Negi et al. 2018).

Wild fruits contribute to diet diversity and flavour, thereby, forming an essential part of nutritionally rich diet of rural people, and provide essential micronutrients (Negi et al. 2011; Bhatt et al. 2017; Aryal et al. 2018; Ray et al. 2020). Further, wild edibles enrich dietary quality of food, and are frequently taken as supplementary nutrition by indigenous communities in the IHR. The wild edibles are not only known for their nutritional value but also for their preventive properties against various diseases (Maikhuri et al. 1994, 2004, 2018; Dhyanani et al. 2011; Rawat et al. 2011; Bhatt et al. 2017). The nutritional strength along with medicinal and therapeutically value highlighted the nutraceutical potential of wild resource in meeting the SDGs. Consumption of fruits rich in minerals and nutrients, have been linked with reduced risk of chronic diseases (Bhatt et al. 2013). A number of wild edibles i.e., *Hippophae salicifolia* (Dhyanani et al. 2011), *Rhododendron arboreum*, *Embelica officinalis* (Maikhuri et al. 2004; Negi et al. 2011), *Myrica esculenta* (Bhatt et al. 2000), *Spondias axillaris* (Sundriyal and Sundriyal 2003), *Parkia speciosa*, *Amorphophallus bulbifer*, and *Diplazium esculentum* (Deb et al. 2013) have begun to draw attention for being the income-generating avenue; thereby sustainably harvested and managed by the indigenous communities in the IHR. Indigenous communities in many IHR states are harvesting wild edibles for long, with prevailing sense of maintaining ecological integrity. For example, *Hippophae rhamnoides* in the union territory of Ladakh is sustainably harvested for their culinary and medicinal uses (Stobdan et al. 2017).

Herbal system of medicines is rooted in the indigenous knowledge systems across the globe. Even today with so much of progress in drug industries, the fact remains that 70–95% population in developing countries still depends on MPs for their primary healthcare (Rawal et al. 2021). In fact, this knowledge made an outstanding contribution to the origin and evolution of many traditional herbal therapies and modern drug formulations (Dhar et al. 2000; Kala 2005; Bhatt et al. 2013). With over 50,000 herbal formulations in the codified medical tradition are known to rural communities in India, and 671,124 registered medical practitioners practicing traditional systems of medicine, and 9000 registered and licensed manufacturing units, India occupies a unique position in traditional system of medicine in the world (Goraya and Ved 2017; Sarkar et al. 2020). MPs in the IHR are reported to contribute significantly toward

affordable healthcare in the rural and remote areas (Goraya and Ved 2017; Negi et al. 2018; Singh et al. 2021). The MPs are also known for making various life-saving drugs and provide livelihood options. It is interesting that inspire the majority of old people from the region less educated, but they possess deep understanding and knowledge of traditional healthcare. Sustainable collection practices by indigenous people are significant in conservation of resources and to fulfill their daily need of resources. Rotational harvesting practice is adopted by rural people for collection of MPs; this is important practice for protecting populations of plants in the wild. These practices ensure sustainable supply of MPs and provide incremental benefits to the villagers in and around the forests. Indigenous communities conserve species that are likely to be at most risk from destructive harvesting, to ensure their viable populations in their habitats. MP sector across the globe has received high momentum in view of its potential for the source of raw material of modern therapeutics and precursor molecules for synthesis and preparation of new drugs (Shahidullah and Emdad 2010). The global market for plant-derived drugs was valued US\$1.2 billion in 1990s, US\$25.6 billion in 2015 (Roosta et al. 2017), US\$27.93 billion in 2019 and is projected to reach US\$35.81 billion by 2027 (Anonymous 2021). With increased global interest in nature-based solutions (NBS) people are looking toward MPs as potential immunity-boosting elements. Amid COVID-19 pandemic situation, the attention on herbal products as immunity booster has grown considerably (Rawal et al. 2021). Understanding market-driven economy, indigenous communities are now cultivating MPs to meet the raw material demand; this is automatically conserving the wild resources. For example, *Picrorhiza kurrooa*, *Sassurea costus*, *Valeriana jatamansi*, *Innula racemosa*, *Allium stracheyi*, *Arnebia benthamii*, *Bergenia stracheyi*, *Rosmarinus officinalis*, *Asparagus racemosus*, *Cinnamomum tamala*, *Aconitum heterophyllum*, *Angelica glauca*, and *Swertia chirata* are important MPs that are being cultivated in different parts of IHR (Kuniyal et al. 2005; Samant et al. 2007; Maikhuri et al. 2017; Negi et al. 2010, 2018), thus creating enormous opportunity for economic gains through nutraceutical and pharmaceutical sectors. Hence, protection of the genetic pool is urgently required for long-run sustainability and making it available for future generations.

