Plant bioresource dependency and climate perspectives in tropical forests of the Eastern Himalaya

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Research

Abstract

Background: The Indian Himalayan Region harbours significant plant bioresources that are essential for species' survival. These plants provide food, medicine, and economic support while preserving cultural heritage and ecological sustainability. The present study investigates the dependency of local communities on forest plant bioresources, the transmission of ethnobotanical knowledge, and the impacts of climate change on resource availability.

Methods: A comprehensive structured questionnaire survey was carried out in 86 households in the Soraipung range using a stratified random sampling method. Data relating to ethnobotanical plants and their socio-economic characteristics were collected over 12 months from September 2021 to August 2022. The informant consensus factor (F_{ic}) was calculated to assess the uniformity of ethnomedicinal plant use across ailment categories. The plant species were identified using relevant literature, the necessary data were collected.

Results: It was found that the local people used a total of 80 plants of ethnobotanical importance available in the forest. Among these, 65 species were identified as edible and economically valuable plants, and 44 species have medicinal values. Notably, 25 plants were classified as having edible, economical and medicinal properties. These plants were found to be utilized either for their own consumption and/or commercial purposes.

Conclusions: This study has highlighted the significance of preserving ethnobotanical knowledge of available plant bioresources. It also emphasizes the need for further research to provide insights into traditional knowledge to support livelihoods and resilience in the face of climate change.

Keywords: Bioresources, Climate change, Ethnobotanical, Forests, Livelihood, Traditional Knowledge.

Background

Many communities all over the world rely on forest resources as their primary source of subsistence. Forests play a significant role in the economic well-being of local people and provide a wide range of goods and services essential for human survival. Approximately, 1.6 billion people worldwide, primarily those living in poverty, depend on forests for their means of livelihoods (World Bank 2004; WRI 2005). These individuals generate income from forest-related activities, which in turn helps to alleviate poverty in rural areas (Angelsen & Wunder 2003; Cavendish 2000; Fisher 2004; Hogarth *et al.* 2013; Sunderlin *et al.* 2005; Sunderlin *et al.* 2008; Vedeld *et al.* 2007; Yemiru *et al.* 2010). Forest dependence is a separate idea that derived from the utilization and reliance of forest resources. Forest use includes the direct harvesting of forest products as well as using their resources like water and land for agriculture and cultural practices (Campbell 2005; Sunderlin *et al.* 2005; Anthwal *et al.* 2010). Relationships between communities and forests range from purely economic to having profound cultural and spiritual dimensions (Byron & Arnold 1999; Youn 2009). A new study that mapped the spatial relationship between people and forests on a global scale by combining data on tree cover and human population density found that 95% of all people living outside urban areas, or 4.17 billion people, lived within 5 kilometres of a forest in 2019. Furthermore, 75% of these people or 3.27 billion people, lived within a distance of one kilometre from a forest (Newton *et al.* 2022).

Dubois (2003) outlined the contribution of forests in providing essential resources for the livelihoods of indigenous communities, including subsistence products, marketable goods, revenue from employment, and indirect benefits in the form of ecosystem services. Newton *et al*. (2016) developed a typology of definitions of "forest-dependent peoples" based on an emphasis on the characteristics of forests, reliance, or peoples individually. Depending on the local conditions, the percentage of households that rely on forests resources around the world ranges from 6 to 65% (Ambrose-Oji 2003; Angelsen *et al.* 2014; Babulo *et al.* 2009; Bosma *et al*. 2012; Fisher 2004; Heubach *et al.* 2011; Hogarth *et al.* 2013; Illukpitiya & Yanagida 2008; Kamanga *et al.* 2009; Kar & Jacobson 2012; Mamo *et al.* 2007; Mcelwee 2008; McSweeney 2002; Quang & Noriko 2008; Rayamajhi *et al.* 2012; Shackleton *et al.* 2007; Tieguhong & Nkamgnia 2012; Yemiru *et al.* 2010). In addition to their dependence, forest-dwelling communities not only have a comprehensive understanding of their local ecosystems but also possess a thorough knowledge of them and practice sustainable resource management. They have traditional knowledge regarding forest regeneration, conservation practices and ecological balance. The strong association between individuals and bioresources fosters a sense of stewardship and promotes the use of forest resources in a manner that ensures long-term sustainability. They live in harmony with their environment, potentially contributing to biodiversity conservation. Their traditional practices, such as crop rotation, agroforestry, and selective harvesting, help to contribute to the conservation of the diversity of plants and animal species in the forest.

The theoretical basis of the study is rooted in socio-ecological resilience theory, which underscores the ability of communities to adapt to environmental changes while maintaining cultural traditions (Folke *et al*. 2004). Ethnobotany traditionally focuses on singular plant use categories, such as medicinal plants (Martin 2010) or edible species (Turner *et al*. 2000). Recent methodologies, however, promote comprehensive frameworks that integrate multifunctional applications to elucidate the holistic link between humans and plant bioresources (Albuquerque & Hanazaki 2009). Cámara-Leret *et al*. (2019) described the diverse range of plant applications in Amazonian communities, demonstrating how cultural preferences influence plant utilisation patterns. In the context of the Eastern Himalayas, Rai *et al*. (2007) studied the significance of oral traditions in the transmission of plant use knowledge, emphasizing the importance of rituals and storytelling in the preservation of cultural continuity. Similarly, Kala *et al*. (2020) examined the mechanisms of cultural resilience that enable communities to modify their ethnobotanical practices in response to environmental changes. These insights emphasize the adaptive strategies that Himalayan communities employ to reconcile plant bioresource dependency with climate adaptation.

Global climate change due to man-induced causes and its effect on the ecosystem is widely recognized (IPCC 2007a 2013; Chakravarty *et al.* 2012, 2015; Shukla *et al.* 2015). Forests have been a source of economic security, a means of promoting consumption, and a strategy for eradicating poverty (Angelsen & Wunder 2003; Fisher 2004; Pattanayak & Sills 2001). The impact of climate change is expected to considerably increase the vulnerability of communities, leading to adverse consequences for their livelihoods due to the depletion of forest resources (Funk *et al.* 2008; IPCC 2007b). The current global ecological crisis, including climate change and forest degradation, will have a negative influence on the livelihoods of forest dwellers and communities that rely significantly on forest ecosystem services. The crisis has resulted in a reduction in available resources of sustenance, a decline in food production, an increase in poverty levels, and a decrease in overall adaptability (Reed *et al.* 2013). To achieve a resilient and sustainable future, it is crucial to have a comprehensive understanding of the intricate and interdependent relationship that exists between human beings and ecological services (IPCC 2014; Ostrom 2010; Rockström *et al.* 2009).

The cultural resilience being defined as the ability of communities to sustain cultural practices under socio-environmental pressures is crucial for preserving ethnobotanical knowledge. Studies by Berkes *et al.* (2000) and Pretty *et al*. (2009) emphasized the adaptive capacities of indigenous communities in managing natural resources sustainably. Further, Bhardwaj *et al*. (2021) highlighted how climate variability disrupts the transmission of ethnobotanical knowledge, particularly among younger generations who face reduced exposure to plant-based cultural practices. In biodiverse regions like the Indian Eastern Himalayas, this knowledge not only supports local livelihoods but also contributes to global challenges such as bioprospecting and biodiversity conservation. Bioprospecting, the exploration of natural products for novel compounds, often relies on traditional knowledge to identify candidate plant species with medicinal or pharmacological potential (Fabricant & Farnsworth 2001; Heinrich *et al*. 2009). Furthermore, traditional ethnobotanical practices offer insights into sustainable resource management, informing global conservation strategies to mitigate biodiversity loss (Berkes *et al*. 2000). The region under study, characterized by its rich biodiversity and socio-cultural complexity, provides a unique lens through which we can examine the intersection of traditional knowledge, conservation, and sustainable development. This study, therefore, aims to not only serve as a repository of traditional knowledge but also lay the groundwork for broader interdisciplinary research that aligns with global sustainability goals.

