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Review: Traditional ecological knowledge of tribal communities of North East India

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Abstract. *Tynsong H, Dkhar M, Tiwari BK. 2020. Review: Traditional ecological knowledge of tribal communities of North East India. Biodiversitas 21: 3209-3224.* Traditional ecological knowledge (TEK) refers to the knowledge, innovations and practices of indigenous and tribal people relating to the understanding of structure and functioning of neighboring natural ecosystems and their use for human welfare. In this paper, we have reviewed the literature relating to TEK held by the tribal and other traditional societies of North East India. The region is very rich in TEK pertaining to species, ecosystems, and their interactions including their sustainable management and utilization in forestry, fisheries, agriculture, food, crafts, dye, and health care. Some of these TEK based knowledge systems are at par or even superior to the resource management practices evolved under the ambit of modern knowledge. Though a substantial chunk of TEK of tribal communities of North East India has been documented, huge treasures of such knowledge remain unreported and hence are on the verge of being lost.

Keywords: Ethnobotany, ethnozoology, fisheries, health care, pest management, sacred forests

INTRODUCTION

Traditional Ecological Knowledge (TEK) refers to the knowledge, innovations, and practices of indigenous and local communities around the world. The term "tradition" used in describing TEK systems does not imply that this knowledge system is old, fashioned out or non-technical in nature, but is considered as "tradition-based", because it is created in a manner that reflects the traditions of the communities (Laudari 2010). TEK develops from the experiences gained over centuries and is adapted to local culture and environment. By and large, it relates to the understanding of the structure and functioning of neighboring natural ecosystems and their sustainable use for human welfare. TEK is transmitted orally from generation to generation and is considered as intangible heritage and intellectual property of the community. It tends to be jointly closely-held and sometimes takes the shape of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, native languages, and practices. Berkes (1999) outlined TEK to knowledge systems like (i) the data supported empirical observations essential for survival (species taxonomy, distribution and life cycles); (ii) the understanding of ecological processes and natural resources management (practices, tools, and techniques); (iii) the socio-economic organization and institutional arrangements necessary for effective coordination and co-operation (rules and taboos) and (iv) the worldview or 'cosmovision' (religion, belief, and ethics). The construct of TEK in conjunction with similar or closely connected terms like native data and native science has a number of its origins in the literature on international development and accommodative management (Molnar 2012; Whyte 2013). Ethnic teams across the world possess a tremendous quantity of TEK, most of that are poorly documented and therefore remain unknown to researchers and natural resource managers. Setting aside areas for the conservation of bioresources are often seen in many sacred groves, royal hunting forests, and sacred gardens as samples of TEK (Langton 2015; Singh et al. 2017). These practices involve a variety of restraints on the harvesting of products from nature in terms of quantity, locality, season and age, gender, and social class (Fitzpatrick 2005; Singh et al. 2017). Tiwari et al. 2013 and Iskandar 2016 reported that norms are set up for the use of these resources by community institutions. These institutions regulate the use and preservation of bioresources like forests through decentralized community control systems (Poffenberger 2007; Singh et al. 2018a; Luintel et al. 2018). In all, prudent use of the natural resources is practiced through an elaborate institutional arrangement which serves as a common good for the communities who in turn share common interest and understanding towards the sustainable use of the common property resource (Oberlack et al. 2015; Malsale et al. 2018).

The distinction between local knowledge and indigenous knowledge is of great significance as local knowledge implies the knowledge of the people of a geographically identifiable area while indigenous relates to

the development of data on indigenous knowledge over an extended timescale (Bruchac 2014; Gilchrist et al. 2005; Dove 2006). Communities that are dependent on natural resources possess deep insight into factors influencing resource availability or quality (Susanti and Zuhud 2019). Such information is shared among its users and over a period of time develops into a substantial body of knowledge through experiential learning (Apffel-Marglin 2011; Smith 2012; Gómez-Baggethun et al. 2013; Hitomi and Loring 2018). There is a realization to achieve the objective of conservation of biodiversity as well as other natural resources of an area that one should have a sound understanding of the techniques and practices used by the local people (Takeuchi 2010).

In literature there exist a number of terms and frameworks for community-based knowledge, such as Indigenous Knowledge (IK), Traditional Knowledge (TK), Traditional Ecological Knowledge (TEK), Local Ecological Knowledge (LEK), and Local Traditional Knowledge (LTK). All these terms have been used to refer to the sources of knowledge about species, ecosystems, or practices held by people whose lives are closely linked to their natural environment (Berkes 1999; Davis and Ruddle 2010; Donogue et al. 2010; Singh et al. 2017; Tiwari et al. 2017; Tynsong et al. 2017). Rist et al. (2010) preferred to use the term TEK because it has predominant usage among conservationists and resource managers and is not restricted in application to indigenous peoples alone. In this paper, we use the term TEK to refer to sources of knowledge about species, ecosystems, or practices held by the tribal people of North East (NE) India. The present research is aimed to document and discuss the current status of rich TEK systems in NE India.

Table 1. Major tribes of different states of North East India

State	Major tribes
Arunachal Pradesh	Adi (Ashing, Bogun, Bokar, Bori, Botng, Galling, Komar, Karka, Lodung, Milang, Minyong, Padam, Pailibo, Pangi, Ramo, Shimong, Tangam), Aka, Aptani, Bangani, Khamba, Khowa, Memba, Miji, Hill Miri, Mishing Miri, Sherdukpen, Sulong, Singpho, Tagin, Tangsa, Wancho, Yobin (Lisu), Zakhring (Meyor) and Galo.
Assam	Chakma, Dimasa, Garo, Hajong, Hmar, Khasi, Jaintia, Synteng, Pnar, War, Bhoi, Lyngngam, Kuki tribes (Baiate, Changsan, Chongloi, Doungel, Gamalhou, Gangte, Guite, Hanneug, Hao Kip, Hanpit, Lhonyem, Lhocwun, Lupheng, Mangje, Misao) Riang, Sairhem, Selnam, Singson, Haolai, Hengna, Hongsungh, Hrangkhwal, Raokhol, Tongbe, Khawathlang, Khothalong, Khawchung, Khelma, Kholhou, Kipgen, Kuki, Lengthang, Lhangum, Lhoujem, Lhouvum, Misao, Riaong, Sairhem, Selnam, Singsom, Sithou, Sukto, Thado, Thangngeu, Uibush Vaiphel, Lakher, Man (Tai speaking), Mizo (Lushai), Mikir, Naga Tribes, Pawi, Syntheng, Barmans in Cachar, Boro, Borokachari, Deori, Hajong, Kachari, Sonowal, Lalung, Mech, Miri and Rabha.
Manipur	Aimol, Anal, Angami, Chiru, Chethe, Gangte, Hmar, Kabui, Kacha Naga, Koirao, Koireng, Kom, Lamgang, Mao, Maram, Maring, Mizo (Lushai), Monsang, Moyon, Paite, Purum, Ralte, Sema, Simte, Suhte, Tangkhul, Thadou, Vaiphui, Zou.
Meghalaya	Bhoi, Boro, Chakma, Dimasa, Garo, Hajong, Hmar, Jaintia, Karbi (Mikir), Khasi, Koch, Kuki, Lakher, Lyngngam, Man (Tai speaking), Mizo (Lushai), Naga, Pawi, Pnar, Rabha, Synteng and War.
Mizoram	Chakma, Dimasa Kachari, Garo, Hajong, Hmar, Khasi, Jaintia, War, Kuki (Baiate, Changsan, Chongloi, Doungel, Gamathou, Gangte, Guite, Hanneu, Hao Kip Hanpit, Lhonyem, Lhocwun, Lupheng, Mangje, Misao Riang, Sairhem, Selnam, Singson, Haolai, Hengna, Hongsungh, Hrangkhwal, Raokhol, Tongbe, Khawathlang, Khothalong, Khawchung, Khelma, Kholhou, Kipgen, Kuki, Lengthang, Lhangum, Lhoujem, Lhouvum, Misao, Riang, Sairhem, Selnam, Singsom, Sitlhou, Sukto, Thado, Thangngeu, Uibush, Vaiphei), Lekher, Man (Tai speaking), Any Mizo (Lushai tribe), Karbi, Naga, and Pawi.
Nagaland	Lotha, Phom, Pochury, Rengma, Sumi, Sangtam, Yimchungru, Zeliang, Ngami, Ao, Chakhesang, Chang, Khemungan, Konyak, Lotha, Phom, Pochury, Rengma, Sangtam, Sema, Yimchunger and Zeliang. Adi, Aka, Dimasa, Galong, Garo, Khasi and Jaintia, Khowa, Kuki, Karbi (Mikir), Mizo, Naga Ao, Angami, Chakhesang, Chang, Chiru, Khiemnungan, Konyak, Lotha, Makwari, Phom, Rengma, Sangtam, Sema, Tikhir, Yimchungree, Zeliang), Syntheng and Momba.
Sikkim	Lepcha, Bhutia and Nepalese.
Tripura	Tripuri, Jamatia, Bhil, Reang, Noatia, Bhutia, Chakma, Chaimal, Garo, Halam, Khasia, Kuki, Lepcha, Lushai Mag, Munda, Kaur, Orang, Santhal and Uchai

