Changing Outlook on Harnessing Biodiversity Values – A Special Focus on Indian Himalaya

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Received 07 February 2021; Accepted 27 February 2021;
Publication 31 May 2021

Abstract

The Himalaya, as provider of goods and range of ecosystem services, is vital for sustaining life of millions of people in uplands and billions in lowlands. Indian National Action Plan on Climate Change has recognized the region vital for ecological security of the country. However, growing demand for bio-resources, combined with inadequate appreciation for values of goods and services provided by Himalayan biodiversity, has led to the unsustainable use of these resources, leading to environmental degradation in the region. The paper also looks into the scenario as to how recent pandemic of COVID 19 has brought increased focus of people on bio-resources of the region. More importantly it has suggested conservation and sustainable utilization of biodiversity to ensure for sustaining the continuous flow of ecosystem services and goods. Biodiversity in the region provides several opportunities, however, under changing scenario, we need to think afresh and differently on possibilities of finding better and optimal livelihood options, and the issues of conservation in the region. In this context, larger focus on conservation education has been stressed as a way forward. This paper attempts to build a case for the biodiversity in Indian Himalayan Region through a SWOT

Journal of Graphic Era University, Vol. 9_1, 55–82.
doi: 10.13052/jgeu0975-1416.914

assessment. Certain cases have been elaborated wherein the outlook has changed to harness the values.

Keywords: Biodiversity conservation, medicinal plants, restoration, traditional crops, wild edibles.

1 Introduction

Mountains, which cover over 22% of total global land surface, harbor nearly a quarter of world's forests, and provide a range of ecosystem services to at least half of humankind (Spehn et al., 2010). They are home to 50% of global biodiversity hotspots, which support approximately one-quarter of world's terrestrial biological diversity (Spehn et al., 2010). In addition, these regions are important source of agro-diversity including locally adapted crop varieties: an asset for assuring food security. The significant role of mountain ecosystem services towards sustaining global population has gained popularity among scientists, policy makers and natural resource managers who have increasingly become interested for sustaining the mountain ecosystem services in the future (Chettri and Sharma 2016).

Among the world's mountain's, Asia has the largest, highest and most populated mountain systems – the Himalaya. This mountain holds a special identity among mountains across the world by being young, massive, and diverse. Especially the unparallel vertical gradient accompanied by its geo-dynamism makes the Himalaya most complex and highly variable. This region forms a diverse geographic and ecological entity endowed with overwhelming richness, representativeness and uniqueness of biodiversity.

The Himalaya acts as a store house of snow and ice, largest outside the two poles. Being provider of large volumes of freshwater, Himalaya is popularly described as 'The Third Pole' of the world (Chettri and Sharma 2016). Ten major rivers of the world, originate from this region, and drain large part of Asia making it a crucial ecological entity (Desai et al., 2011).This region is known for its unique flora and fauna, and listed among the 'Mega Biodiversity Hot Spot' areas. High degree of endemism in the region implies occurrence of various critical habitats and eco-regions having global importance. It is estimated that 210 million people in the Hindu Kush Himalaya (HKH) and 1.3 billion peoples in downstream benefits from food and energy services of Himalaya (Sharma 2017).

The Indian Himalayan Region (IHR) contributes for a large proportion of the Himalayan biodiversity. IHR greatly matters for the ecological and

economic security of India. While the region represents nearly 4% of total human population of the country, it exhibits diversity of ethnic groups (30%; 171 out of a total 573 reported scheduled tribes in India).The diversity of biophysical features in IHR is adequately represented through 3 biogeographical zones (Trans-Himalaya, Himalaya and North-East) and 9 biogeographic provinces (33% of India). The great wealth of biological diversity in the region is attributed to the wide variety of bio-physical conditions across the IHR. It extends over 9 states fully (Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya), 02 states partially (hilly districts of Assam, and West Bengal) and 02 Union Territories fully (Jammu & Kashmir and Ladakh). In the context of India, IHR represents about 4% of the total population (48.6 million), 16.2% of the total geographical area (5,33,604 km^2), 30% of the total ethnic group's (170); 36% of the total forest cover (2,50,708 km^2), 44% of the total biodiversity, 63% of the total water flow budget and 100% of the alpine and glacial systems (Rawal et al., 2013)

The IHR is represented with rich floral diversity i.e., about 8,000 species of angiosperm (40% endemic), 44 species of gymnosperm (16% endemic), 600 species of Pteridophytes (25% endemic), 1737 species of bryophytes (33% endemic), 1,159 species of lichen (11% endemic) and 6,900 species of fungi (27% endemic) (Singh et al., 1996). However, about 436 species have been reported threatened (Mehta et al., 2020). Similarly, the region is rich in faunal diversity and 65% mammals, 50% birds, 35% reptiles, 36% amphibians and 17% fishes of India are reported from IHR. All this reflects the high representativeness of IHR biodiversity. However, to harness the value of IHR biodiversity, there is a need to understand it more holistically in the context of the global commitments under the Convention on Biological Diversity (CBD). The convention broadly calls upon the parties for conservation and sustainable use of biological diversity (Han et al., 2014).