Role of IKS in Conserving Traditional Agrobiodiversity

Traditional farming systems are the original method of farming practiced by traditional farmers from generation to generation. These practices develop a balance between meeting our present needs and the needs of future generations. Indigenous knowledge practices of agriculture and

seed conservation thus are important for agrobiodiversity in the region (Maikhuri et al. 1997, 2001). Indigenous biodiversity-related knowledge is of great significance to food security in the region; reflected by a huge diversity of crops/landraces in diverse farming systems across IHR (Negi and Maikhuri 2013). The farmers ensure adequate supply of organic inputs to their fields from the surrounding forests. This system of nature-based farming has evolved and flourished over millennia following trial and error approach. The traditional methods of maintaining seed stock and cultivars have been critical for sustenance of indigenous people in the region and play an important role in *in situ* conservation. For example, farmers of Central Himalaya grow about 170 varieties of kidney beans, 100 varieties of paddy, 8 varieties of wheat, and more than 12 varieties of pulses each year in the traditional mixed farming system (Rao et al. 2005; Saxena et al. 2005). Uttarakhand in west Himalaya harbors over 40 different crop species and hundreds of their local cultivars, grown and conserve through a variety of crop composition and crop rotations along wide altitudinal transect (Semwal and Maikhuri 2015). Agrobiodiversity maintained by the indigenous knowledge system plays a significant role in (i) increasing productivity per unit area, (ii) improving soil fertility by incorporating legumes, (iii) minimizing crop loss to insect pest attacks, (iv) increasing productivity per unit area, (v) providing diversity to food, (vi) conserving soil erosion, and (vii) insurance against absolute crop failure (Semwal and Maikhuri 2015).

The cropping patterns in the western Himalaya are built around two major cropping seasons viz. *Kharif* (April–October) and *Rabi* (October–April). Mixed cropping (commonly known as *Baranaja*) of millet and pseudo-millet with grain legumes and some vegetables in Uttarakhand is a common and unique practice of *in situ* seed conservation, maximizing yield per unit area (Maikhuri et al. 2001; Nautiyal et al. 2008; Negi et al. 2012). The advantage of mixed cropping is that it ensures yield even if one of the crops fails due to any reason (Zardhari 2000; Maikhuri et al. 1997, 2001; Nautiyal et al. 2008; Negi and Maikhuri 2013). Furthermore, crop rotation and mixed farming is an important feature to maintain soil fertility in the traditional agroecosystem (Sen 1997; Maikhuri et al. 2001). In the North-East Himalaya, the rural forestry management practices and the agriculture-forestry inter-phase linkages of Apatani peoples of Arunachal Pradesh are examples of their nature-culture interconnections (Rai 2007). The traditional wet rice cultivation of the Apatani peoples is an example of sustainable agriculture as it ensures and maintains sustainable productivity (Rai 2005). The agro-ecosystems in North-East Himalaya are sustainable, self-sufficient, and efficient due to strong organizations and sharing of ecological knowledge among farmers from generation to

generation. Indigenous classification of agricultural land use into seven different categories for efficient land management is an example of innovative ecological design by the farmer groups in North-East Himalaya (Dollo et al. 2009). Among others, terrace system of cultivation and Bamboo drip irrigation system in Meghalaya, and ZABO system and Alder based agriculture in Nagaland are important traditional systems of agriculture. Thus, indigenous people are not only the custodians but also managers of crop diversity; the key elements of sustainable agricultural system in the IHR.