Source: Modified from Dutta and Dutta (2005) and Chakraborty et al. (2012)

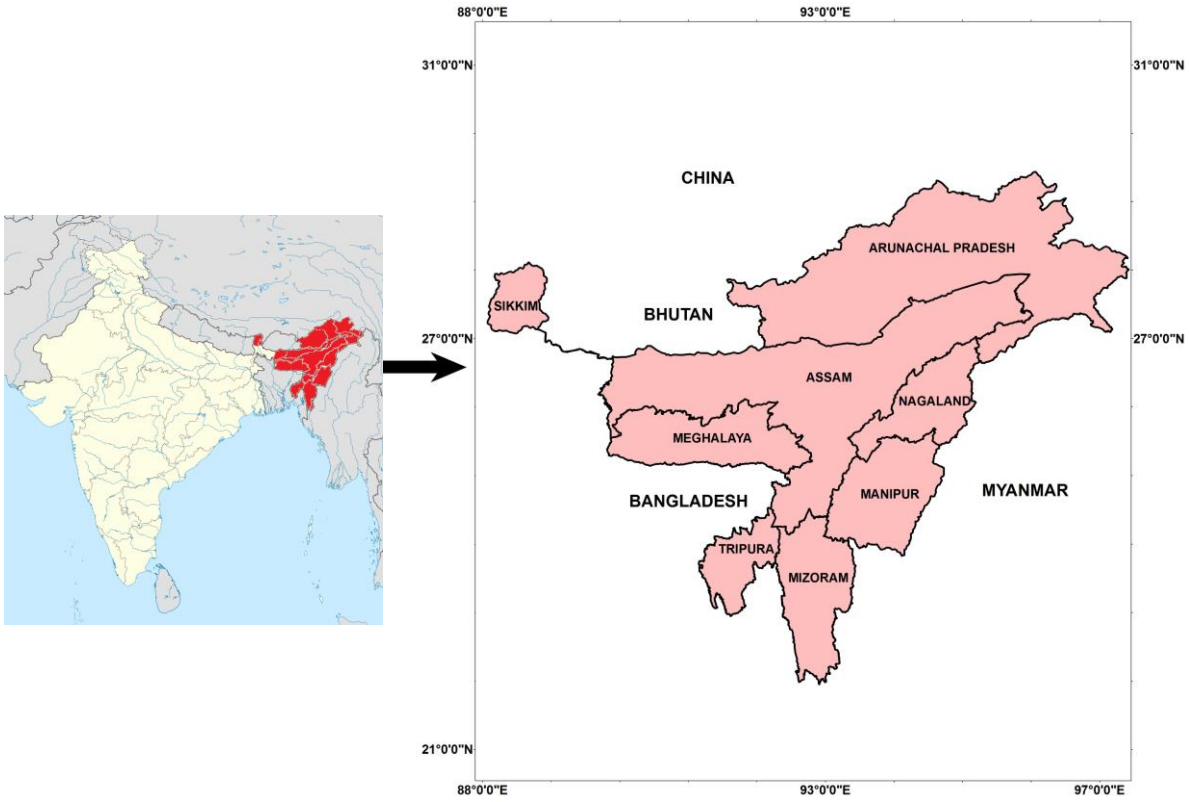

Figure 1. Location map of North East India

STUDY AREA

NE India lies between 21°34 ′N to 29°50 ′N latitude and 87°32 ′E to 97°52 ′E longitudes covering an area of ca 262179 sq. km It includes eight states namely, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura having a population of 45772188 persons. NE India represents 7.9 % of the country's total geographical area. The region shares 5182 km of the international border with Myanmar, Bangladesh, Bhutan, Nepal, South Tibet and China (Fig. 1). NE India is a part of the Indo-Burma biodiversity hotspot harboring about 50% plant biodiversity of India (ca. 8000 species), of which 31.58% (ca. 2526 species) is endemic (De and Medhi 2014). Ripunjoy and Indira (2012) reported that NE India, besides its rich floristic diversity, is also a living anthropological museum as it is the abode of a large number of tribes with varied social-cultural traditions and they lead an intricate life largely dependent on the surrounding biological resources. Mao et al. (2009) reported that more than 200 ethnic tribes with distinct cultural entities inhabit NE India. These tribes possess a wide range of TEK. Documenting such a knowledge system is crucial before it gets lost forever within the speedy drive of modernization and globalization. The role of TEK in meeting the larger goals of biodiversity conservation and understanding the impacts of climate change at small scales is gaining importance in current mainstream conservation paradigms (Tiwari et al. 2017). As such one may come across the concept of sacred groove, sacred sites, sacred forests or trees, etc. which not only conforms to their religious faith and practices but also promotes sustainable development by way of conservation of flora and fauna (Tiwari 2000; Dhar et al. 2000; Kala 2005a; Tiwari et al. 2017), healthcare (Rao 1981; Dolui et al. 2004; Tiwari et al. 2004; Tynsong et al. 2006), fisheries (Mahapatra et al. 2004; Tynsong and Tiwari 2008), forest management (Tiwari et al. 2010; Tynsong and Tiwari 2010; Tynsong et al. 2017), pest management (Umdor 2004; Deka et al. 2006; Bhattacharjee and Ray 2010), traditional bird trapping (Acharya et al. 2009; Tynsong et al. 2010), traditional agriculture (Jeeva et al. 2006; Tiwari 2007; Upadhaya et al. 2020), ethnic food (Singh et al. 2007; Sohliya et al. 2009) traditional crafts (Jha et al. 2014; Pradhan 2019), traditional dye (Akimpou et al. 2005; Mahanta and Tiwari 2005; Kar and Borthakur 2008) and hence are on the verge of being lost.