2 SWOT Assessment of IHR Biodiversity

While actions for conservation of Biological Diversity are more oriented towards addressing associated weaknesses and threats, the sustainable use perspective mostly targets strengths and opportunities. Therefore, to ensure conservation and sustainable use, SWOT (Strength, Weakness, Opportunity and Threat) assessment has been conducted across 4 major attributes of IHR biodiversity, which include (i) richness and representativeness,

(ii) uniqueness, (iii) strong IKP, and (iv) strong conservation area coverage. The outcome of SWOT is summarized in Table 1.

3 Addressing Weaknesses and Threats-conserve Biodiversity

Following the SWOT assessment, IHR biodiversity, despite being rich and representative suffers from issues of high dependence of people, poor management, and lack of holistic understanding. All this has led to severe degradation and endangerment of biodiversity. Further, increasing pressure of development infrastructure, concurrent habitat loss, over and unscientific harvesting accompanied by increasing people's apathy, have increased the threats on IHR biodiversity. The region being young is geologically in dynamic state that makes the system fragile from geo-morphological point of view. Further, under increasing threat of global warming the Himalayan region is reported to be vulnerable on two main counts: (i) warming trends are higher in the region, and (ii) the impacts are magnified by the sharp change in altitude over small distances. Indian National Action Plan on Climate Change (NAPCC) also underlines the intense vulnerability of this region towards climate change. The change in climate is predicted to impact the global mountains including Himalaya and thus the biodiversity and human wellbeing. In addition to climate change, anthropogenic disturbances like massive deforestation and rapid land use changes are also leading to habitat loss of threatened/ endemic species in the Himalaya (Reddy et al., 2013).

Over the years, the urbanization has increased from 25.7% in 1991 to 31.14% in 2011. It is well known that any erosion in the biodiversity would influence forestry, agriculture, livestock husbandry, Non-timber Forest Products (NTFPs) based livelihoods and many other intangible services of the ecosystems connected with the lowlands of India. Shifting cultivation in northern India, has posed serious environmental threats such as deforestation, biodiversity loss, soil and nutrient erosions and a loss of a variety of food crops (Umakant et al., 2017). Among various alien invasive species, *Lantana camara*, *Eupatorium* spp., *Parthenium hysterophorus* and *Ageratum* spp. have spread over large areas of IHR, severely impacting the plant diversity of the region (Pathak et al., 2019). The growing list of threatened species reflects the increasing magnitude of the problem. A recent report on threatened species of Indian Himalaya indicates the presence of 456 taxa under various threat categories of IUCN (Mehta et al., 2020). The vulnrrability of the Himalayan

Table 1 Himalayan Biodiversity – SWOT analysis

Strengths	Weaknesses	Opportunity	Threats
Richness & Representativeness			
Forested Landscape (one third of India)	High dependence	Carbon sink	Increasing pressure – infrastructure
Alpine Ecosystem (100% of India)	Poor management	Harnessing diversity – e.g., tourism	Habitat loss
Biodiversity (high proportion of India)	Missing holistic understanding	Harvesting values – medicinal, wild edible plants	Over & unscientific harvesting
		Sustaining flow of ESs	Increasing people's apathy
Uniqueness – 'incomparable value'			
Endemic species	Fragility of ecosystem	Maintaining unique genes for posterity	Climate change impacts
Specific habitats (e.g., wetlands, timberline)	Inadequate knowledge base	Harnessing potential – e.g. nature tourism	Increasing invasion
Special ecosystems (e.g., alpine meadows; cold deserts, agro-ecosystems)	No specific management focus and poor appreciation of values	Effective use for economic upliftment	Human induced perturbations
Strong Indigenous Knowledge & Practices (IKP)			
Food, Fibre, Medicine, Fodder, Fuel	Economic marginality-poverty	Building on IKP	Erosion of IKP
Agro-diversity & Farming Practices	Heavy dependence on bioresources	Value addition for income generation	People's disinterest on agriculture & resource management
Community management – Van Panchayat, Sacred sites	Overlaps in institutional interests	Expansion of food base-climate resilient crops	Non use focus of Conservation
	Misfit policies & programmes	Participatory management	

(*Continued*)

Table 1 Continued

Strengths	Weaknesses	Opportunity	Threats
Strong Conservation Area Coverage			
PA coverage (more than national average)	PAs as no go area	Promotion of community based conservation	Strong conflicts with people
Biosphere Reserves (40% of country)	Lack of research integration in PA Management	Scientific management	Shifting species/community boundaries under CC
Community Conservation Areas	Inadequate infrastructure	Provisioning of PES	Departmental Resistance
	Poor awareness on BRs and CCAs	Securing livelihoods	

region to various threates call for increased attention to the conservation of biodiversity and sustaining the liveliood in changing outlook.