Materials and Methods

Study area

Dehing Patkai National Park is located in the Dibrugarh and Tinsukia districts of Assam, a state in northeastern India. The park is situated within the Patkai Hills, which are a subrange of the larger Patkai range, also known as the Purvanchal Range. It covers an area of 111.19 square km (42.93 sq. mi) of rainforest and lies between latitudes- 27°17′53′′N and longitudes- 95°30′59′′E and has an elevation ranging from 100m (328 ft) to 450m (1476 ft) above sea level. It was declared a wildlife sanctuary under the Wildlife Protection Act of 1972 on 13 June 2004 and became the thirteenth wildlife sanctuary in Assam. The park is part of the larger Dehing Patkai Elephant Reserve which is recognised for its great biodiversity. Soraipung range of the Dehing Patkai National Park is the primary entry point. The study encompasses diverse ecological zones within the Indian Eastern Himalayas with annual precipitation and diverse vegetation. The climate of the study area is tropical monsoon characterised by an annual precipitation exceeding 4,000 mm. The region is renowned for its verdant evergreen forests, tropical rainforests, and grasslands. It is home to elephants, tigers, leopards, hoolock gibbons, and crested langurs, as well as several kinds of birds, reptiles, and butterflies. The vegetation in this rainforest is characterized by dominant tree species, including *Dipterocarpus retusus* Blume in the emergent layer. Additionally, there are many flowering plants such as *Mesua ferrea* L*., Aglaia spectabilis* (Miq.) S.S.Jain & S.Bennet and *Dysoxylum gotadhora* (Buch.-Ham.) Mabb. The park is not just ecologically and culturally significant, but also historically significant. It is inhabited by indigenous groups, including tribes such as the Tai Phake, Khamti, Singpho, Tangsa, Tai Ahom, Moran, Mising, Bodos and Adivasis. Among the communities, Nepalis, Marwaris and Bengalis possess distinct cultural traditions and practises that are unique to the forest. The geographical location and the specific study sites within the Soraipung range are illustrated in Figure 1, providing a visual context for the selected five villages. The map was created by the authors using QGIS (v.3.22).

Data collection

For the socio-economic study, a survey was conducted on five villages namely, Phekelajan, Gelipung, Phekelajan Bengali, Sopatuli Bengali and Soraipung which are located near the forest (Figure 1). A total of 86 households were randomly selected from the villages of Phekelajan (n=8), Gelipung (n=13), Phekelajan Bengali (n=14), Sopatuli Bengali (n=25) and Soraipung (n=26). Villages were stratified based on proximity to forests, primary livelihood activities and income levels ensuring a representative sample of the community. The survey was conducted in multiple stages using the household survey methodology following Sah and Heinin (2001), Shrivastava & Heinen (2007), and Baral & Heinin (2007).

1. Survey Design: This involved the identification of crucial research questions and selection of suitable sampling method. The survey was designed to capture relevant information pertinent to plant bioresources, livelihood dependency, the socio-economic profile of the households and climate change perceptions using open-ended questions.

2. Sampling method: The stratified random sampling method was used to select households for the survey. The present study was guided by specific criteria, such as geographic location, socio-economic characteristics or vulnerability to climate change.

3. Data Collection: Face-to-face interviews were conducted with household representatives by the interviewer using a structured questionnaire. Interviews were conducted in the local language to ensure clarity and cultural relevance. Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) supplemented the questionnaire-based survey to capture a

holistic view of the issues under study. From each stratum, households were randomly chosen and one adult member from each household was interviewed, providing insights into the household's socio-economic dynamics, livelihood dependence on forest bioresources, and vulnerability to climate change. Data were collected over 12 months from September 2021 to August 2022.

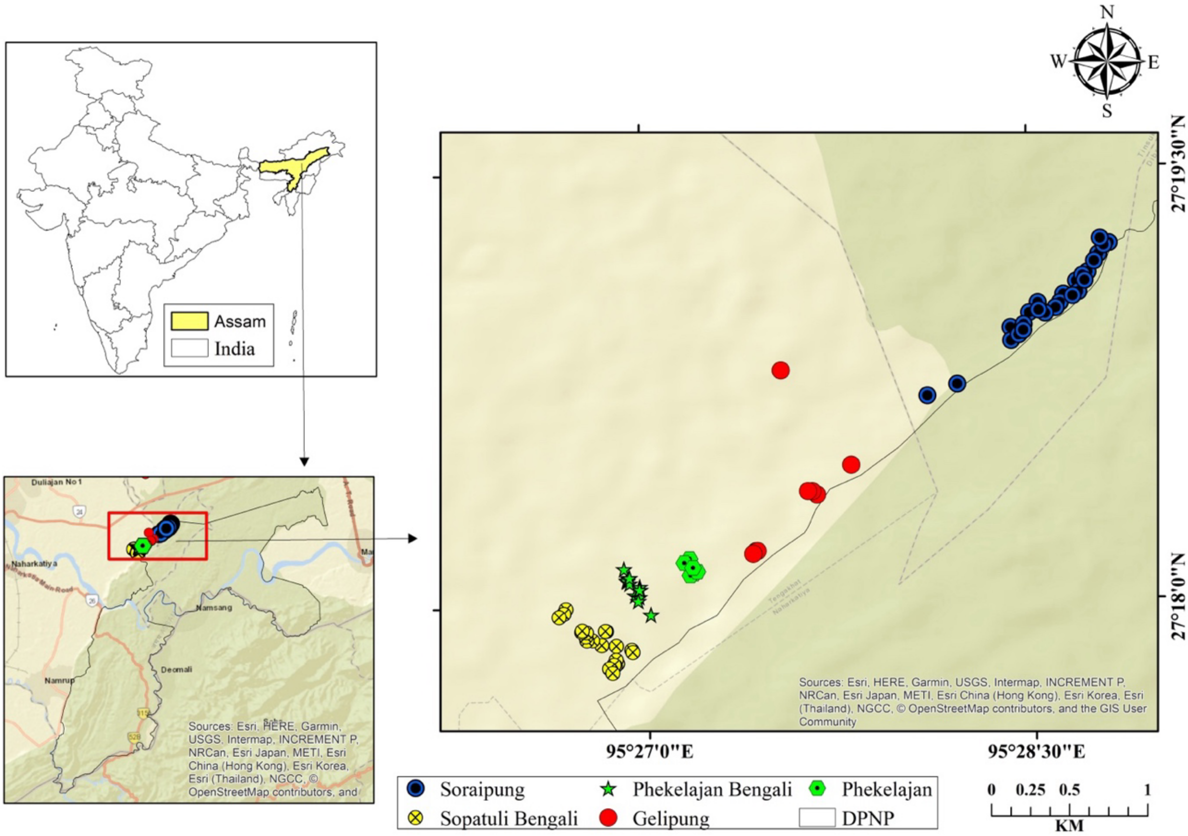

Figure 1. Map showing the sampling points in each of the 5 villages in Soraipung range of Dehing Patkai National Park, Assam

4. Questionnaire Content: The survey questionnaire included different sections that covered household demographics, socioeconomic position, perceptions, awareness, and impacts of climate change, adaption measures utilised, resource access, and vulnerabilities.

5. Data Validation and quality control: To ensure the accuracy and reliability of the data, regular oversight, spot-checking and validation of responses were implemented.

6. Ethical considerations: The study followed ethical norms and obtained prior informant consent from the participant. The anonymity and privacy of respondents were safeguarded as the data collected is utilised exclusively for research study.

7. Data Analysis: Once data collection was completed, the acquired information was compiled, structured and analysed using appropriate statistical methods and tools for studying livelihood dependency and to make conclusions. The data collected during the survey were analyzed using IBM SPSS Statistics (Version 21). The Chi-Square Test of Independence was used to analyze the relationship between age groups and perception of climate change determining whether differences between groups were statistically significant. While the Chi-Square goodness-of-fit test was applied to assess the variation in the utilization of different plant bioresources (fodder, firewood, fruits, medicinal plants, edible plants, and economically important plants) among respondents. To generate figures of the study, we have used Microsoft Excel sheet 2021.
Additionally, specific interviews were also conducted with knowledgeable villagers who were part of the broader sample of 86 households to gather information about the plant bioresources found in the forest. This group primarily included elderly community members, whose knowledge is derived from generations of traditional practices, and local forest guards, who regularly inspect and interact with forest ecosystems as part of their professional duties. The acquired data from these interviews was then validated with available literature.