DATA SOURCES

The research is based on the reports of original investigations as well as reviews. The conclusions are based on the author's interpretation of the published researches. This paper mainly covers the researches published in English. Most literature was consulted from the journals and databases such as Google Scholar, Research Gate, Academia.edu, web sites of author's institutions, and official website of concerned journals. All the screened articles were downloaded and stored in the

computer to facilitate future accessibility. The review of the literature was comprehensive but not all-inclusive for reasons of brevity and to avoid publications reporting the same or similar results. Based on a survey of literature some important TEK systems of NE India are briefly discussed hereunder.

FOREST MANAGEMENT

In the hill region of NE India, large tracts of lands are under the control of local communities (Tiwari et al. 2017). Several communities continue to manage their forests through community institutions (Poffenberger 2007; Tiwari et al. 2017). A study by Tiwari et al. (2010) in Meghalaya, confirms the role of TEK of tribal communities in environmental sustainability, which is inherently developed in their harmonious existence in the given environment. The idea of setting aside protected forests such as 'sacred groves, village restricted forests, village supply forests, clan forests and other traditionally managed forests' which comprises about 90% of Meghalaya's total forest area enables the tribal communities to nurture and conserve forest/trees in the vicinity of their habitations, near water sources, on steep slopes, and other ecologically sensitive regions (Tiwari et al. 2010). These forests are home to rich terrestrial as well as aquatic biodiversity. They harbor diverse species of medicinal plants and animals, wild food, herbs, and many other economically important bioresources. Such traditional conservation of forests and associated vegetation not only helps in conserving biodiversity and natural resources but also acts as a 'safety net' and 'resource ground' for the communities. As such the sacred forests are, according to local belief, the home of a deity who protects the village from natural calamities, famine and diseases while providing vital requirements in daily life, such as fuel, food, construction materials, water, medicinal herbs, edible plants, etc (Mahapatra et al. 2005; Singh et al. 2017; Manoharan and Chinnappan 2019). The local people of Manipur, have a tradition of sacred groves mostly associated with temples. A total of 166 sacred groves have been reported in the state of Manipur which harbors 173 plant species representing 145 genera and 70 families (Khumbongmayum et al. 2005). The Sacred groves in Manipur are repository of high value medicinal and economic plants and function as a refuge to vulnerable and threatened species. Sacred groves are also present in the state of Assam locally known as *Dikhos* by the Dimasa community (Medhi and Borthakur 2013). Further, Medhi and Borthakur (2013) in their study have reported a total of 34 plant species considered to be sacred; 13 species are related to worshiping; 21 species are involved in the naming of areas/villages and 8 species are associated with the naming of the clans in the 12 sacred groves (*Dikhos*) of the Dimasa community. Further, sacred groves are also reported in the state of Arunachal Pradesh, where Chatterjee et al. (2000) reported 58 sacred groves while Khan et al. (2007) reported a total of 101 sacred groves. Similarly, in the state of Sikkim, a total of 56 sacred groves have been reported by Chatterjee et al. (2000).

Further, in Meghalaya, large areas of lowland tropical forests have been converted into betel leaf agroforestry systems (Tynsong et al. 2017) and areca nut agroforestry systems (Tynsong and Tiwari 2010) by the tribal people living in the area. The study on betel leaf agroforestry systems by Tynsong et al. (2017) reveals that it is diverse and structurally complex shade canopies and conserves a significant part of the original forest biodiversity. Local folks through experiential learning over many generations have developed betel leaf agroforestry systems that have emerged as a reasonably sustainable agroforestry system inflicting stripped impact on plant diversity. Similarly, areca nut agroforestry systems support a variety of economically important plant species and other native plant species which contribute to the livelihood of local people in many ways such as the source of food, construction materials, medicines and cash income (Tynsong and Tiwari 2010).

In the light of the above, there's dire urgency to acknowledge, recognize and include TEK in traditional forest management practiced by the tribal groups and indigenous communities, keeping in mind its ecological significance and efficacy, in the modern forest conservation policies and practices (Ens et al. 2015; Boafo et al. 2016; Mavhura and Mushure 2019). It is further recommended that the policymakers, environmentalists, conservationists, resource management committee, etc. should include local communities in planning and development of the natural resources besides utilizing their ecological knowledge and resource management methods for conserving the forest and other terrestrial bioresources. Further studies need to be carried out regarding ecosystem services and other social and economic benefits provided by traditionally managed forests in NE India.

HEALTH SECURITY

Folk medicine/traditional medicine is widely practiced in NE India. Its practitioners include housewives and village elders, plant-based healers, bonesetters, and 'Visha vaidyas' (poison healers). Almost every hamlet in a rural area has a medicine man (Tiwari et al. 2004). Several Indian folk medicine plants or their extracts have already been adopted by Western modern medicine, e.g., *Psyllium husk* for bowel problems and *Cassia fistula* for antibiotic activity. According to the World Health Organization, 80% of the rural population in developing Asian and African countries utilizes locally available medicinal plants for their primary healthcare needs. About 90% of plants having medicinal values in India are found in the natural forests while the remaining 10% is distributed among other landscape elements like open grasslands, plantations, wasteland, botanical gardens, etc. The medicinal plant sector has traditionally occupied an important place in the sociocultural, spiritual, and medical arena of rural and tribal life in India (Pradhan 2008). For rural poor of NE India, medicinal plants are as important as the food they eat every day and that they cannot survive without herbal medicines which they consume both as preventive as well

as curative for specific ailments (Tynsong et al. 2006). NE India has a rich knowledge of folk medicine. Meghalaya, a small state with 3 million population have thousands of traditional herbal practitioners (Tiwari et al. 2004). In NE India, traditional healers use both plants as well as animal products. One example is the use of *Achyranthes aspera* against urinary disorders among the Chakma community in Arunachal Pradesh (Sarmah et al. 2006) while in the Coastal region of Cape Comorin India it is employed against eye burns (Jeeva et al. 2005). The root powder of *Asparagus racemosus* has been found to be effective in chronic peptic ulcer (Mangal et al. 2006) while the Jaintia tribe of Meghalaya use it for urinary disorders as well as stomachache (Sajem and Gosai 2006). *Catharanthus roseus* is known as an anti-cancer drug yielding plant, however, the tribes of Arunachal Pradesh use the same against diabetes (Haridasan et al. 2002). The use of *Centella asiatica* against stomach disorder is common to different tribes and communities of NE India (Haridasan et al. 2002) and is also used as a brain tonic (Jeeva et al. 2005). Similarly, the Khasi tribe of Meghalaya uses *Piper peepuloides* mixed with honey and egg yolk for the treatment of severe cough (Tynsong et al. 2013). Khasi and Garo tribes of Meghalaya use three different species of wild *Citrus* for treatment of various ailments such as cold, headache and body aches, fever, cuts and wounds, food poisoning and stomach disorder (Upadhaya et al. 2016). In India different researchers have reported altogether 2416 ethnomedicinal uses of plants in which researchers from NE India, itself have contributed to the knowledge of 1962 ethnomedicinal uses of plants (Sajem and Gosai 2006) (Table 2).