The innumerable ecosystem services provided by the IHR are not only significant to the local inhabitants but also vital for downstream and adjoining neighbouring countries. Considering the importance of IHR, National Action Plan on Climate Change (NAPCC) has recognized IHR vital for ecological security of the country. This unparalleled plant diversity of the IHR, besides fulfilling the provisioning requirements and utilities of local populace, is widely used in traditional/modern health care systems, and carries a great existence and option value. Considering the value of biodiversity and its benefit to human well-being, effective and urgent global action was initiated to halt biodiversity loss through the Convention on Biological Diversity and its "Aichi Biodiversity Targets" (Han et al., 2014). The mission of CBD is to halt the loss of biodiversity in order to ensure that by 2020 ecosystems become resilient and continue to provide essential services, thereby securing the planet's variety of life, and contributing to human well-being, and poverty eradication. The growing concern is therefore to save biodiversity for sustaining the future.

The Himalaya is important from the standpoint of a biodiversity hotspot that maintains the flow of ecosystem services and basic raw materials for the subsistence livelihoods of the inhabitants. However, these resources are overexploited for various use, which make them more vulnerable under changing climate. Further, the region is fragile and also the resources in

the region are vulnerable to environmental perturbations, and anthropogenic disturbances. High dependency on these resources, resulted degradation and deteriorating conditions of the forests and alpine ecosystems.

In spite of the crucial ecological, cultural and economic importance of the Himalayan ecosystem, the ecosystems are deteriorating due to increasing anthropogenic pressure. The situtaion of resource degradation is speedily changing with globalization and global warming. Among others, warming contributes changes in phenology of climate sensitive species (Filter and Filter 2002), and will continue to be affected with projected climate change in the Himalayan region (IPCC 2007). Climate change has already impacted forests, agriculture and the food system in the region. For example, decline in production of apple and other agri-horticultural crops due to low snowfall in the Himachal Pradesh is well cited. Also, shift in species/community boundaries in the region under climate change scenarioare reported (Telwala et al., 2013; Singh et al., 2016). Further, fast erosion of indegenous knowledge practices (IKP)is alarming as this knowledge had remained foundation of sustainable resource mangement by the indigenious communities in the region. While the Himalayan region is considered strong w.r.t. the existing conservation area network, putting Protected Areas (PAs) as 'No go area' for people, poor integration of researches in PA management, inadequate infrastructure, and poor awareness on Biosphere Reserves (BRs) and Community Conserved Areas (CCAs) makes this conservation network weak in the context of current global thinking on conservation.

4 Building on Strengths & Opportunities – Sustainably Use of Biodiversity

The wealth of biodiversity of this region supports peoples' livelihoods directly and indirectly through a range of ecosystem goods and services. For instance, for centuries the subsistence living of local communities has depended on traditional agriculture and livestock farming, which largely revolves around biomass harvesting from the forests. According to an estimate, to generate one unit of energy from agriculture, 10–12 energy units of forest biomass are required (Negi et al., 2012). More than 41.5% of geographical area of IHR is under forest cover representing one-third of forest cover of India, and of which nearly half (47%) is of the "very good" forest cover category of the country. Forests are obviously one of the most important resources in the IHR states, and have direct role in supporting rural

livelihoods not only by meeting the people's day to day needs of fuel wood, fodder and timber but also by providing employment in some areas. The potential or the opportunities with IHR has been described in the following sections:

4.1 Carbon Pools Sequestration

The Himalayan forests form a very large reservoir of carbon pool. As per, India's State of Forest Report-2019 (FSI 2019), the forests in Indian Himalayan region (excluding hill district of Assam and West Bengal) has 2849.2 million tonnes of total stock of carbon (both biomass and soil), which represents nearly 40% of total carbon pool of India's forests. The forest carbon stock in IHR states has increased by 20.6% from 2017 estimates. In this period, national increase of carbon stock was about 1% only. More importantly, the carbon stock in forest biomass (above and below ground) has increased from 802.8 million tonnes (2019) thereby registering an increase of 57% carbon in biomass pool. This suggests Himalayan forests are great accumulator of carbon. A recent study by Tolangay and Moktan (2020) indicates that the IHR sequesters about 65 million tonnes of carbon each year, and conclude 'the Himalayan forests have the potential to mitigate climate change and global warming'. Carbon sequestration is among the most important ecosystem services provided by forested regions that play an important role in global climate mitigation. Therefore, as part of action during UN decade of ecosystem restoration (2021–29), the restoration of degraded land through plantation of multifarious species integrating traditional and scientific knowledge with local participation in the Himalayan region would not only ensure biodiversity conservation, flow of forest goods to the local inhabitants, but also contribute for climate change mitigation. Sustainable forestry practices can increase the ability of forests to sequester atmospheric CO_2 while at the same time enhance other ecosystem goods and services. This can be made possible with optimal participation of local people in restoration and management practices.