The plants were identified referring to regional taxonomic literature, Flora of Assam (Kanjilal 2005), an official record book on the flora of Dehing Patkai available at Soraipung Range Forest office and consulting expert's taxonomist of the team. The correct nomenclature of each species was checked with The Plant List (The Plant List 2013) and Plants of World Online (POWO 2024). Herbarium specimens for unidentified species were prepared and housed in the Tezpur University Herbarium, Department of Environmental Science for voucher samples.

Quantitative analysis

The data collected in the field was transformed into user reports (UR), with each UR representing an informant (i) who indicated the use of a species (s) for the treatment of a specific disease (u). Likewise, if an informant (i) utilized a species (s) for the treatment of two distinct kinds of ailments, it was regarded as two unique records (UR). The utilization of a species for addressing a type of ailment, as reported by a minimum of two informants, was quantified as two UR. The health conditions were categorized into different ailment classifications (Chellappandian *et al*. 2012).

The factor of informant consensus (F_{ic})

This is one of the widely used indices in quantitative ethnobotanical studies. The consistency of the healer's knowledge in treating a particular illness category was tested with this index as proposed originally by Trotter and Logan (1986).F_{ic} was calculated to know the uniformity of ethnomedicinal plants shared by all the informants in a particular ailment category. The factor was calculated as.

$$F_{ic}=(N_{ur}-N_t)/(N_{ur}-1),$$

where,

N_{ur} number of URs of an informant for a particular ailment category
N_t total number of species used for a specific ailment category by all informants.

The value of F_{ic} is between 0 and 1, with a value near 0 indicating that there is disagreement among informants regarding the plants used to treat a specific ailment. The value that is nearly 1 indicates that the informants have a high degree of shared knowledge regarding the plants that are employed to treat a particular ailment (Devi *et al.* 2020).

Results

Socio-economic status

We interviewed 86 respondents from 86 households in five villages to collect the data. Table 1 provides the socio-economic profile of each of the five villages: Phekelajan, Gelipung, Phekelajan Bengali, Sopatuli Bengali, and Soraipung. The majority of the respondents are in the age group of 21-40 (n = 31; 36.05%), and most of them are males (n = 76; 88.37%). In the survey, only 10 female respondents participated. The majority of the families, accounting for 62.79% (n=54), followed Hinduism as their religion. Approximately 72.09% (n=62) of the respondents belong to the Antyodaya category in terms of their socio-economic status, and their monthly income ranges from Rs. 5000 to Rs. 10000. Analyzing their occupation, it has been found that the majority of the participants were employed as daily wage laborers, accounting for 51.16% (n=44) of the respondents. Additionally, a smaller percentage (n=13; 15.12%) consisted of farmers who cultivate various types of rice, such as Ranjit, Bahadur, Masuri, Bora, and Joha. While 18 respondents contributing 20.93% are involved in domestic chores, 6.98% (n=6) of them are engaged in agricultural activities and also work as daily wage laborers. A few of the responders (n=5) are carpenters and security guards working in oil fields and have established small shops nearby to their houses, which contribute 5.18%. It was noted that 20.93% (n=18) of the respondents are engaged in domestic work, and they directly depend on the forest for collecting bioresources like edible plants, fruits, and fuelwood.

Table 1. Socio economic characteristics of respondents of Soraipung Range.

Variable	Frequency	Percentage
Age of individuals		
21-40	31	36.05
41-60	24	27.91
61-80	25	29.07
81-100	6	6.98
Gender		
Female	10	11.63
Male	76	88.37

Religion		
Hindu	54	62.79
Adivasi	27	31.40
Christian	5	5.81
Occupation		
Farming	13	15.12
Daily wage	44	51.16
Domestic work at home	18	20.93
Both farming and daily wage	6	6.98
Others (carpenter, shop, security guard)	5	5.81
Socio-economic status of family		
AAY	62	72.09
BPL	22	25.58
None	2	2.33
Total monthly income (in rupees)		
<5,000	39	45.30
5,000-10,000	46	53.50
>10,000	1	1.20

Forest Bioresource dependency

The forest is abundant in many plant bioresources that provide provisional services in the form of fruits, firewood, and edible plants. The villagers are collecting these bioresources, which are species of ethnobotanical importance, to meet their daily requirements. The study documented a total of 65 species of ethnobotanical importance, belonging to 60 genera and 41 families (Table 3). The bioresources utilized by the villagers were grouped into 4 categories: wild fruits, wild vegetables, medicinal plants, and economically important plants. The highest number of species was recorded in medicinal plants with 44 species followed by wild vegetables, which had 34 species; economically important plants with 25 species; and wild fruits with 23 species. The villagers grow plants like *Allium sativum* L., *Capsicum chinense* Jacq., *Carica papaya* L., *Cocos nucifera* L., *Curcuma longa* L., *Luffa aegyptiaca* Mill., *Moringa oleifera* Lam., *Ocimum tenuiflorum* L., *Phyllanthus emblica* L., *Lablab purpureus* (L.) Sweet, *Saccharum officinarum* L. and *Zingiber officinale* Roscoe in their home gardens and nearby fields to meet their needs. In all the studied 5 villages, firewood (n=61) and wild fruits (n=62) are found to be primary resources used by the villagers for their livelihood, each contributing 21%. This was followed by wild vegetables, which accounted for 20% (n=58) of the plants, fodder (18%; n=53), medicinal plants (14%; n=40) and other economically important plants, which accounted for 6% (n=17) (Fig.2). The people of Phekelajan Bengali (25%; n=14), Gelipung (24%; n=13), and Phekelejan (21%; n=6) collected wild vegetables as their most common plant bioresource. While in Sopatuli Bengali village, 26% of the households collected economically important plants having 25 species (Fig. 2d); however, wild fruits (27%; n=22) and firewood (26%; n=21) are collected mostly by the villagers of Soraipung village (Fig. 2e). The villagers collect these bioresources for their subsistence and, to a limited extent, for commercial purposes. The dependence on forests for a variety of resources, including firewood, fodder, fruits, medicinal plants, and edible plants, is a phenomenon observed in many rural communities across the globe. It has been found that only the dried and fallen parts of timber, firewood, and fodder are allowed for household use. A Chi-Square test revealed a statistically significant difference in the utilization of bioresources by the respondents, $\chi^2(5) = 65.96$, $p < 0.001$. It was observed that plant bioresources that are economically important (timber, firewood, and fodder) are the most commonly used, followed by fruits, vegetables and medicinal plants.

The assessment recorded a total of 65 plant species from 60 genera belonging to 41 families, as valuable bioresources that are edible and have economic importance. *Dipterocarpus retusus* Blume, the state tree of Assam and locally referred to as 'Hollong' is widely used for timber and woodcraft production by the majority of households accounting for 67% (Fig. 3). Different species of *Dipterocarpus* are utilized as valuable resources for both timber and balsam, as well as for boat caulking (Huang 2011). *Elaeocarpus angustifolius* Blume is another highly valued tree species by the villagers with 62% of the respondents citing its spiritual and religious importance, as well as its utilization in timber production and jewellery making. The majority of the respondents (58%) reported cultivating *Carica papaya* L., an edible plant, in their home gardens for self-consumption. While *Diplazium esculentum* (Retz.) Sw., *Mesua ferrea* L. and *Centella asiatica* (L.) Urb. are found wild in the forest, and these edible plants are highly valued by the villagers for their nutritional value and are commonly used for sustenance as well as for economic gain through marketing. 40% of the villagers used *Mesua ferrea* L. for timber production, natural dye and other religious and traditional uses. According to the survey, among the edible fruits, villagers generally consume and sell *Artocarpus chama* Buch.-Ham., *Citrus medica* L., *Dillenia indica* L., *Mangifera indica* L. and *Citrus medica* L. (Fig.4). *Dysoxylum gotadhora* (Buch.-Ham.) Mabb., *Gmelina arborea* Roxb. ex Sm., *Tetrapilus dioicus* (Roxb.) L.A.S.Johnson and *Dipterocarpus retusus* Blume are important source of fuel wood used by the villagers. The woods of these trees provide a renewable source of energy for cooking and heating. Additionally, *Dysoxylum gotadhora* (Buch.-Ham.) Mabb. woods are highly suitable for the production of charcoal, which has numerous industrial and domestic applications. Villagers went into the forest to collection these plants, either in groups or individually, as the situation demanded.