Using animals and their product to treat patient's plight by a variety of health conditions encompasses a long history and continues to be common in NE India. Jugli et al. (2019) reported that the two tribes of Arunachal Pradesh namely, Tangsa and Wenchow use the body fats of tiger, civet, hornbill, eagle, and python to treat ailments and diseases like joint, bone and muscle pains. The bile of bears is used by both the tribes to ameliorate pain-causing conditions such as stomachache, headache, and toothaches and to reduce labor pain. They also use leeches to remove blood clots and consume either earthworm or tortoise carapace extracts to ward off malaria. They fed to children older than 4 years of age with the flesh of roasted bat wings to stop bed-wetting. In Arunachal Pradesh, Adi tribe use 35 faunal species for ethnomedicinal purposes, to treat coughs, asthma, tuberculosis, paralysis, earache, weakness, muscular pain, malarial fever, convulsion, and diabetes while tribal communities of Mizoram uses 48 faunal species as food, medicine and/or for spiritual and cultural purposes (Chinlampianga et al. 2013). According to Dollo et al. (2009), there's huge TEK embedded within the hill communities of Arunachal Himalaya, notably the Apatani community. This knowledge is based upon the centuries of informal experimentations with the local environment, adapted to the local ecosystem, and is effectively functioning in sustainable resources tapping and conservation. The TEK of Apatani tribe is unique and effective in functioning. The Biate tribe of Dima Hasao,

Table 2. Ethnobotanical survey of medicinal plant based in NE India

State	No of plants reported	Author
Arunachal Pradesh	158	Kala (2005b)
Arunachal Pradesh	19	Ali and Ghosh (2006)
Arunachal Pradesh	50	Namsa et al. (2011)
Arunachal Pradesh	37	Sen et al. (2008)
Arunachal Pradesh	10	Goswami et al. (2009)
Arunachal Pradesh	15	Doley et al. (2010)
Arunachal Pradesh	7	Panda and Srivastava (2010)
Arunachal Pradesh	74	Tangjang et al. (2011)
Assam	85	Saikia et al. (2006)
Assam	39	Sajem and Gosai (2006)
Assam	68	Buragohain and Konwar (2007)
Assam	24	Buragohain (2008)
Assam	107	Das et al. (2008)
Assam	62	Sikdar and Dutta (2008)
Assam	12	Borah et al. (2009)
Assam	26	Choudhury et al. (2010)
Assam	49	Gogoi and Islam (2010)
Assam	20	Saikia et al. (2010)
Assam	24	Choudhury et al. (2011)
Assam	22	Namsa et al. (2011)
Manipur	120	Khumbongmayum (2005)
Manipur	20	Singh and Singh (2005)
Manipur	4	Devi and Pattanayak (2008)
Manipur	44	Khan and Yadava (2010)
Manipur	33	Sharma et al. (2011)
Manipur	20	Yumkham and Singh (2011)
Meghalaya	46	Dolui et al. (2004)
Meghalaya	7	Agrahar-Murugkar and Subbulakshmi (2005)
Meghalaya	80	Laloo et al. (2006)
Meghalaya	249	Sawian et al. (2007)
Meghalaya	54	Hynniewta and Kumar (2008)
Meghalaya	19	Chhetri (2010)
Meghalaya	42	Tiwari (2000)
Mizoram	135	Sharma et al. (2001)
Mizoram	17	Bhardwaj and Gakhar (2005)
Mizoram	89	Lalfakzuala et al. (2007)
Mizoram	159	Rai and Lalramnghinglova (2010)
Nagaland	51	Rao and Jamir (1982)
Nagaland	35	Jamir et al. (1999)
Nagaland	109	Changkija (1999)
Nagaland	55	Jamir et al. (2010)
Sikkim	15	Maity et al. (2004)
Sikkim	28	Hussain and Hore (2007)
Sikkim	36	Chanda et al. (2007)
Sikkim	118	Pradhan and Bodola (2008)
Sikkim	19	Bharati and Sharma (2010)
Sikkim	31	Panda and Misra (2010)
Sikkim	25	Lapcha et al. (2011)
Tripura	37	Singh et al. (1999)
Tripura	33	Majumdar et al. (2006)
Tripura	40	Sankaran et al. (2006)
Tripura	50	Majumdar and Datta (2009)
Tripura	33	Das et al. (2009)
Tripura	16	Shil and Dattu Choudury (2009)
Tripura	26	Das and Chaudhury (2010)
Tripura	63	Das et al. (2010)
Tripura	113	Sen et al. (2011)

Assam uses the fermented fat of *Python molurus*, *Gallus gallus*, and *Rhyticeros undulates* and dried or fresh flesh of *Lutrogale perspicillata* to cure burns (Betlu 2013). The Ao tribe of Nagaland uses twenty-five different vertebrate species for traditional therapeutic use (Kakati et al. 2006). Singh (2014) conducted an ethno-entomological survey on the edible insects in the state of Manipur and recorded eleven species of insects having medicinal value.

Sustainable management of medicinal plants can support sustainable economic development, affordable health care, and conservation of biodiversity. Research attention is especially required for rural poor dependent on the medicinal plants for their healthcare and people living on the forest fringes to diversify their livelihood prospects through sustainable production and trade of medicinal plants. There is a need for more work to make sure that the benefits from new drugs developed by using TEK are fairly and equitably distributed, as mandated by the Convention on Biological Diversity. The problem is that traditional healers are often reluctant to share their knowledge and youth of today's generation are less and less interested in learning traditional medicine practices. Lack of dedicated investigators willing to spend time in distant places and visit and conduct interview with traditional healers and obtaining reliable information also act as bottleneck in documenting the TEK on health security. The tribal people must understand that preserving animals in their be sensitized and made aware of the extant Acts and Rules pertaining to wildlife conservation.

TRADITIONAL AGRICULTURAL PRACTICES

Though shifting agriculture (locally called jhum or shifting cultivation) is a main land-use system in the NE India (Ramakrishnan 1992), the tribal people of NE India have several other important agroecosystems types as well. Rai (2005) reported that Apatani tribe of Arunachal Pradesh have evolved inactive agriculture, known as wet rice cultivation (Jebi Aji cultivation) in their in-depth depression lands, using indigenous techniques and classified into three types locally known as *Jebi*, *Aane*, *Ditor* based on the availability of natural and artificial water supply. *Ditor* is fully dependent upon the irrigated water supply while *Jebi* and *Aane* depend on water supply from natural streams and rainwater. Singh and Gupta (2002) in their study reported that wet rice cultivation, using a combination of paddy and fish together with millet on the bunds separating each plot is considered to be one of the most productive and efficient agricultural systems of the region. It is further elaborated that in *Jebi Aji* cultivation, a small pit is dug in each terrace in a series of terraces where paddy is grown and fingerlings are put in the water in these pits. Thereafter, when the water supply is enough in monsoon season, the paddy field is kept under shallow submergence of 5 to 10 cm and fishes come out of the pits and move around the submerged space of the terrace field, whereas during water deficiency period, fishes run back to the pits and grow. Further, it is reported that fishes get better nutrition due to the manuring of paddy fields and their growth is better due to the availability of larger surface area during full submergence of paddy fields. Rai (2005) concluded that both paddy and fishes are produced together by proper management of rainwater. Another indigenous form of paddy cultivation on terraces is practiced in the state of Nagaland. It is locally known as *Zabo*. According to Kithan (2014), *Zabo* is devised by the people based on the available resources and began in Kikuma village of Phek district of Nagaland. Singh et al. (2018b) elucidate that the *Zabo* system of farming has a mixture of biological science, agriculture, animal husbandry and soil and water conservation.