Biodiversity Act in Ensuring Biodiversity Management and ABS for Local Peoples

The foundation of international environmental law was laid with the United Nations Stockholm Conference on the Human Environment in 1972, wherein the United Nations Environment Programme (UNEP) was established (Jeffery 2008). The Earth Summit of Rio de Janeiro, also known as the United Nations Conference on Environment and Development (UNCED), resulted in the Convention on Biodiversity, a multilateral treaty, which entered into force on December 1993 (Jeffery 2008). India enacted its own national legislation to fulfill its commitment agreed under the CBD. The Biological Diversity Act, 2002 aimed at the conservation of biodiversity in the country, sustainable utilization of the components of biodiversity, and equitable sharing of benefits arising out of the biological resources and the associated traditional knowledge. Regulation of access to the nation's biological resources and traditional knowledge through the Biological Diversity Act, 2002 can prevent misuse and appropriation of these resources and knowledge through patents on intellectual property rights (IPR). The Biodiversity Act in India has established a three-tier structure for implementation. The National Biodiversity Authority (NBA) is responsible for all matters at the national level, and the State Biodiversity Board (SBBs) is responsible at the state level through the formation of Biodiversity Management Committees (BMCs). The NBA provides technical assistance and guidance to the SBBs and BMCs for sustainable use of its biodiversity, fair and equitable sharing of benefits arising out of their utilization. BMC regularly assists the SBBs and the NBA in matters of access and benefit-sharing related to the local biological resources and traditional knowledge through preparing People's Biodiversity Registers (PBRs). The NBA and SBBs consult BMCs while granting approval for access to biological resources or associated knowledge sought by the researchers or companies. In India, preparation of PBRs for the villages has been undertaken in a few states, i.e., Kerala and Uttarakhand earlier, but as per the recent update (April 2021) on website of NBA, 248,156 PBRs have been