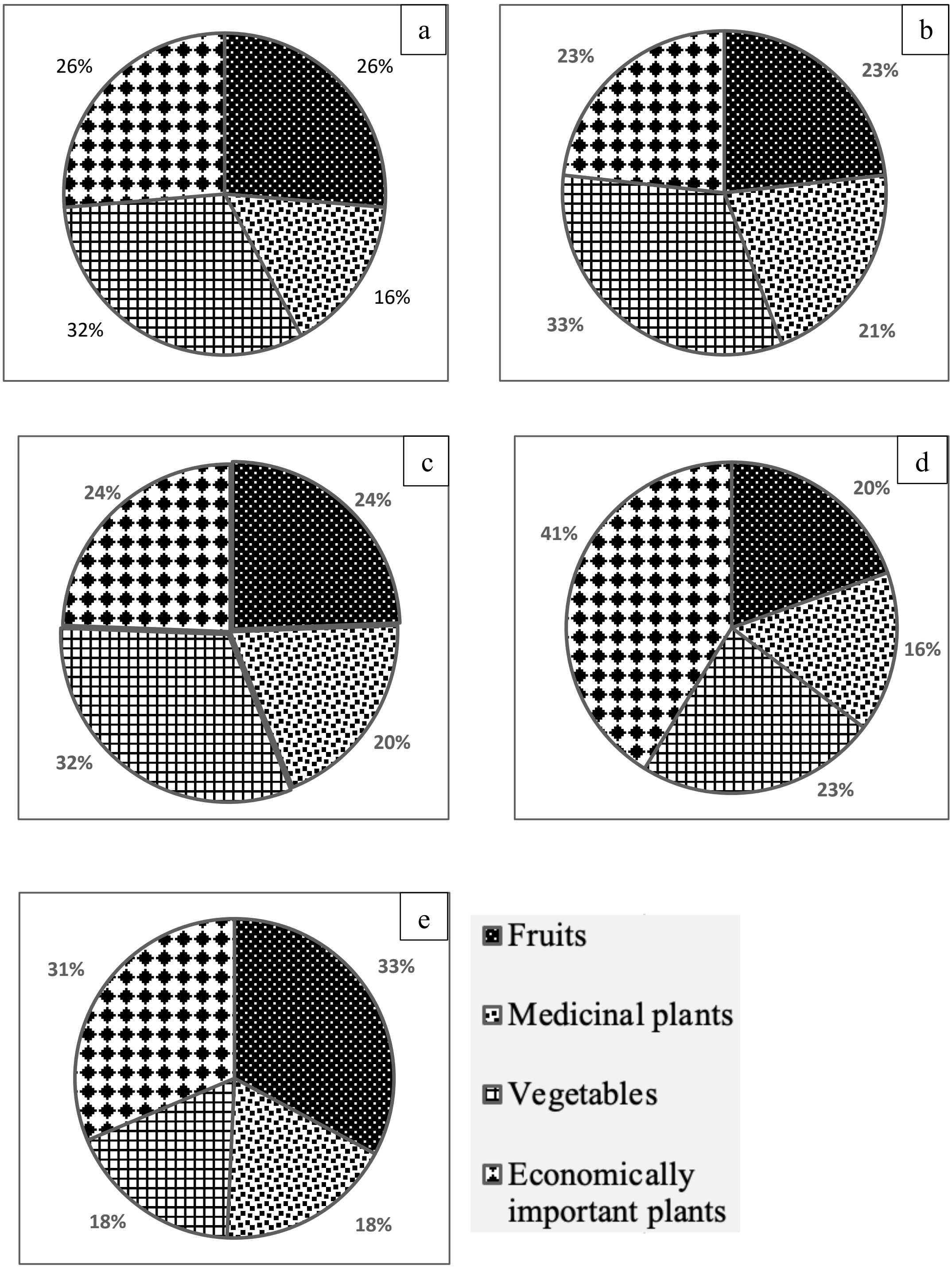

Figure 2. Distribution of forest resources utilized by the villagers (a- Phekelajan, b- Phekelajan Bengali, c- Gelipung, d- Sopatuli Bengali and e- Soraipung village) in Dehing Patkai National Park

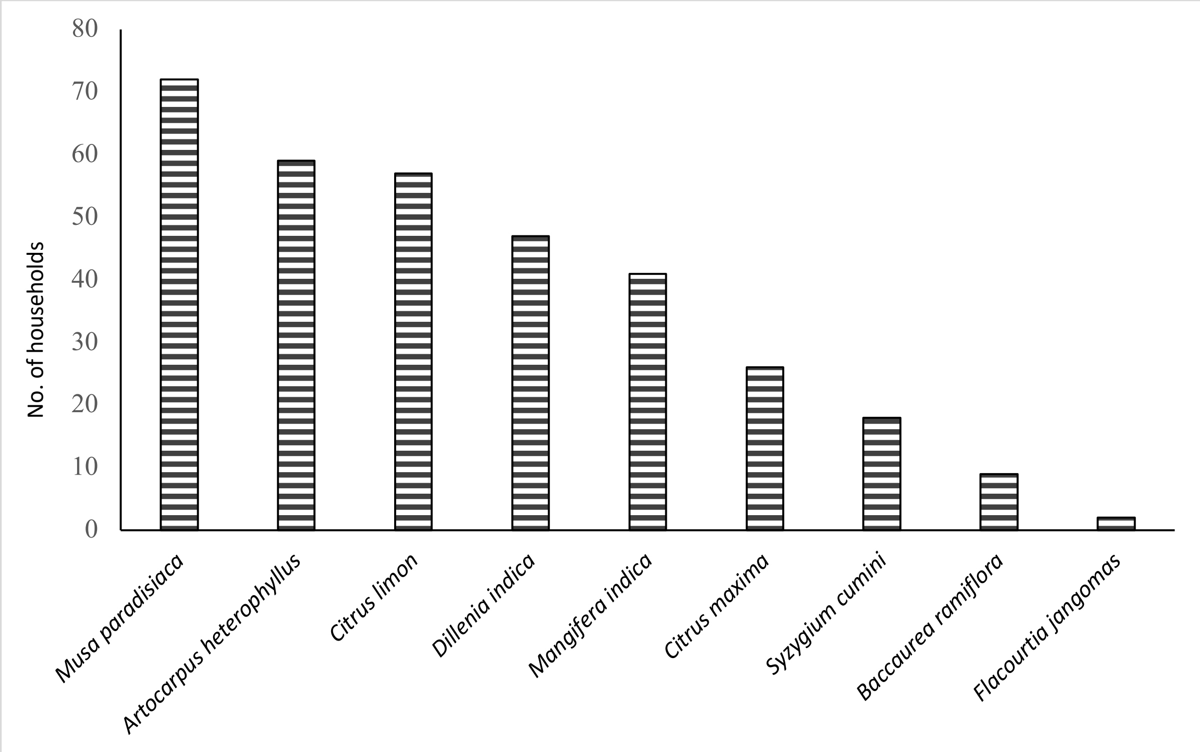

Figure 3. Edible fruits commonly utilized by surveyed households in the study area