Traditional agriculture practices in the state of Meghalaya are reported by Jeeva et al. (2006). The local communities follow two major types of agricultural practices viz., *jhum* (shifting cultivation) and *bun* (raised bed cultivation). Jhum is practiced in and around forests, whereas bun is mostly practiced in higher elevations on gentle slopes and foothills, and sometimes within plantation forests. These traditional systems of cultivation practices are well adapted to the environmental conditions and the traditional knowledge of local communities growing cereals and other agricultural crops has enabled them to maintain an ecological balance. Tree-based farming practices are also prevalent in the state of Meghalaya. The principal crops are always grown in association with tree species like alder, Aquileria, areca nut, coconut, bamboo, Khasi pine, etc. Due to undulating topography and hilly terrain, the farmers of south Meghalaya at times use bamboo/pipe drip irrigation practice for the cultivation of betel leaf. Tiwari (2007) reported that the local tribe of Meghalaya practices four types of shifting agricultural systems viz., traditional, distorted, innovated, and modified shifting agriculture. Tiwari (2007) found out that in recent years *bun* agricultural practice in Meghalaya has undergone several changes due to an increase in population, growing food demand, limited land availability, and the socio-economic condition of the farmers (Alston and Pardey 2014). Similarly, a detailed account of *bun* agricultural practice by the Khasi and Jaintia tribes of Meghalaya was reported by Upadhaya et al. (2020), where farmers grow the crops under a completely rainfed condition and make use of limited biomass and land resources, organic fertilizers and pesticides, thereby making the system sustainable and fallow the land for a period of one to three years to restore soil fertility. Tiwari (2020) reported that shifting agriculture in Meghalaya embody changes in cropping pattern, choice of crop, management of pest and management of fallow that adapt well to native climate with higher food production and economic benefits.

Another example of TEK based agricultural practices is the Alder Based Agroforestry System practiced since time immemorial by indigenous tribes of Nagaland viz., Angami, Chakhesang, Chang, Yimchunger and Konyak (Ramakrishnan 2000); Das et al. 2012). In alder-based agroforestry system a number of crops such as rice, tapioca, potato, colocasia, cardamom, turmeric, beans, etc., are grown as an intercrop with alder trees (*Alnus nepalensis*). The root nodule of alder trees is responsible

for fertilizing the soil and the roots help in preventing soil erosion in slopes (Rathore et al. 2010; Das et al. 2012). In this system, the seedlings area unit planted in jhum field maintaining a spacing of 3-4 m between plants and 5-6 m between rows. In the first year, primary crops (rice) and secondary crops (amaranthus, colocasia, chilli, tapioca, and potato) are grown intermixed in the jhum field. According to Kehie et al. (2017), alder-based agroforestry is an outstanding sustainable model of land use that evolved through many years of testing among the indigenous tribes of Nagaland.

Traditional forms of farming knowledge and practices need preservation as it helps in maintaining biodiversity, enhance food security, and protect the world's natural resources (Syarief et al. 2017). Achieving food security and production along with preservation of the environment is the urgent need of the hour (Wiryono et al. 2019). The constraints in achieving sustainable agriculture are due to limited land and water resources along with its adverse effects on environmental health due to excessive use of chemicals for maintaining soil fertility and pest management in modern agriculture. Traditional agriculture practices have proven to be more sustainable in this respect. However, more research needs to be done on traditional agricultural practices particularly on their impact on the environment like depletion of nutrients, deforestation, and erosion.

WILD EDIBLES

The people of NE India depend to a great extent on forest resources for their requirements, ranging from food, fuel to shelter (Tynsong et al. 2012b and Dutta and Dutta 2005). Tiwari (2000) reported a total of 106 plants and animal-based Non-Timber Forest Products (NTFPs) from NE India, including 36 plant-based NTFPs used as food, vegetables, fruits, and tubers. Sharma et al. (2015) reported that a total of 135 plant-based NTFPs were collected by different tribes of Arunachal Pradesh. Chettri et al. (2005) reported 94 NTFPs from Sikkim collected by different tribes as wild edible. Similarly, Lalfakzuala et al. (2007) reported 44 wild edible fruits from Mizoram. Ethno-botanical surveys carried out by Kayang, (2007) from the state of Meghalaya noted that the *Khasi*, *Jaintia*, and *Garo* tribes are consuming in the raw or cooked form a total of 110 wild-growing plants. Lynser and Tiwari (2016) reported that out of a total of 139 wild plants collected by different tribes of Meghalaya; the majority are collected for food (40%). Medhi et al. (2014) reported a total of 168 species of plants and fungi used by tribes of Dima Hasao district of Assam as wild edible. Singh and Teron (2015) reported the use of 84 wild edible plants belonging to 68 genera from 40 families by the Angami-Nagas of Nagaland. In Meghalaya, NTFPs have become an important source of cash and subsistence income for poor people living in or near forests (Tynsong et al. 2012b). People within the region have historically been collecting different forest products from non-public forests as well as community preserved forests. A good number of studies have been carried out on wild edible used by different tribes in NE India. Some of the studies on wild edible in NE India are given in Table 3.

The literature survey revealed that NE India is immensely rich in wild edible plants. It is recommended to undertake detailed ethnobotanical studies of the entire NE region involving as many ethnic groups as possible to make sure and unearth many more information relating to the wild edible plants before, the knowledge is lost or the plants become extinct. The information will be useful for conservation purposes as well as for taking up breeding programs for the rare, endangered and threatened wild edible plants.

FISH CULTURE AND HARVEST

The Apatani tribe of Arunachal Pradesh, practices a composite of rice cultivation combined with fish culture in which a stocking rate of 2,500-5000 fingerlings/ha using common carp, grass carp, and silver carp fishes has been reported (Dollo et al. 2009). Integrating fish with rice cultivation assures higher per square measure economic productivity and year-round employment opportunities for farmers. The farmers apply a variety of domestic waste products to their rice fields to enhance soil fertility and for fish food, which in turn improves rice as well as fish productivity. Tynsong and Tiwari (2008) reported that the War Khasi community of south Meghalaya possesses a wealth of knowledge related to ethnofishery techniques. Further, it has been highlighted that these techniques are specialized according to the structure and size of the stream, the season, and species of fish intended to be harvested. Tynsong and Tiwari (2008) further reported that the fishers have evolved many specialized and creative fishing techniques, principal among them regionally best known as *Krang Wah*, *Buh Kroh*, *Riam Kkriah*, *Riam Khohka*, *Ring Khashiar*, *Riam Kkyllong*, *Buh Ruh*, and *Bia Dohpieh*.