The community forests (i.e. Van Panchayats) of Uttarakhand are known to play a vital role in forest protection and resource management. Across the world, Community Forests (CFs) are considered as an important means of forest management, biodiversity conservation, poverty reduction and ecological sustainability. However, due to increased vulnerability these VPs in the Himalaya needs urgent attention for continuous flow of goods and services (Thakur et al., 2020). The scenario can be changed with appropriate

interventions to make these VPFs more relevant for local people as well as towards the emerging global targets of conservation and sustainable development. This calls for adequate policy and practice encouragement, and resource sharing from the government. Also, engagement of relevant R&D institutions to bring-in knowledge and technical inputs would accelerate the process of ecological restoration of community forests.

4.2 Restoration of Degraded/Forest Land

One of the India's important global commitment is the Bonn challenge, which was joined by India in 2015 and pledged to bring under restoration 13 million hectares of degraded land by 2020, and an additional 8 million hectares by 2030. These targets, although ambitions, are achievable if the drivers of forest landscape degradation are identified and appropriate intervention set in motion (Bhattacharya et al., 2018). Forest Landscape Restoration (FLR), the ongoing process of regaining ecological functionality and enhancing human well-being across deforested landscape, is one of the most practical ways of achieving these national targets and international commitments. The Himalaya being a forested landscape inherently becomes the major candidate for FLR programmes. Particularly such programmes need greater attention during decade of ecosystem restoration. Ecological restoration tries to restore the original biodiversity and ecosystem processes that existed before the degradation (Díaz et al., 2015). This is relatively a difficult task. However, regaining ecological functionality as enshrined in the concept of FLR is more feasible.

Many restoration projects have been implemented and many are under consideration, but only few have made significant impacts. Few success stories of GBP-NIHE are available in different part of IHR, which succeeded in converting converted conceptual idea into a practical implementation (Maikhuri et al., 1997, 2000a; Negi et al., 2015). Such pilots need to be upscaled in the region. Also, other agencies, including forest departments have made significant contribution w.r.t. forest conservation. However, considering the interests of local inhabitants, participatory action research framework and approaches for restoration of degraded forest land, are likely to deliver better results (Negi et al., 2015; Bhatt et al., 2020). Active participation of local stakeholders is a prerequisite to success of any land restoration effort in the region. This can be done very effectively with empowering the community through their skill and capacity building on plantation techniques, identification of most suitable species, and sharing of knowledge (Maikhuri et al.,

1997). In order to harness the opportunity offered by the Himalayan Biodiversity to implement the restoration and rehabilitation programme, following need to be considered:(i) selection of plant species by the local stakeholders and scientist, (ii) ensure soil and water management, (iii) ensure long term benefits in terms of fuel, fodder, timber and ecological safeguards to the community, and (iv) involve local people in all stages of implementation.

4.3 Medicinal Plants (MPs) – Emerging Options

Indian classical (i.e. Ayurveda, Siddha, Unani, and Swa-rigpa) and the folk health care systems are largely dependent upon the wide diversity of plants which is estimated about 6,500 species. The Indian Himalaya harbours over one-fourth of these plants. A large number of these medicinal plants are considered globally significant (Table 2).

Medicinal Plants (MPs) 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). MPs in the IHR are also reported to significantly contribute to affordable healthcare in the rural and remote areas (Goraya and Ved 2017; Negi et al., 2018). The global market for plant-derived drugs was valued $1.2 billion in 1990s, and has increased to $25.6 billion in 2015 (Roosta et al., 2017). This is expected to reach $35.4 billion in 2020 with a compound annual growth rate of 6.6% from 2015 to 2020. Even today with so much of progress in drug industries, the fact remains that 70–95% population in developing countries still depends on Medicinal and Aromatic Plants (MAPs) for their primary healthcare. In the Himalaya, traditional herbal medicines are rooted in indigenous knowledge systems, and play a crucial role in decision making with respect to the use of medicinal plants resources (Kala 2005; Negi et al., 2018).