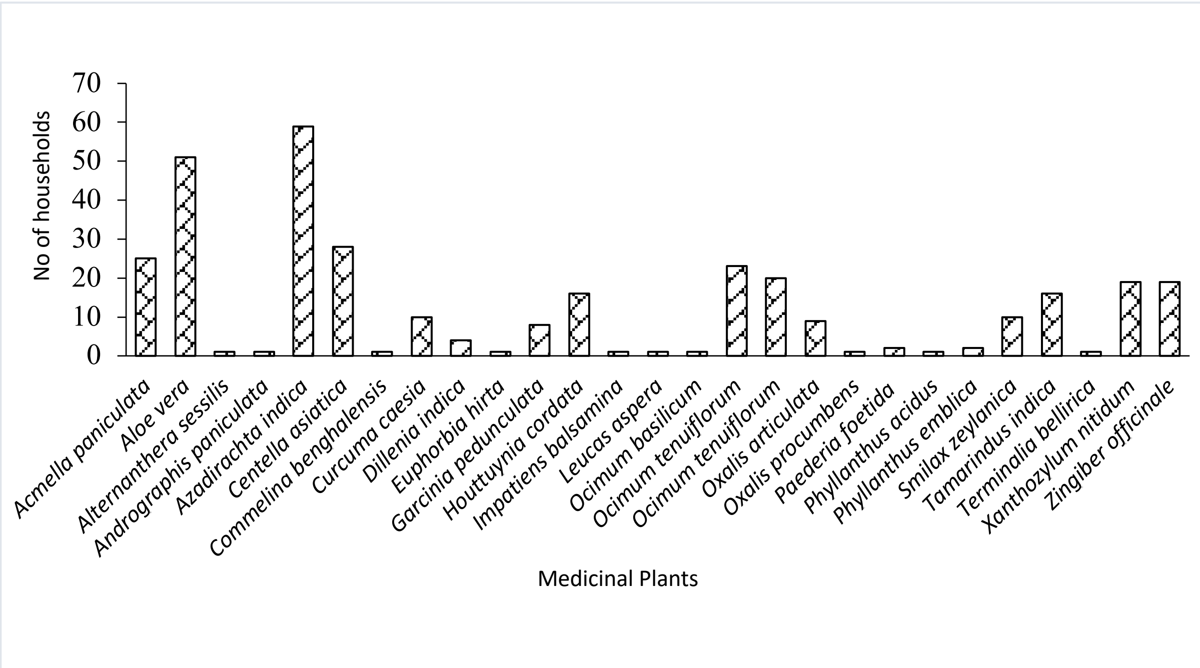

Figure 4. Medicinal plants commonly used by the villagers of each village in the Soraipung range in DPNP

Traditional ethnobotanical knowledge has historically guided the search for novel medicinal compounds, with many pharmaceutical drugs tracing their origins to plants used in traditional medicine (Newman & Cragg 2020). The present study revealed that the plant bioresources exhibit high medicinal values (Table 4). There were a total of 45 medicinal plants used by villagers, which belonged to 41 genera and 30 different families. These plants provide medicinal efficacies to alleviate respiratory and digestive ailments, in addition to having anti-inflammatory, diuretic, and antipyretic potency. Different parts of the plants like leaves, flowers, roots, and bark are used for the preparation of medicine to treat various health ailments in the villages. 68.6% of households use *Azadirachta indica* (A. Juss) as a medicinal plant to treat inflammation and its anticarcinogenic properties (Fig. 5). *Aloe vera* (59.3%) and *Centella asiatica* (L.) Urb. (32.56%) are also prevalent in the wild and can be cultivated by forest dwellers, and many households used these plants. In addition*, Acmella paniculata* (Wall.ex

DC.) and *Ocimum tenuiflorum* L. are among the most frequently collected edible plants by villagers for their use. The villagers were found to be cultivating these plants. The villagers consume the leaves are for their medicinal properties and believe they hold spiritual and religious significance among the local people. The study recorded 10 ethnobotanical plants (10 genera and 10 families) that are having edible, medicinal, and of economic significance. For instance, *Alpinia nigra* (Gaertn.) Burtt is a widely recognized shrub known for its medicinal properties that alleviate digestive issues. People consume the tender leaves as vegetables, and they also use the leaf sheath to make ropes for cattle. *Amaranthus spinosus* L. and *Amaranthus viridis* L. are considered valuable antidotes to snakebites, and their shoots are an essential part of their diet. The villagers extensively utilize *Neolamarckia cadamba* (Roxb.) Bosser for timber. And the villagers consume fruits fresh and grind the barks and leaves into a paste to treat wounds and other skin infections.

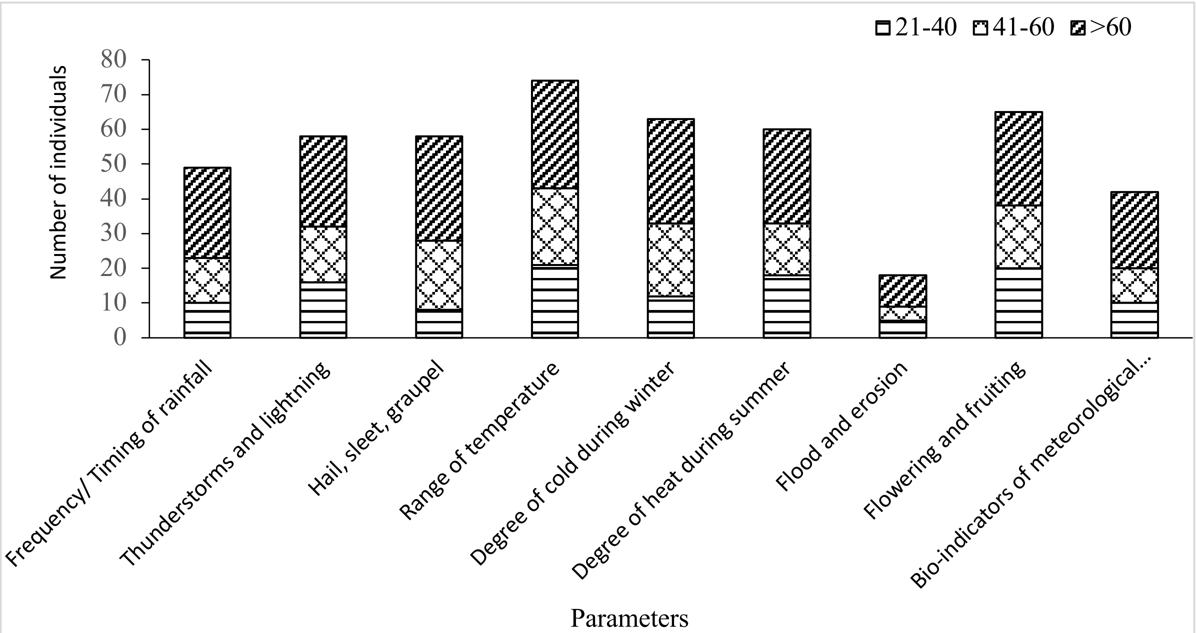

Figure 5. Graph showing perceptions of climate change in different age-groups

Based on user reports (UR), he recorded human ailments were classified into 15 ailments (Table 2). In the Soraipung range, gastrointestinal disorders and skeletal muscular pain and inflammation are the categories recorded with a large number of UR. The calculated F_{ic} values were found to be the highest recorded (0.99) in dermatological and lowest in infectious disease and genito-urinary disorder (0.55). Having the high F_{ic} values in a variety of disorder categories is an indication that majority of the respondents who answered the survey only used a few or a single species for a certain ailment category. The low F_{ic} value of 0.55 revealed that the respondent disagreed on the use of species in the treatment within the same health ailment category.