Table 3. Number of wild edible plants used by different tribes of North East India

Tribes/ethnic/groups/ indigenous people/ area	No. of plants reported	Authors
Hmar, Jaintia, Khasi, Kuki, Riang, Rengmai	63	Nath and Dutta (2000)
Khasi, Jaintia	30	Joseph and Kharkongor (1997)
Manopas	37	Dam and Hajra (1997)
Mikirs	25	Borthakur (1997)
Mishing	18	Singh et al. (1996)
Mishing	51	Hajra and Baishya (1997)
Naga	56	Rao (1997)
Naga	30	Jamir (1999)
Nishi Apatani	39	Rawat and Choudhury (1998)
North East India	213	Arora (1997)
Shan	8	Bora and Pandey (1996)
Tea Tribes	35	Das et al. (2000)

Traditional fish harvesting is generally sustainable as they work under regulations framed by the community. Ethnoecological knowledge and community control of fish harvesting is in place since time immemorial and is passed on from generation to generation by word of mouth. However, more information needs to be collected on traditional fish culture and harvest practices by ethnic groups of NE for adopting and or incorporating traditional approaches into scientific fish farming.

PEST MANAGEMENT

TEK in pest management is reported by Deka et al. (2006) in the rice fields of Assam. The farmers use TEK for control of rice pests. It is reported that farmers use extracts of plants such as neem (*Azadirachta indica*), pumalo (*Citrus grandis*), phutuka (*Melastoma malabathricum*), drumstick (*Moringa oleifera*), fern, Coconut (*Cocos nucifera*) bamboo, duck dung, and cow dung, to control common insects and infections such as Thrips (*Thrips oryzae*) infestations, rice stem borer (*Scirpophaga incertulus*), rice case worm (*Nymphula depunctalis*), rice leaf folder (*Cnaphalocrocis medinalis*), fruit fly (*Bactrocera cucurbitae*), rhinoceros beetle (*Oryctes rhinoceros*), rice moth (*Sitotroga cerealella*) and potato tuber moth (*Pthorimaea operculella*). Use of plants in pest management is also reported by Paul and Choudhury (2016) where indigenous plants of Meghalaya namely *Lantana camara, Gaultheria fragrantissima, Litsea cubeba, and Pinus kesiya* show insecticidal activity against fourth instars larvae of the cotton bollworm (*Helicoverpa armigera*). Further, a study conducted by Umdor (2004) in the southern part of Meghalaya brings out a vivid picture of TEK in pest management of areca nut. The areca nut seedlings are often damaged by the grubs of a red palm weevil that kill the seedling. However, the farmers with their ancient knowledge simply see the plagued seedlings, and with their native practices of "checking the grubs in nuts" domestically referred to as "peit ksain kwai" control the damage of the young plants. TEK of Khasi tribe in identifying and protecting Areca nuts damage in the young stage is very effective and widely practiced. Another study conducted by Bhattacharjee and Ray (2010) illustrated how *Meitheis* of Manipur residing in Barak Valley, Assam use traditional knowledge-based methods to protect their paddy from insects. For example, twigs of *Vitex negundo* are used to control the rice hispa (*Dicladispa armigera), Dillenia indica* leaves are used to repel rice weevil (*Sitophilus oryzae*), *Polygonum hydropiper* is used to repel rice moth (*Sitotroga cerealella*), *Clerodendrum viscosum* twigs are used to control *Leptocoryza* sp and leaves of *Azadirachta indica* are used to repel rice weevil (*Sitophilus oryzae*).

There has been a growing concern in recent years that insecticides constitute a possible risk to the well-being of nature and natural resources including human beings. Therefore, biological control and bio-pesticides need to be encouraged. A good volume of research is being conducted on the biopesticides and biocontrol of crop diseases; however, the linkage of these researches with TEK is conspicuously missing. Since the extent of research is limited, there may be many TEK based pest management practices which require to be documented, for example, the TEK of Khasi tribe in disease management of betel leaf agroforest has not yet been properly documented.

BIRD CATCH AND CONSERVATION

In Meghalaya, the art of bird catching has evolved with the native communities and is being passed on from generation to generation. The War Khasi community of Meghalaya possesses a wealth of knowledge associated with bird catching and hunting. In an effort to understand the importance of birds as a wild resource of rural tribal people of Meghalaya, Tynsong et al. (2012a) documented the local hunting techniques, the season of availability of birds, tools used in hunting and purpose of hunting. It was found by Tynsong et al. (2012a) that bird catching and hunting in the forests of Meghalaya has been practiced since time immemorial and represents not just a form of resource extraction but also a traditional form of wildlife management. Thirty species of birds were reported to be most hunted and were used by the local communities for various purposes such as food, pets, recreation, sports, and cash income. The hunters have evolved many specialized and innovative techniques for birds catching and hunting. The local people think that degraded and secondary forests harbor fewer species of birds than primary forests in the same locations which corroborate recent ecological studies elsewhere (Peres 2000). Tynsong et al. (2012a) felt that it is this congruence between TEK and conventional scientific studies that form the basis of a constructive goal-based dialogue among scientists, conservationists, and indigenous people. Although catching and hunting of birds may be damaging to the wild populations, it's vital to notice the hunter's perspective who felt that jhum cultivation, commercial logging, and conversion of natural forests into agroforests have led to the loss of habitats of the birds. Such data on hunters' 'guild' would be helpful to grapple with the issues of setting sustainable limits on the use of wild bird resources in this region. Acharya et al. (2009) highlighted how *Lepcha* community of Sikkim identifies birds using the indigenous knowledge system.

Further research must be conducted, on traditional uses of wild bird resources to develop a more sustainable management approach to the conservation and utilization of this wild resource. The traditional bird hunters should be made aware of the extant Acts and Rules regarding wildlife.

ETHNIC FOODS

A significant study by Singh et al. (2007), confirms the rich traditional foods processed and prepared by women folk in NE India who are intimately connected to their socio-cultural, ecological, spiritual life and health. Ethnic foods diversities embody foods made from native soybean, vegetable, tree bean, *lai patta* (leafy mustard) and *rai*

(*Brassica juncea*). The process and preparation of ethnic foods undisputable the creativeness and treasure of food heritage of tribal women folks and their incremental learning to sustain the life and ecosystem. Tribal women of NE India have a good vary of variability within the ethnic foods wherever process technique of those foods is somewhat totally different in every tribe supported the culture, variability within the materials used in the food, climate and overall information of the process and preparation (Singh et al. 2007). The ethnic foods are reported to be nutritionally rich and culturally important in various ceremonies and festivals. Sohliya et al. (2009) also reported about the famous local dish known as *Tungrymbai*, a fermented indigenous soybean food in Meghalaya.

Different fermented and non-fermented foods in a variety of combinations are included in tribal culinary fulfill the food and nutritional security. Documentation of indigenous knowledge pertaining to food preparation and its association with knowledge on indigenous farming systems is urgently needed. Each state in NE India has something special to add to the culinary landscape of Indian subcontinent. More information needs to be gathered from the NE region particularly on the nutritional value of such ethnic foods.