Medicinal plants form an important component of livelihood and critical source of income in the IHR states. This is particularly true in areas such as high alpine regions, where agricultural outputs are low and opportunities for income generation largely depend on natural resources. Till date most of the herbal raw material is coming from the wild. However, with changing laws and protection regimes accompanied by increasing global demand there is a need to bring these plants under cultivation. The gap between the demand and supply is widening, which has affected pharmaceuticals companies on one hand and livelihoods of local people on the other. While efforts are on, there are big gap areas. This creates great

Table 2 List of Globally significant medicinal plants found in the IHR

Species	Family	Parts Used	Medicinal Value/Use
Aconitum heterophyllum	Ranunculaceae	Roots	Fever, diarrhea
Aconitum violaceum	Ranunculaceae	Roots	antidote
Aconitum balfouri	Ranunculaceae	Roots	Arthritis, leprosy & paralysis
Aegle marmelos	Rutaceae	Fruit	Stomach ulcer & heartburn
Allium stracheyi	Liliaceae	Whole plant	Jaundice, cold, cough
Angelica glauca	Apiaceae	Root	Dysentery, Constipation
Arnebia benthamii	Boraginaceae	Root	Respiratory troubles, wound healing
Berberis aristata	Berberidaceae	Root, Bark	Anti-bacterial, cough, anti-diabetics
Bergenia cilaiata	Saxifragaceae	Rhizome	Fever, cough, cold, and Kidney stone
Bergenia stracheyi	Saxifragaceae	Rhizome	Kidney stone & gastro intestinal disorder
Dactylorhiza hatagirea	Orchidaceae	Tubers	cough and cold, stomachache, cuts & wounds healing
Dioscorea deltoidea	Dioscoreaceae	Tuber	Vermifuge, asthama, arthritis
Emblica officinalis	Euphorbiaceae	Fruit	Diarrhea
Fritillaria roylei	Liliaceac	Bulb	Jaundice & inflammation cough
Malaxis muscifera	Orchidaceae	Pseudo-bulb	Fever, dysentery
Nardostachys grandiflora	Valerianaceae	Rhizome/root	Heart pain, urination, digestion
Paeonia emodi	Paeoniaceae	Roots, stem & leaf	Fever, diabetes & stomach pain
Paris polyphylla	Liliaceae	Roots	Burns, cut, diarrhea, dysentery

(*Continued*)

Table 2 Continued

Species	Family	Parts Used	Medicinal Value/Use
Picrorhiza kurrooa	Scrophulariaceae	Root/stem	Fever, diabetes, stomach disorder, jaundice
Podophyllum hexandrum	Berberidaceae	Fruits	Cough, cancer
Rheum emodi	Polygonaceae	Rhizome	Fever, cough, indigestion
Rheum moorcroftianum	Polygonaceae	Rhizome	Hyperlipidemia, anti-cancer,
Swertia chirayita	Gentianaceae	Whole plant	Fever, ulcers, diabetes
Taxus baccata	Taxaceae	Leaves, Bark	Anticancer, cold, cough, fever
Terminalia chebula	Combretaceae	Fruit	Cough, dysentery
Tinospora cordifolia	Menispermaceae	Stem	Diabetes, fever
Valeriana jatamansi	Valerianaceae	Tuber	Stomach disorder, epilepsy, skin diseases

opportunity for both science and technological interventions. For instance, propagation packages developed by various R&D organizations for high value medicinal plants now need to be transferred to farmer's field for development of cultivation packages. The research being conducted on chemical and genetic constituents of Himalayan medicinal plants can prove greatly beneficial. For example a study by Rawat et al. (2016) on anti oxidant anti-microbial properties of some ethno-therapeutically important medicinal plants of IHR suggest that extract of these species can be used as natural anti-oxidant to reduce free radical mediated disorders and as alternative for food preserves. Further, *in-situ* and *ex-situ* conservation of MPs need to be promoted through local participation and quality seed production through scientific organizations. For instance, recognizing the conservation value of threatened species, the GBP-NIHE is effectively using the biotechnological approaches especially in case of species which are difficult to propagate through conventional methods and having scarce availability in the wild. Around 82 species have been successfully used for developing *in vitro* propagation protocols and the list is continuously growing (Palni et al., 2018).

Some of the medicinal herbs are unique to Himalaya region, especially those growing in alpine areas and endemic. Among others, recently one particular species, *Ophiocordyceps sinensis* (Caterpillar fungus, locally Keera jari), from higher altitudes of Himalaya has attracted special attention with the market demand increasing multiple folds. In last three decades collection of high-value, low-volume Caterpillar fungus has become an important livelihood activities and source of income in the IHR. In India, it has emerged as an important contributor to economy of many high altitude villages (earning between Rs. 1-3 lakhs per annum), those engaged in pastoral activities especially in Uttarakhand (Negi et al., 2014, 2020). The species is used for the treatment of many ailments like diarrhea, headache, cough, rheumatism, asthma, pulmonary diseases, cardiovascular disorder, sexual dysfunction, renal and liver disease for centuries (Winkler, 2009). The product named as Himalayan Herbal Viagra with its widely popularized aphrodisiac properties has resulted in multifold increase in its price within a small period of time. However, on account of its ever increasing demand and rapid decline in natural populations, the species has been listed in the endangered category (IUCN 2020). Reports indicate, the availability of the resource has declined, and harvesting has become difficult in recent years. This calls for attention with respect to sustainability of its habitats in particular and alpine meadows in general. Further, the emergence of caterpillar fungus as game changer, both in socio-economic and ecological domain, brings issues pertaining to governance of this common's resource on fore front.