Table 2. Ailment categories based on the information of user reports (UR)

Ailment category	F_{ic}
Allergy (Skin, eyes)	0.86
Cardiovascular (HBP, heart)	0.95
Circulatory system (blood related)	0.97
Cold	0.94
Dermatological (cuts, wounds, burns)	0.99
Ear, Nose and Throat (Sinuses, tonsillitis, toothache, nosal bleeding)	0.93
Endocrine and liver disorder (Diabetes, liver disorder)	0.91
Fever (malaria, typhoid, jaundice)	0.92
Gastrointestinal disorder (Diarrhoea,Stomache, gastric, dysentry, ulcers, bloating, constipation)	0.88
General health (body pain, fatigue, weight management)	0.90
Infectious disease and genito-urinary disorder (Cholera, urinary infection, kidney problem)	0.55
Poisonous snake bites (Snake bite)	0.75
Reproductive and birth disorder (uterine pains, placenta expulsion, promote fertilityin women, sexual fluids in women)	0.93
Respiratory infections (Whooping cough, lung infection, asthma)	0.89
Skeletal muscular pain and inflamation (Headache, joint pains, bone fracture, cancer/tumour)	0.88

Table 3. Ethnobotanical important plant species recorded during household survey at Dehing Patkai National Park, Assam

Scientific name & Voucher number	**Common name**	**Family name**	**Life form**	**Cultivated/ wild**	**Used category**	**Parts used and utilization purpose**
Aegle marmelos (L.) Corrêa	Bel	Rutaceae	Tree	Wild	Fruits	The fruit is eaten raw
Aglaia spectabilis (Miq.) S.S.Jain & S.Bennet	Lali	Meliaceae	Tree	Wild	Fruits and medicinal	Trunk and fruit; antibacterial, antioxidant; timber
Allium sativum L. [682]	Garlic	Amaryllidaceae	Herb	Cultivated	Vegetable	The bulb is eaten as spice and flavoring agent in curries or chutney
Alpinia nigra (Gaertn.) Burtt [564]	Tora	Zingiberaceae	Herb	Wild	Fruits, vegetable, medicinal, and economic	Tender leaves as vegetables; Fruits, rhizome as medicine, leaf sheath for making ropes for cattle.
Alstonia scholaris (L.) R.Br. [579]	Sotiona	Apocynaceae	Tree	Wild	Economic	Trunk for timber
Alternanthera philoxeroides (Mart.) Griseb. [686]	Panikaduri	Amaranthaceae	Herb	Wild	Vegetable and economic	Whole plant as vegetables; as fodder for cattle.
Amaranthus spinosus L. [587]	Hati khutora	Amaranthaceae	Herb	Wild	Vegetable, medicinal and economic	Tender shoots as vegetables; as antidote to snake bite, as fodder to milk giving cows.
Amaranthus viridis L.[643]	Khutora	Amaranthaceae	Herb	Wild	Vegetable and medicinal	Tender shoots as vegetables; as antidote to snake bite.
Amorphophallus paeoniifolius (Dennst.) Nicolson	Ol kochu	Araceae	Herb	Wild	Vegetable and medicinal	Corm, peduncle and inflorescence as vegetables; corm as medicine against piles.
Antidesma bunius (L.) Spreng.	Pani helos	Phyllanthaceae	Tree	Wild	Vegetable and medicinal	Ripe fruits as raw; leaves as medicine against snake bite.
Artocarpus chama Buch.-Ham.	Sam kothal	Moraceae	Tree	Wild	Vegetable and economic	Ripe fruits as raw; Wood as timber for house, furniture, agricultural implements
Artocarpus heterophyllus Lam.	Kothal	Moraceae	Tree	Wild	Fruits and vegetable	Ripe fruit as raw, young fruits as vegetables
Azadirachta indica A.Juss.	Neem	Meliaceae	Tree	Wild	Medicinal and economic	Leaves for medicinal purpose; timber for furniture
Baccaurea ramiflora Lour.	Leteku	Phyllanthaceae	Tree	Wild	Medicinal and economic	Trunk and fruits; treats stomachache, toothache; fruit edible, fish farming
Balakata baccata (Roxb.) Esser	Seleng	Euphorbiaceae	Tree	Wild	Economic	Trunk for timber, wood
Bambusa balcooa Roxb.	Bholuka bah	Poaceae	Grass	Wild	Vegetable and economic	Tender shoots as vegetables, pickle, Stem in house making, furniture, fencing, firewood

Bombax ceiba L.	Simalu	Bombacaceae	Tree	Wild	Vegetable and economic	Flowers and unripe fruits as vegetables; Cotton from mature fruits for making mattress and pillow, wood as timber, bark as medicine, flowers as fodder, wood as minor timber.
Calamus erectus Roxb.	Raidang bet	Arecaceae	Cane	Wild	Vegetable, medicinal and economic	Tender shoots as vegetables and medicine for worms; Stem for making furniture, household articles.
Canarium strictum Roxb.	Dhuna	Burseraceae	Tree	Wild	Vegetable, medicinal and economic	Trunk, leaves; treats rashes, snake bite; resin, air purifier
Capsicum chinense Jacq.	Bhut jolokia	Solanaceae	Shrub	Cultivated	Vegetable and economic	The fruit used as vegetable and spice
Carica papaya L.	Papaya	Caricaceae	Tree	Cultivated	Fruits and vegetable	Ripe fruits as raw and unripe as vegetable
Cassia fistula L. [594]	Sonaru	Fabaceae	Tree	Wild	Fruits, medicinal and economic	Pulp of fruit as raw; Wood as timber in house construction; pulp from fruit medicine for liver trouble, piles.
Centella asiatica (L.) Urb.	Manimuni	Apiaceae	Herb	Wild	Vegetable	Leaves, young shoots as vegetables
Chrysophyllum flexuosum Mart.	Bonpitha	Sapotaceae	Tree	Wild	Fruits and economic	Ripe fruits as raw, Wood as timber for house construction, furniture making.
Citrus medica L.	Jora tenga	Rutaceae	Shrub	Wild	Fruits	Mesocarp, juice of fruit as raw
Clerodendrum colebrookeanum Walp.[590]	Nefafoo	Lamiaceae	Shrub	Wild	Vegetable and medicinal	Tender leaves, shoots as vegetables; leaves as medicine against blood pressure.
Cocos nucifera L.	Coconut	Arecaceae	Tree	Cultivated	Fruits and economic	The nut is a fruit, and the leaves are used for making ropes
Curcuma longa L.[689]	Halodhi	Zingiberaceae	Shrub	Cultivated	Medicinal and economic	The rhizomes as spice and medicine
Dillenia indica L.	Outenga	Dilleniaceae	Tree	Wild	Fruits, medicinal and economic	Trunk and fruits; Stomachache, jaundice, diarrhea, dysentery, dandruff; timber, fruit edible
Diplazium esculentum (Retz.) Sw.	Dhekia Sak	Athyriaceae	Herb	Wild	Vegetable	Tender leaves as vegetables
Dipterocarpus retusus Blume	Holong	Dipterocarpaceae	Tree	Wild	Economic	Trunk for timber
Dysoxylum gotadhora (Buch.-Ham.) Mabb.	Bandardima	Meliaceae	Tree	Wild	Fruits, vegetable and medicinal	Trunk, leaves and fruits; Diarrhea, dysentery; timber
Elaeocarpus serratus L.[627]	Jalphai	Elaeocarpaceae	Tree	Wild	Fruits and economic	Ripe fruits as jams, pickles; wood for firewood