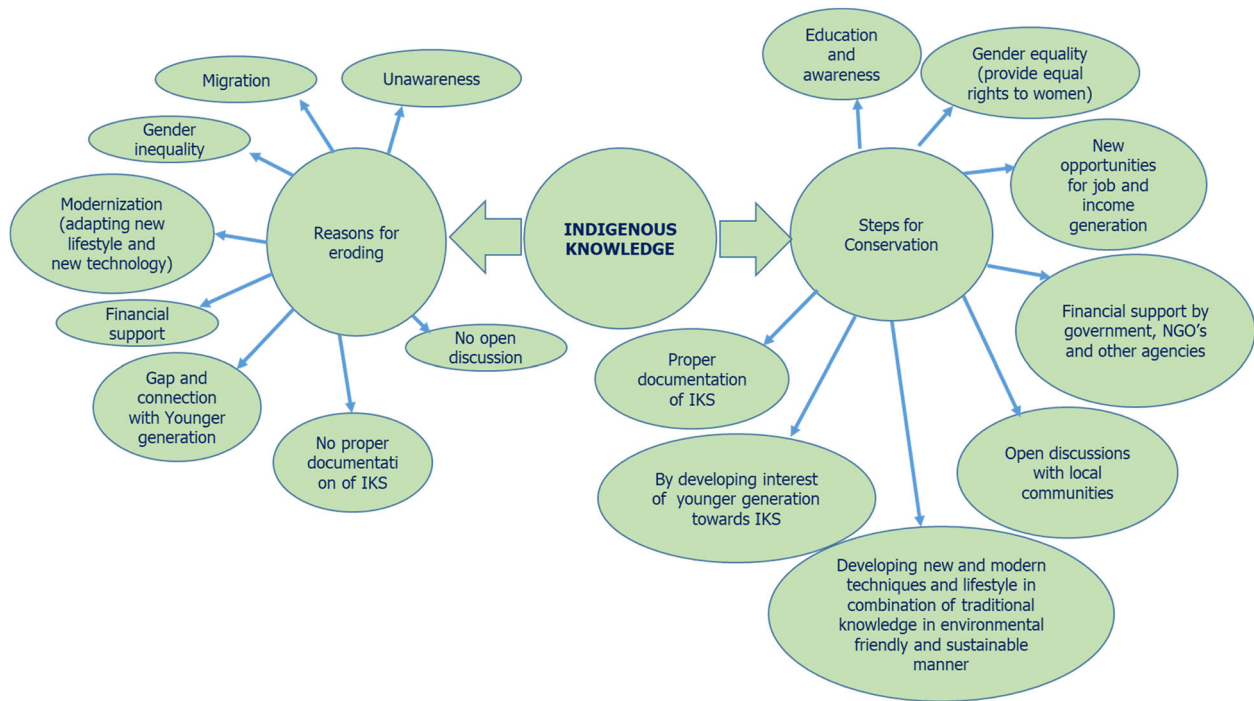


Fig. 1 Steps toward conservation of indigenous knowledge

prepared in all the 28 states and 3 union territories (i.e., Andaman & Nicobar islands, Jammu & Kashmir, and Lakshadweep). In particular, section 36(iv) of the Indian Biodiversity Act 2002 provides for the protection of traditional knowledge through knowledge/biodiversity registers. Sections 19 and 21 of the Biodiversity Act require prior approval from NBA to access the resources, which ensure equitable sharing of benefits. Section 6 provides intellectual property rights on research-based needs to obtain prior approval from the NBA.

Role of IKS in Gender Inclusiveness

In indigenous communities, women and elders play a special role (Ramphel 2004); they are not only the main caregivers, but also the custodians of traditional knowledge, culture, and biological diversity (Negi and Rawat 2010). Women in mountain are naturally more familiar and concerned for biodiversity use and its conservation because of their close association and connection with the surroundings. Women in the Himalayan region work harder and for longer hours than men, and have a vital role in ecosystem management (Negi and Rawat 2010). They hold extensive traditional knowledge related to forest management and agricultural practices (Howard 2003; Chambers and Momen 2007; Abdelali-Martini et al. 2008); women and elders are considered as primary holders and communicators of traditional knowledge (Magni 2017). Women in the IHR

always play a significant role in managing and operating most of the household and agricultural activities (Maikhuri et al. 2011). However, the gender dynamics and their roles in biodiversity conservation are complicated and debatable. For example, in Uttarakhand, there are four reserved seats in the forest council (van panchayat) out of the nine committee members. However, we did not find any female members in most of these committees during field visits in Pithoragarh district. Few studies (Schmink and Gómez-García 2015; Germain et al. 2018) reported male always underestimate the knowledge of women. Our field-based studies also indicated that women are not able to contribute much in decision-making (Thakur et al. 2020). In developing countries like India and Nepal, participation of women is mostly passive (Chhetri et al. 2013; Thapliyal 2013). Pant and Pandey (2007) reported that women were indulged in most of the household activities and community work, however, they are less appreciated in any committees in the villages and any type of decision-making process. The CBD clearly mentions the role of women for sustainable use and conservation of biodiversity, but the role of women in policy-making is still underestimated. Still there is limitation on evidence-based and empirical studies on gender dimensions. There is a need to highlight the role and contribution of women in biodiversity conservation and recognize their participation at all levels of policy-making and decisions (Howard 2003; Oakley and Momen 2007). Many studies reported that 80–90% of the seed