TRADITIONAL CRAFTS

NE India is the land of traditional crafts and artisans, who perpetuate and innovate their original skills to make it suitable for the emerging markets (Pradhan 2019). Traditional crafts are labeled as "folk art", "local art", and "green art". The products are designed for rural, domestic, and international markets. Popular traditional crafts available in the state of Assam includes craft on jute diversification, bamboo, cane, areca nut leaf, etc., in Meghalaya the traditional crafts include weaving on textile or cane, woodcarving, bamboo work, baskets, caps, winnowing fans, umbrellas, stools, cane mats, etc. Nagaland traditional crafts include wood carving, weaving, basket, etc. Tripura traditional crafts include wood, cane & bamboo and Manipur traditional crafts include natural fiber crafts, cane and bamboo crafts, woodcarving, textile weaving, etc. Making of bamboo and cane products in NE India has been practiced for hundreds of years and is probably the foremost wide use of all the crafts practiced by a huge variety of artisans scattered throughout the region. Jha et al. (2014) reported that artisans in the state of Assam make varieties of bamboo, cane and wood-based products such as sofa sets, pen, decorative items, wall hangings, *jhapies*, *murrahs*, baskets, fishing accessories, weaving accessories, musical instruments, *jharia*, *darma*, table mats, handbags, folders, etc. Bamboo plays a very significant role in rural livelihood in providing employment and cash income to local people through the production of artifacts and crafts (Lynser et al. 2015). The study conducted by Lynser et al. (2015) revealed that in the southern parts of Meghalaya large percentage of the households are involved in bamboo mat making and considered as one of the important occupations that supplement the income of the rural people especially women during periods of the year when employment is scarce. Similar findings reported by Kuokkanen (2011) where indigenous women are often overlooked in terms of their importance to subsistence practices and economies.

Providing skill development to villagers on marketing, sustainable harvesting, forest conservation, and developing business linkage is extremely important for the artisans as well as conservation of bioresources used for making the crafts. Giving financial assistance also will improve quality, quantity, and design of artisan's products. Lately, there has been a decrease in the availability of raw materials like bamboo, cane and wood, because of which area of collection has decreased, and hence the volume of production of the craft products is declining. There is a necessity to conduct further research and document community-based TEK relating to traditional craft in NE India as there is a threat of loss of the knowledge with shrinkage of resource base and reduction in number of artisans.

TRADITIONAL DYES

Natural dyes are used in coloring textiles, drugs, cosmetics, etc. Different ethnic groups, residing in Manipur before the introduction of the chemical dyes into the state, used the dyes extracted from the plants (Akimpou et al. 2005). Different ethnic communities of Manipur commonly use a total of eighteen dye yielding plants belonging to sixteen families for dyeing the cloth and other items (Akimpou et al. 2005). The use of dye extracted from plants have also been reported by Mahanta and Tiwari (2005) in which the Monpa tribe of Arunachal Pradesh use *Daphne papyracea* for preparing dye and for making hand-made paper for painting and writing scripts. Kar and Borthakur (2008) also reported that different tribes of Assam use forty-seven dye yielding plants to dye their cotton, woolen yarns, garment, and silk. Tribes of Manipur have been using indigenous dyes extracted from plants since time immemorial, in handlooms, handicrafts, and fine arts. Potsangbam et al. (2008) reported that in Manipur more than fifty plant species are used as dyes right from ancient times. *Parkia javanica, Strobilanthus flaccidifolius, Melastoma malabathricum, Pasania pachyphylla, Solanum incidum, Bixa orellana, and Tectona grandis* are most commonly used plants by different tribes of Manipur for dye extraction. Tiwari and Tynsong (2004) reported that in Meghalaya fifteen plant species are used by Khasi, Jaintia and Garo tribes as a natural dye and most commonly used species included *Artocarpus lakoocha, Albizzia odoratissima, Castanopsis indica, C. tribuloides, Smilax* sp., *Symplocus racemosa, Musa* sp. and *Terminalia chebula.*

The review of literature shows that it is essential to safeguard and conserve the dye yielding plant resources in order that the commercialization of natural dye gains ground resulting into improvement in the socio-economic condition of the local people. There is a need to document

the use of natural dye by local weavers involved in handloom and textile-based cottage industries in the region.

FORECAST AND BELIEFS

Birkumar (2011) reported a total of ten plant species that are used as indicators in weather forecasting, predicting natural calamities, or as taboos or signals of bad omens, among the Meitei community of Manipur. This knowledge system is still prevalent among the local people, especially in rural areas (Birkumar 2011). For example, Birkumar (2011) reported that it is believed that *Quercus serrata* is often hit by lightning and houses constructed with its wood might be harmed by the lightning. Similarly, *Agave americana* is used to predict the direction of winds and storms in a given year. It also believes that the wind or storm is expected to blow from the opposite direction from where the greatest number of flowers is positioned on an inflorescence. Also, it is assumed that the family that cultivates *Alocasia indica* and flowering is noticed, that family could face lots of difficulties and bankrupt. Cutting down of *Bambusa* sp., on Tuesdays and Saturdays is prohibited; it is believed that the bamboo colony may die shortly and the prosperity of the family may decline. The plant species viz., *Brassica campestris, Ficus rumphii, Hibiscus cannabinus, Mangifera indica, Platycerium wallichii,* and *Terminalia tomentosa* are also associated with different belief in Manipur. Similarly, the study conducted by Chinlampianga (2011) in Mizoram revealed that tribal peoples forecasted the weather through TEK. Tribal folks of Mizoram show sixteen distinct indicators for the detection of distinctive situations i.e., the behavior of insects, birds and mammals, characteristics of plants, and site, temporal order, and patterns of clouds, stars, moon, lightning, wind, and sun. For example, Chinlampianga (2011) reported that rain is expected if male bamboo partridges (*Bambusicola fytchii)* roar often during spring and summer in the morning after sunrise. Also, it is believing that rain will not come again for some time when *Reticulitermes* sp. come out of the soil in a group after rainfall occurs and heavy rain is expected on the same day, or within one or two days when a number of ants (*Lasius alienus*) moving along a path carrying their food items. If the frogs (*Rana temporaria*) croak in a water body in the afternoon until sunset, the rain will be coming soon, even during winter and spring season.

Local communities across the planet, are able to make forecasts about seasonal and extreme weather events, like floods, tropical cyclones, and drought, by observing the environment around them (e.g., Lefale 2010; Orlove et al. 2010; Garay-Barayazarra and Puri 2011; Masinde 2015). However, there are concerns over the loss of traditional forecast and belief, in part, through rapid urbanization and stress on western science and a reported changing reliability and loss of traditional indicators (Masinde 2015; Plotz et al. 2017). More studies have to be carried out with regard to TEK on bioindicators in weather forecasting, predicting natural calamities, or as taboos or signals of bad omens possessed by different tribes of NE India.

DISCUSSION AND CONCLUDING REMARK

Indigenous people over several generations have developed a holistic TEK system of their lands, natural resources, and surroundings, which could be a lot of or less integrated information system that focuses more on cultural adjustment to bio-physical surroundings at the local level. This review reflects that documentation of TEK is fundamental for preserving such knowledge systems both for current and future generations, as well as for protecting intellectual property rights of indigenous/traditional communities. Local tribes of NE India due to lack of development and scientific knowledge through experimental experience employ TEK in every aspect of their life such as forestry, agriculture, health care, food, insect pest management, craft, belief system, dye, etc.