Elaeocarpus angustifolius Blume	Rudraksh	Elaeocarpaceae	Tree	Wild	Vegetable and economic	Trunk and fruits; Cultural and religious use
Eryngium foetidum L.	Maan dhonia	Apiaceae	Herb	Wild	Vegetable	Leaves in curry or chutney
Ficus religiosa L. [637]	Ahot	Moraceae	Tree	Wild	Fruits, vegetable and medical	Trunk, fruits and flowers; Dysentery, fever, scabies, piles, skin diseases, gonorrhea; religious, cultural, timber, fodder, fruit edible
Flacourtia jangomas (Lour.) Raeusch.	Ponial	Salicaceae	Tree	Wild	Fruits	Ripe fruits as jams and pickles
Garcinia pedunculata Roxb. ex Buch.-Ham.	Bor Thekera	Clusiaceae	Tree	Wild	Fruits, vegetable, medicinal and economic	Fruits, Trunk; Flashy fruits as raw, acidifying agent for curry, pickles, as timber for house making, traditional rice husking implements, firewood.
Gmelina arborea Roxb. ex Sm. [633]	Gomari	Lamiaceae	Tree	Wild	Fruits, vegetable and medicinal	Trunk, flower and fruits; treats stomach disorder; timber, fruit and flower edible
Houttuynia cordata Thunb. [638]	Moshundari	Saururaceae	Herb	Wild	Vegetable	Young plant as vegetables
Hydrocotyle sibthorpioides Lam. [675]	Horu manimuni	Araliaceae	Herb	Wild	Vegetable and medicinal	Young plant as vegetables; the whole plant as medicine for stomach trouble
Ipomoea aquatica Forssk.	Kalmou	Convolvulaceae	Herb	Wild	Vegetable and medicinal	Tender shoots as vegetables; juice made from the plant as medicine for jaundice, urinary trouble
Leucas aspera (Willd.) Link [520]	Durun	Lamiaceae	Herb	Wild	Vegetable and medicinal	Tender shoots and leaves as vegetables; leaves as appetizer, stomach trouble, flower with honey to cure cough
Lablab purpureus (L.) Sweet	Urohi	Fabaceae	Climber	Cultivated	Vegetable	The beans as vegetables
Luffa aegyptiaca Mill.	Bhul	Cucurbitaceae	Tree	Cultivated	Vegetable	The fruit used as vegetable
Mangifera indica L.	Mango	Anacardiaceae	Tree	Wild	Fruits and vegetable	Ripe fruits as raw, premature fruits as pickle
Marsilea mutica Mett.	Pani tengeshi	Marsileaceae	Herb	Wild	Vegetable	Tender shoot, leaves as vegetable
Mesua ferrea L.	Nahor	Calophyllaceae	Tree	Wild	Economic	Trunk for timber
Morus alba L.	Nooni	Moraceae	Tree	Wild	Fruits	The ripe fruit is eaten raw
Moringa oleifera Lam.	Sajina	Moringaceae	Tree	Cultivated	Vegetable	The fruit is eaten as vegetable
Neolamarckia cadamba (Roxb.) Bosser [469]	Kadam	Rubiaceae	Tree	Wild	Fruits, medicinal and economic	Trunk and fruits; Blood purifier, antidiuretic, abortifacient; timber, fruit edible
Ocimum tenuiflorum L.	Tulsi	Lamiaceae	Herb	Cultivated	Medicinal	The tender leaves are consumed for its medicinal properties
Phyllanthus emblica L. [587]	Amla	Phyllanthaceae	Tree	Cultivated	Fruits and medicinal	Edible fruit with medicinal properties
Psidium guajava L. [453]	Madhuriam	Myrtaceae	Tree	Wild	Fruits and medicinal	Ripe fruit as raw and tender leaves for upset stomach

Saccharum officinarum L.	Sugarcane	Poaceae	Grass	Cultivated	Fruits	The cane is eaten as fruit and also as made jaggery from its extract
Smilax zeylanica L. [625]	Tikoni Baruah	Smilacaceae	Climber	Wild	Vegetable and fruits	Tender shoots as vegetable; Leaves, young shoots as vegetables; Ripe fruits as raw, premature fruits as pickle
Spondias pinnata (L.f.) Kurz [572]	Amara	Anacardiaceae	Tree	Wild	Vegetable, fruits and medicinal	Trunk, fruits and flowers; Dysentery; fruits and flower buds edible
Sterculia villosa Roxb. ex Sm. [569]	Udal	Malvaceae	Tree	Wild	Vegetable, medicinal and economic	Trunk, bark and seed; Dysentery; timber, fibrous bark, seeds edible
Syzygium jambos (L.) Alston [695]	Bogi jamu	Myrtaceae	Tree	Wild	Fruits, economic and medicinal	Ripe fruits as raw; Wood as timber for making of traditional houses. Juice of the bark as medicine for gastritis.
Terminalia chebula Retz. [452]	Hilikha	Combretaceae	Tree	Wild	Fruits and medicinal	Trunk, fruits; Diarrhea, dysentery, bleeding gums, conjunctivitis, appetizer; timber, tanning
Tetrapilus dioicus (Roxb.) L.A.S.Johnson	Poreng	Oleaceae	Tree	Wild	Medicinal and economic	Trunk; Skin diseases, fever; fuelwood, charcoal
Zingiber officinale Roscoe	Ada	Zingiberaceae	Herb	Cultivated	Vegetable and medicinal	The tuber is eaten raw as well as spice for its medicinal properties and taste
Ziziphus mauritiana Lam. [579]	Bogori	Rhamnaceae	Tree	Wild	Vegetable, fruits and medicinal	Ripe fruits as raw, powder or as pickles; bark as medicine for diarrhea, pain, cut and wounds.
Ziziphus rugosa Lam.	Bon bogori	Rhamnaceae	Tree	Wild	Vegetable and economic	Fruits, Trunk

Table 4. Utilization of medicinal plants recorded during household survey at Dehing Patkai National Park, Assam

Scientific name	Common name	Life form	Family	Parts used	Cultivated/Wild	Treatment/Health ailments	Mode of preparation	Mode of administration
Acmella paniculata (Wall.ex DC.) [521]	Huhoni bon	Herb	Asteraceae	Flowers and leaves	Wild	Cuts or bleeding and toothaches.	The leaves and flowers are plucked and grinded to extract juice.	Topical
Aloe vera (L.) Burm.f. [507]	Aloe vera	Herb	Asphodelaceae	Leaves	Both	Sunburns, burns and minor cuts.	The gel from the plant is extracted and used freshly.	Topical
Alpinia nigra (Gaertn.) Burtt [564]	Tora	Shrub	Zingiberaceae	Fruits & rhizome	Wild	Digestive issues, respiratory problems, anti-inflammatory & pain relief	The rhizome is boiled or crushed into fine powder	Oral
Alternanthera sessilis (L.) DC [653]	Mati-Kaduri	Herb	Amaranthaceae	Leaves	Both	Wounds, nausea, vomiting, cough, bronchitis, diarrhea, dysentery and diabetes.	Roots are grinded and made into paste.	Topical
Amaranthus spinosus L. [587]	Hati khutora	Herb	Amaranthaceae	Shoots	Wild	Digestive, respiratory, anti-inflammatory, diuretic and blood disorders	Leaves crushed to extract juice, ground into pastes and roots & leaves boiled to prepare an infusion.	Oral and also topical.
Amaranthus viridis L. [643]	Khutora	Herb	Amaranthaceae	Shoots, roots	Wild	Digestive, respiratory, anti-inflammatory, diuretic, liver and skin conditions	Leaves and roots boiled to make an infusion, crushed to extract juice, ground into a paste	Oral and also topical.
Amorphophallus paeoniifolius (Dennst.) Nicolson	Ol kochu	Herb	Araceae	Corm	Wild	Digestive issues, anti-inflammatory, antimicrobial, weight management, & rheumatism & arthritis	Corm is boiled or ground into a paste	Oral and also topical.
*Andrographis paniculata (*Burm. fil.) Wall.ex Nees	Kalmegh	Herb	Acanthaceae	Aerial parts, roots and whole plant	Both	Snake-bite and poisonous stings of some insects, dyspepsia.	The leaves are grinded to obtain the extract.	Topical