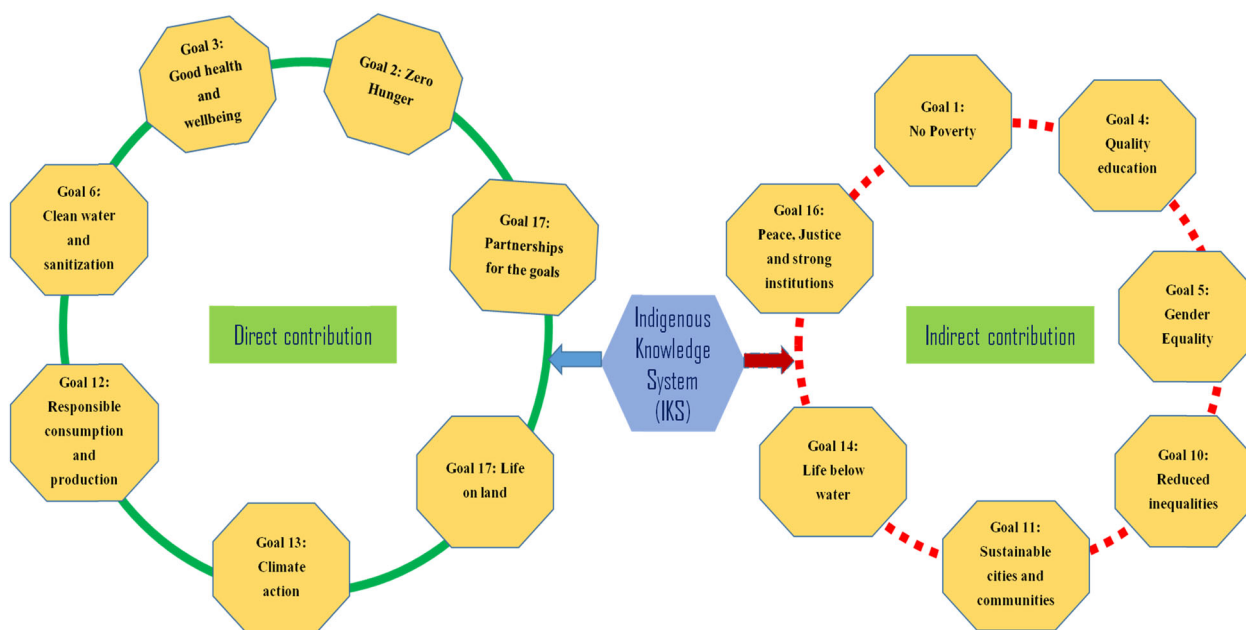


Fig. 2 Contribution of IKS toward achieving Sustainable Development Goals (SDGs)

requirements were met through indigenous seed management and exchange practices, in which women plays the crucial role (Aumeeruddy-Thomas and Shengji 2003). Therefore, gender inclusiveness, especially inclusion of women in resource management and conservation, needs to be ensured (Fig. 1).

Contribution of IKS toward Global Obligations (SDG's)

The global obligations of sustainable development (The 2030 agenda for sustainable development), as adopted by all United Nations Member States, is envisaged to provide the road map for peace and prosperity of people and the planet in the present as well as in the future. The focus of the agenda is to achieve the 17 goals of sustainable development, i.e., SDGs, by both, developed and developing countries, in concurrence. Toward achieving these sustainability goals, the role of Indigenous people becomes putative. Indigenous people constitutes <5% of the total world's population, and manages 28% of the world's land surface, which makes them the actual guardians of 80% of the known global biodiversity (Jerez 2021). Indigenous people across the globe have a wide range of knowledge systems for natural resource management varying with geographical and climate regime. This knowledge is complex, complete, dynamic, and practical having scientific validation (Battiste 2005; Bates et al. 2009; Sillitoe 1998). The traditional methods of resource management applied by the indigenous people have often proven their resilience and sustainability in the face of environmental changes. These traditional

methods and knowledge systems ensure the sustainability of the resources, as these resources are vital for subsistence of the indigenous people. The indigenous knowledge systems are being recognized to embrace most of the dimensions of SDGs toward achieving the goals. The indigenous knowledge on MPs plays a crucial role in ensuring healthy living and well-being. This is evident from the current pandemic of COVID-19, wherein the role of MPs in treating the infectious viral disease is realized and recognized (Vandebroek et al. 2021). Similarly, IKS contributes toward achieving SDGs like Quality education (through promoting lifelong learning opportunities), No poverty (providing livelihood options), Zero hunger (ensuring food security through sustainable agricultural practices), clean water, and sanitation (through spring management), and many more (Fig. 2). All these contributions of IKS thus ensure the sole purpose of the 2030 agenda for achieving sustainable development.

Conclusion

The current method and pace of development have contributed irreversible and irreparable harm to natural resources and diminished capacities of ecosystems to emanate goods and services. Further, the contemporary use practices, often exploitive in nature have been emerging as a new way of living and transcending across various cultural ethnic boundaries. The efforts of mainstreaming people without their knowledge have further speed up the process of homogenization, thus leaving our systems more

vulnerable to further exploitation and degradation. Indigenous knowledge, which has evolved in consonance with natural surroundings, climatic perturbations, and is often based on the principle of coexistence and communitarianism is rather overlooked and considered obsolete in conservation planning and management. The skills and techniques of indigenous people provide valuable information to the global community and a useful model for biodiversity policies. Research has demonstrated that participatory approaches are key to ensure the right and balanced representation of different knowledge systems, particularly of traditional and scientific knowledge. The success of IKS when economies were closed and people were interdependent needs to be duly appreciated by affecting the mainstreaming of their knowledge as well as exploring its possibilities of upscaling.

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Compliance with Ethical Standards

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