In view of declining production due to overharvesting as well as changing climate, and likely implications of this decline for dependent community, there is an urgent need to find alternative livelihood options for communities associated with. There exists a great opportunity to explore possibility of the value addition in caterpillar fungus in the form of supplementary food as well as medicinal products for creating the livelihood opportunity to the local community in the IHR states particularly Arunachal Pradesh, Sikkim, and Uttarakhand. Amid COVID-19 pandemic situation the attention on herbal products as immunity booster has grown considerably. The Ayurvedic products have gained huge ground and thus creating enormous opportunity for economic gains through nutraceutical and pharmaceutical sectors.

4.4 Wild Edibles as Source of Food and Nutrition Security

In recent decades, particular attention has been paid to mainstreaming local biodiversity for food and nutrition security by several UNGA Resolutions

including World Health Assembly (WHO 2013; United Nations 2020). Forest products constitute an important source of livelihood for millions of people across the world (Mamo et al., 2007). Among these products, wild edible plants form a large part. Of the various components of biodiversity, the conservation and sustainable use of wild edibles is receiving increased attention due to their crucial roles in global healthcare system, particularly in the developing world (Chen et al., 2016).Wild edibles are used as source of food in many developing countries and thus provide an adequate level of nutrition to the human beings (Maikhuri et al., 2004; Murphy et al., 2005).

In the Himalaya, wild fruits contribute to diet diversity and flavour thereby forming an essential part of nutritionally diet of rural poor, and provide essential micronutrients (Bhatt et al., 2017). Wild edibles enrich dietary quality of food and frequently eaten as supplement of proteins, essential minerals, micronutrients, and vitamins and thus provide an affordable source of nutrition for rural and indigenous in the IHR (Table 3). A total of 675 species of wild edibles in 149 families and 384 genera have been reported in the Himalaya (Samant et al., 1998).The rich diversity of wild edibles in Indian Himalaya not only provides nutritious food, but also income to tribal and poor people living close to forests and rural areas. For example consumption of branded cold drinks in urban and semi-urban areas in Uttarakhand is being gradually replaced by juice/squash/pickle prepared from wild edible fruits/flowers i.e., *Myrica esculenta, Rhododendron arboreum, Hippophae salicifolia, Aegle marmelos, Emblica officinalis* (Negi et al. 2011; Figure 1).

A study in Almora district, Indian west Himalaya, reveals that the sale of *Myrica esculenta* fruits brings each household Rs. 913–3713 (US$ 26–106) per season, which was significant considering low annual per-capita income in the region (Bhatt et al., 2000). Likewise the study by Rawat et al. (2014) on nutritional and antioxidant potential of selected vitality strengthening Himalayan plants has highlighted the possibilities of harnessing potential of such plants. An assessment of antioxidant properties in fruits of *Myrica esculenta* reveals that the consumption of this wild edible fruit helps in reducing free radicals. At present there is an increasing demand of wild edibles for diverse health related solutions and livelihood need. However, the use of wild edibles is limited to certain traditional communities/areas, inspite of their huge commercial potential. This offers great possibilities in the development of wild edible based local and regional entrepreneurship, and source of alternate food and nutrition to global society.

Table 3 List of potential wild edible species having potential for value addition and small scale entrepreneurship in Uttarakhand

Plant Species	Harvesting Period	Traditional Uses	Medicinal Use in Traditional Healthcare System
Aegle marmelos	Jun–Jul	Fruits used for preparation of juice and squash	Unripe fruit is consumed raw to treat diarrhea. Juice prepared from ripe fruit is used to cure constipation
Berberis aristata	May–Jun	Fruits used for preparation of juice and squash	Root decoction is taken orally in ulcer, stomachache, diabetes, skin disease and asthma
Bauhinia variegata	Apr–May	Flowers used for preparation of pickle and as vegetable	Dried root and bark are taken orally to treat diarrhea
Diplazium esculentum	May–Jul	Circinately coiled juvenile leaves used for pickle and vegetable	It is used to cure jaundice and constipation
Ficus auriculata	Jun–Jul	Fruits used for preparation of pickle and vegetable	Leaves decoction is taken orally to cure jaundice and hepatitis
Hippophae salicifolia	Oct–Nov	Fruits used for preparation of juice, squash and chutney	The decoction of the fruit juice is taken to treat liver disorder, jaundice and cough
Myrica esculenta	Apr–Jun	Fruits used for preparation of jam, squash and juice	The fresh fruit and its juice are consumed in indigestion and headache
Prinsepia utilis	May–Jul	Fruits oil used for cooking	Seed oil is used to treat high blood pressure and high level of cholesterol
Pyracantha crenulata	Set–Oct	Fruits used for preparation of jam, squash and juice	Powder of dried fruit is used to cure bloody dysentery