Understanding the TEK of indigenous people in the resource management system is essential for sustainable natural resource management. Many studies also suggest that TEK is increasingly seen more as an efficient and practical tool for forest management by involving the local communities (Khumbongmayum et al. 2005; Tiwari et al. 2010; Tynsong and Tiwari 2010; Tynsong et al. 2017; Singh et al. 2017). TEK in the traditional forest management system of indigenous people is rooted in their cultures, norms and belief systems practiced by such communities. Indigenous people usually hold excellent knowledge about the reproductive habits and life history of plant and animal species (Tiwari et al. 2010). Hill et al. (2020) also echoed that working with indigenous and local knowledge is vital for inclusive assessments of nature and nature's linkages with people. It is also important as it is a source of biological knowledge and ecological insights (Russell et al. 2015; Garnett et al. 2018). Traditional forest management contributes to water availability, livelihood, food security, biodiversity conservation and health care of the people (Halim et al. 2012). Traditional forest management is built upon the active participation of the local people; social justice and equity are the key ingredients of bioresources management (Geronimo et al. 2016). Most indigenous natural resource management system needs little or no external input, is flexible and evolves with time for which an in-built mechanism in the form of traditional institutions is in place. The TEK of all ethnic communities in traditional forest management system may serve as valuable data for developing conservation strategies (Kim et al. 2017). It is mistaken to view forest management practice only in the term of silvicultural approach. This issue has to be viewed with the social, cultural, religious, and ecological dimensions for its sustainability (Bortolamiol et al. 2018; Erawan et al. 2018). The TEK suggests that forest management should integrate sociocultural and ecological phenomenon and should be aimed to sustain human needs and nurture the ecosystem integrity (Ceuterick et al. 2011; Turnhout et al. 2012; Gómez-Baggethun et al. 2013).

The international bodies have recognized and emphasized the importance of TEK practices within the conservation of biological diversity. For example, Article 8 (j) of the United Nations Convention on Biological

Diversity clearly states the necessity to "respect, keep, and support innovation and practices of indigenous and native communities associated with sustainable use of biological diversity" (United Nations, 1992). The World Bank (1998) and Millennium Ecosystem Assessment Report (Millennium Ecosystem Assessment, 2005) embraced the contributions of TEK in sustainable forest management. This clearly emphasizes the high impacts of TEK in biodiversity conservation issues where, ecologists, ethnobiologists, and arborists share an interest in TEK for scientific, social, or economic reasons (Berkes et al. 2000). Most TEK studies have focused on a range of topics including biodiversity (Charnley et al. 2007; Adom et al. 2016), natural resources (Juanwen et al. 2012; Berkes 2017), wetland (Adams 1993) and ecosystem services (Boafo et al. 2016). TEK has contributed to forest conservation and management in various parts of the world including Ghana (Osei-Tutu 2017), Iran (Ghazanfari et al. 2004), Zimbabwe (Mavhura and Mushure 2019) and Philippines (Camacho et al. 2016).

The review shows that tribal people of NE India use wild plant resources for innumerable uses such as food, medicine, dye, weather forecasting, and craft. Therefore, TEK and related practices are the instruments for promoting cohesion between the ecosystem and human well-being (Harisha et al. 2015). Sustainable management of medicinal plants and the wild edible plants can lead to sustainable economic development, affordable healthcare, and conservation of vital biodiversity. Commercialization, coupled with proper management for intensive cultivation (domestication), can bring brighter prospects for the future of forest-dependent people (Tiwari et al. 2009). Conservationists and development managers need to address the challenges of balancing livelihood improvement, medicinal and wild edible plant trade and biodiversity conservation concerns. Introduction of right, simple, and low-cost technologies needs to be encouraged for sustainable use of medicinal and wild edible plants through local production centers. Utilizing TEK the state governments of the region should list the important plant species and frame guidance on the collection and uses of these species to regulate the overexploitation of rare and threatened species (Tynsong et al. 2006). The involvement of all stakeholders, i.e., collectors, traders, manufacturers, and consumers, through sharing of benefits can help a great deal in the conservation of this resource so vital for human health and survival. Appropriate management and harvesting methods need to be developed to allow regeneration and maintenance of a viable population of medicinal plants in natural habitats including forests. The full participation of local communities in the conservation and management of medicinal and aromatic plants (MAPs) is desirable. Multi-national pharmaceutical industries and drug manufacturers need to invest part of their income in the conservation and management of MAPs (Tiwari et al. 2004). There is a need for more work to make sure that the benefits from new drugs or botanical developed and manufactured using TEK are and equitably distributed, as required by the Convention on Biological Diversity. While people in most parts of India as well as the world have already forgotten the use of wild plants for edible and medicinal purposes, it is still well preserved and practiced by tribal communities in NE India. According to Timothy and Eyzaguirre (2002), conservation and sustainable use of biological diversity (Rizza et al. 2017) is of critical importance in meeting food, fiber, fodder, water, health and other needs of a growing population, for which purpose, access to and sharing of both genetic resources and technologies are essential. Overexploitation of natural resources in favor of capital formation is the prominent factor for the depletion of such resources. This has caused various ecological problems like land degradation, desertification, denudation, landslides, floods, drought, and several other environmental hazards.

TEK of *War Khasi*, Meghalaya relating to their traditional bird hunting practices from a conservation point of view are unsustainable and therefore undesirable. Maybe in the past, the practice was desirable as it acted as a source of food for the forest dwellers. When the extraction from wild exceeds the sustainable production, the system becomes unstable and ecosystem decline sets in (Tiwari et al. 2009; Ayaa and Waswa 2016). This is an example that all traditional ecological knowledge does not deserve to be perpetuated in a present-day situation. Some of these may have been sustainable when the human population was small and natural ecosystems abound all around. The *Lepcha* tribe of Sikkim also monitors and conserves avifauna using TEK (Acharya et al. 2009). Research and documentation of TEK of tribal people related to conservation and sustainable use of biological diversity are needed for the benefit of the present as well as future generations. Involving all stakeholders in a participatory mode including tribal people, ecologists and government officers for the conservation and utilization of bioresource wealth of this region is the need of the hour. Awareness creation among people, school children, students in colleges and universities is very important to conserve the biodiversity wealth. It is worth noting that despite growing awareness of TEK in the field of natural resources management, such knowledge systems are rapidly vanishing in many Asian countries (Tiwari et al. 2017). TEK embedded in the cultural practices is likely to be lost irretrievably when the culture or society experiences drastic socio-economic changes as has happened in the most developed world. The loss of TEK, often adversely influences local level land-use-practices and forest resource management. One of the causes of failure of mainstream sustainable forest management is due to the lack of attention given for addressing the importance of TEK systems in government policies designed for forest management (Tiwari et al. 2017). It is most essential to incorporate TEK systems into scientific forest management systems particularly in the hill regions of NE India predominantly inhabited by tribal people. To move towards sustainable ecosystem governance at multiple scales, building synergies between TEK and scientific knowledge systems has been recognized as a key opportunity (Takeuchi 2010; Emery et al. 2014; Ulicsni et al. 2019).

Many recent studies have emphasized on the urgency to offer a proper platform to TEK by way of adopting, re-

defining, and integrating it into mainstream policy and programs for the planet to attain greater sustainability (Housty et al. 2014; Polfus et al. 2014). Further, documentation needs to be carried out with respect to TEK of local tribes in NE region on food preservation, food processing, use of poisonous plants, rituals, living root bridges, hunting of animals and avifauna and climate change.

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