(*Continued*)

Table 3 Continued

Plant Species	Harvesting Period	Traditional Uses	Medicinal Use in Traditional Healthcare System
Phyllanthus emblica	Mar–May	Fruits used for preparation of pickle, squash and juice	Fruits are used to treat diabetes, anaemia and jaundice
Rhododendron arboreum	Mar–Apr	Flowers used for preparation of squash, juice and sauce	Flowers juice is used to treat diabetes, respiratory and digestive problems
Rubus ellipticus	Apr–May	Fruits used for preparation of jam and jelly	The juice of the root is used in the treatment of fevers, gastric troubles and dysentery
Spondias pinnata	Jan–Mar	Fruits used for preparation of juice, squash, candy and sauce	Ripened fruits and its juice used to cure dysentery, diabetes, and gastric problems
Viburnum mullaha	Sep–Oct	Fruits used for preparation of juice and sauce	Juice of the fruit is used to treat indigestion

4.5 Indigenous Knowledge and Practices-rich Agro-biodiversity

IHR is well recognized for prevalence of Indigenous Knowledge and Practices (IKP) which have helped the communities in meeting their needs related to food and nutrition as well as health care. Besides strengthening medicinal plant and wild edible sectors, the IKP has helped in sustaining the traditional agriculture system in the region, which is seen in the form of enormous enrichment of genetic diversity in the land races. Agro-diversity is the major life support system of the people living in the Himalayan region. In the Himalaya, subsistence agriculture remains the core of household economy (Maikhuri et al., 2001). Food consumption is, therefore, both driving force as well as outcome of mountain livelihood systems and social organization. Rural communities in the region have developed several indigenous and traditional methods of farming to manage and conserve the traditional varieties/landraces of crops, and celebrate agro-diversity with religious and cultural passion in the region (Negi and Maikhuri 2013). The farmers ensure

Figure 1 Potential wild edibles and local engagements through value addition in Uttarakhand.

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 genetic heterogeneity of agricultural crops in the region not only enables farmers to face challenges of crisis, such as under changing climate, but also ensures food and nutritional security to most vulnerable groups (Maikhuri et al., 2001; Farooquee and Maikhuri 2009).

Traditional crops provide ranges of options to address the complex interface between food insecurity, and natural resource degradation, allowing coping mechanism specific to the adverse climatic conditions (Maikhuri et al., 2001; Farooquee and Maikhuri 2009). Many location specific traditional crop produces are increasingly being appreciated across the world as the possible solution to food and nutritional security (Hajjar et al., 2008). Various varieties as well as the traditional cuisines made out of these have been found nutritionally rich and full of antioxidant potential. Therefore, promotion of such underutilized crops in farming system is very much needed. For example, government of Uttarakhand is promoting traditional crops, and the recipes prepared of these crops through home-stay accommodations. The traditional farming system in the region, especially in rainfed conditions, represents a true model of organic farming and produce, having high demand in the regional market. Motivation is urgently required to the farming

communities by supporting premier and minimum support price to tradition food commodities.

Improvement of crop yield through enhancement of biodiversity i.e., pollinators may be a sustainable pathway towards greater food supply (Garibaldi et al., 2016). For example Gaira et al. (2016) reported increasing abundance of bumble-bee (*Bombus* sp.) resulted in significantly ($p < 0.03$) higher yield of the crop (average 17–41 g/plant). The study further reported increasing abundance of all bees lead to significant ($p < 0.01$) increase in crop yield (average 21–41 g/plant). Moreover, from a food-security point of view, pollinator dependent crops provide essential micronutrients to human health where needed (Chaplin-Kramer et al., 2014). Such sustainable increases may be especially important for the 2 billon global people reliant on small farms, many of which are undernourished. Therefore, great scope exists for extensive research and knowledge generation in this aspect considering that market based sourcing of food fails in meeting the quality and diversity needs that produced in homesteads. Also, realizing that the dependence on markets alone leads to crisis during pandemic situations like COVID-19, this is high time to frame strategies to harness potential of agro-ecological farming practices in the Himalaya by promoting principle of 'Collectively'. The traditional farming systems and practices also provide great scope for promoting agro-diversity based rural tourism.

4.6 Strong Conservation Area Coverage

IHR has a strong coverage of Protected Areas, which is more than national average. Strong networks of Biosphere reserves and community conserved areas further contribute for the *in situ* conservation of biodiversity. These conservation areas, being pristine in nature, provide scope for evolutionary processes of biodiversity. However, in the context of human well-being these conservation sites are gaining importance as nature based tourism promotion sites. While discussing institutional arrangements for managing tourism in Protected Areas of Himalaya, Badola et al. (2017) indicated that the tourism has the potential to advance biodiversity conservation through the creation of societal constituency by providing alternative livelihood to resource dependent communities. The community forest (i.e. Van Panchayats) in Uttarakhand have already proved a highly potential sites for sustainable ecotourism development through integration with women run home stays in Munsiyari, Pithoragarh (Badola et al. 2017). Earlier, Maikhuri et al. (2000b) had suggested potential of ecotourism in buffer zone areas of Nanda Devi

Biosphere Reserve as an option for resolving people-policy conflict in the region. Among others, the sacred groves or sacred natural sites in the IHR are also gaining tourism popularity due to their pristinely as well as linkages with cultural heritage. Mawphlang sacred forest of Meghalaya is one such example which has emerged as an ideal site for nature lovers (incredibleindia.org).

4.7 Unique Genes for Posterity

Among other features of Himalayan biodiversity, the endemism (i.e. uniqueness) of species deserves special attention. While in general 30–40% plant species are considered endemic, the percentage goes high in higher altitudes towards alpine regions (Dhar 2002). As the alpine ecosystems, in the context of Indian landmass, are confined in the Himalaya therefore, the biodiversity of these ecosystems become unique to entire country. Especially the endemics having other than conservation value, such as medicinal, edible, etc., provide greater opportunity for human well fare, provided the potential is harnessed in systematic and scientific way. Besides wild, the diversity of genes prevalent in domesticated biodiversity is another major potential in the region. The Himalaya represents 3 sub-centres of plant origin and distribution out of 8 in the country. This along with the eco-climatic diversity of the Himalaya accompanied by diversity of socio-cultural system has resulted in diversity of agricultural crops and practices. The diversity of landraces across the region makes the agro-diversity rich and unique, which provides various opportunities for harnessing benefits. The value of agrodiversity in nutritional security of Himalayan region is well documented (Bungla et al., 2019). However, in recent times when COVID-19 pandemic has impacted entire humanity, the immunity boosting features of traditional crop varieties in the Himalaya are being highlighted. Adaptability of several traditional crops has protected the hill farmers from absolute crop failure since millennia. All this gives us opportunity to build on this potential.

5 Appreciation of Biodiversity

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. Yet, the appreciation for this valuable resource has remained at the low ebb. Especially the people in low lands, inhabiting areas much beyond physical boundary of the Himalaya, pay very little attention to these valuable services provided by Himalayan biodiversity. As a result

they are unable to appreciate these values. Therefore, while thinking about harnessing the potential of Himalayan biodiversity there is a need to promote awareness among masses, both in upland and lowlands, about values of biodiversity. In this context, conservation education can be seen as a potential tool for empowerment leading to action, involving actual participation of students, teachers and scientists (Maikhuri et al., 2009). Students and teachers being the most influential components of society need to be engaged in the biodiversity related initiatives.

GBP-NIHE has played an important role in developing curiosity and encourage students in the field of biodiversity conservation and management (Dhar et al., 1999; 2002). Students and teachers of different schools, and also the villagers in different locations were the major target group of such capacity building training programmes. The students and teachers were encouraged to make detailed observations and engage themselves with vegetation sampling, herbarium preparation and general awareness on the types of forests and plants. The noteworthy feature of this programme was open and face-to-face discussions of students from remote and rural areas with eminent scientists and researchers, without any hesitation. These programmes have yielded good results. The students and teachers exposed to these programmes had subsequently shown greater appreciation for biodiversity. These programmes were found effective and have gained momentum towards understanding the biodiversity from micro to macro level. Such mechanism is required to be up-scaled across IHR states and in areas where ecosystem services from Himalaya are realized. Further, Government of India has lauched Green Skill Development Programme to sensitize the local people in natural resource based livelihood options and biodiversity conservation in general. The programme endeavors to develop green skilled workforce having technical knowledge of sustainably using the nature and its components, and commitment for sustainable development. Increasing number of such stakholders will go a long way in providing income opportunity in the region. There is a great need to systematically and frequently organize such biodiversity based green skilling pragrammes across the IHR. These programmes are expected to yield benefits of biodiversity conservation and sustainable use in the region.

6 Conclusion

The Indian Himalaya, as provider of global goods and range of ecosystem services is vital for sustaining life of billions of people both in uplands and

downstream. The potential of bio-resources such as medicinal plants, wild edibles, traditional crops, etc., is getting attention for optimal and sustainable use to enhance the livelihood options for local inhabitants. However, while developing a strategy for harnessing potential of Himalayan biodiversity, there is a need to critically evaluate Strength, Weakness, opportunities and Threats (SWOT). The 2021-2030 being decade of ecosystem restoration, there exists an opportunity to enhance the scope of biodiversity through wide range restoration activities. The benefits of the same will be multipronged and long-lasting, both for realizing conservation and sustainable use efforts of Himalayan biodiversity. More importantly the Himalayan biodiversity values require due appreciation from the beneficiaries. In this context, promotion of conservation education emerges as a practical tool.

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