Antidesma bunius (L.) Spreng.	Pani helos	Tree	Phyllanthaceae	leaves, fruits, bark & roots	Wild	Digestive, antioxidant, diuretic, hypertension, skin & antimicrobial	Leaves are boiled, bark & roots are ground into a paste.	Oral and also topical.
Azadirachta indica (A. Juss)	Neem	Tree	Meliaceae	Leaves	Both	Inflammation, ulcer, malaria, and anticarcinogenic properties.	The leaves are crushed to obtain the extract and can also be cooked.	Oral and also topical
Baccaurea ramiflora Lour.	Leteku	Tree	Phyllanthaceae	Fruits, leaves, bark & roots	Wild	Digestive, antimicrobial, anti-inflammatory, skin conditions, liver problems.	Fruit can be eaten fresh or processed into juice, bark & roots boiled or ground into paste	Oral and also topical.
Bombax ceiba L.	Simalu	Tree	Bombacaceae	Bark, flowers, leaves, roots, gum & seeds	Wild	Anti-inflammatory, antimicrobial, respiratory issues, fevers, skin infections, wound, analgesic, digestion and anti-microbial	Bark, seeds & roots grinded into powder form, leaves into paste, gum dissolved in water	Oral and also topical.
Canarium strictum Roxb.	Dhuna	Tree	Burseraceae	Bark, resin & leaves	Wild	Anti-inflammatory, antimibrobial, antipyretic, fevers, diabetes, wound, analgesic, digestion and anti-microbial	Bark & leaves as paste, resin can be eaten fresh or oil for application	Oral and also topical.
Cassia fistula L. [594]	Sonaru	Tree	Fabaceae	Pods, pulp, leaves, bark, roots & flowers	Wild	Constipation, anti-inflammatory, anti-microbial, skin infections, fever, anti-pyretic	Pulp from pops consumed directly, leaves, bark, roots & flowers made into paste or decoction	Oral and also topical.
Centella asiatica (L.) Urb.	Manimuni	Herb	Apiaceae	Leaves	Both	Blood purification, high blood pressure, memory enhancement and promoting longevity.	The leaves are crushed to obtain the extract	Oral and also topical

Clerodendrum colebrookeanum Walp. [590]	Nefafoo	Shrub	Lamiaceae	Leaves & roots	Wild	Anti-inflammatory, antimicrobial, antipyretic, fevers, diabetes, wound, analgesic, digestion and anti-microbial	Leaves & roots into power or paste	Oral and also topical.
Curcuma caesia Roxb.	Kola Halodhi	Herb	Zingiberaceae	Leaves	Both	Gastric issues, inflamed tonsils, infections, wounds, snake bites and stiff joints.	Rhizome or root is to crush it into a paste and can also be preserved as powder.	Oral and also topical
Dillenia indica L.	Outenga	Tree	Dilleniaceae	Fruits	Wild	Fruit treats nervousness, stomach upsets and fatigue. When the fruit's gummy substance is rubbed into the scalp, it treats dandruff and reduces hair shedding.	The fruit is used in curries or raw.	Oral and also topical.
Dysoxylum gotadhora (Buch.-Ham.) Mabb.	Bandardima	Tree	Meliaceae	Bark, leaves, flowers & Fruit	Wild	Anti-inflammatory, antimicrobial, gastrointestinal disorders, fevers, skin infections, wound, analgesic, digestion and anti-microbial	Bark, roots into powder form, fruits consumed directly and leaves into paste.	Oral and also topical.
Euphorbia hirta L. [659]	Gakhiroti bon	Herb	Euphorbiaceae	Leaves	Both	Breathing disorders including asthma, bronchitis, chest congestion.	The roots are ground into a paste or powder, leaves are used as emollient.	Oral and infusion
Ficus religiosa L. [637]	Ahot	Tree	Moraceae	Leaves, bark, fruit & roots	Wild	Anti-inflammatory, antimicrobial, antipyretic, fevers, diabetes, wound, analgesic, digestion and anti-microbial	Leaves crushed into paste, bark & roots into powder and fruit can be consumed directly	Oral and also topical.

Garcinia pedunculata Roxb. ex Buch.-Ham.	Bor Thekera	Tree	Clusiaceae	Fruits	Wild	gastrointestinal ailments	The fruit is consumed fresh, preserved dried or powder.	Oral ingestion
Gmelina arborea Roxb. ex Sm. [633]	Gamari	Tree	Lamiaceae	Leaves, bark, fruit	Wild	Anti-inflammatory, antimicrobial, antipyretic, fevers, skin infections, wound, analgesic, digestion and anti-microbial	Leaves crushed into a paste; bark & fruit processed into powder	Oral and also topical.
Houttuynia cordata Thunb. [638]	Mosunduri	Herb	Saururaceae	Leaves	Both	Pneumonia, hypertension, constipation, and hyperglycemia.	The leaf extract can be obtained or the whole plant can be used raw or cooked.	Oral and also topical
Hydrocotyle sibthorpioides Lam. [675]	Horu manimuni	Herb	Araliaceae	Leaves & stems	Wild	Anti-inflammatory, antimicrobial, antipyretic, fevers, skin infections, wound, analgesic, digestion and anti-microbial	Leaves & stems used as a paste, consumed fresh or decoction.	Oral and also topical.
Impatiens balsamina L.	Keruphul	Herb	Balsaminaceae	Leaves	Both	Warts, snakebites, burns, rheumatism, fractures, and other ailments.	Juice from the leaves is obtained by crushing. Flower is applied to burn.	Oral and also topical
Ipomoea aquatica Forssk.	Kalmou	Herb	Convolvulaceae	Leaves & stems	Wild	Hypertension, diabetes, digestive issues, anti-inflammatory, antioxidant, diuretic effects	Leaves & stems usually cooked or made into juice	Oral.
Leucas aspera (Willd.) Link	Durun	Herb	Lamiaceae	Leaves	Both	Treat snake bites, fevers, inflammation, allergy, diarrhea and insect bites.	The whole plant can be used to get the extract,	Oral and also topical

Neolamarckia cadamba (Roxb.) Bosser	Kadam	Tree	Rubiaceae	Bark, leaves, flowers & Fruit	Wild	Used as astringent, anti-inflammatory, anti-bacterial properties, diarrhea, dysentery, wounds, skin conditions, fever, and digestive issues.	Bark & leaves as a paste,	Oral and also topical.
Ocimum tenuiflorum L.	Tulsi	Herb	Lamiaceae	Leaves	Both	Infection, hyperglycemia, hypercholesterolemia, joint pain and stomach issues.	The leaves are crushed to obtain the extract and can also be consumed raw.	Oral and also topical
Oxalis corniculata L.	Indian sorrel	Herb	Oxalidaceae	Leaves	Both	Nasal inflammation, bacterial infections, anuria and anti-carcinogenic.	Leave juice extract is obtained by crushing the plant or used raw.	Oral and also topical
Oxalis debilis Kunth	Pink wood sorrel	Herb	Oxalidaceae	Leaves	Both	Indigestion, gastritis, irritable bowel syndrome, headache, skin problems and loss of appetite.	Extract is crushed out.	Oral and also topical
Paederia foetida L.	Bhedai lota	Climber	Rubiaceae	Young shoots and leaves	Both	Weak health and fever.	The leaves are chopped into smaller pieces and cooked properly.	Oral ingestion.
Phyllanthus emblica L.	Amla	Tree	Phyllanthaceae	Fruits, leaves, bark & roots	Cultivated	Digestive, immunity, anti-inflammatory, diabetes, heart health, hair & skin, liver protection	Fruits juiced, processed into oil, leaves boiled, dried fruits powdered	Oral and also topical.
Phyllanthus L.	Pora Amlokhi	Tree	Phyllanthaceae	Fruits	Wild	Inflammation, bronchitis, asthma, respiratory disorder, hepatic diseases and diabetes	The fruit is eaten raw or preserved as powder, dried or as pickles.	Oral ingestion
Psidium guajava L. [453]	Madhuriam	Tree	Myrtaceae	Leaves, fruits, bark & roots	Wild	Digestive, diabetes, anti-inflammatory, respiratory & skin conditions	Leaves boiled or ground into paste, bark & roots powdered or boiled, and fresh fruits can be juiced	Oral and also topical.

Smilax zeylanica (L.) [625]	Tikoni borua	Climber	Malvaceae	Young shoots and leaves	Both	Urinary problems and dysentery	The leaves and roots are boiled with other medicinal plants	Oral ingestion
Scleromitrion diffusum (Willd.) R.J.Wang	Bon Jaluk	Herb	Rubiaceae	Whole plant	Wild	Abscesses, infections, fever, flu, UTIs, liver & kidney disorders	Decoction or infusion or boiled	Oral.
Tamarindus indica L.	Teteli	Tree	Leguminosae	Fruits	Wild	Women sometimes use tamarind to treat pregnancy-related nausea.	The fruit extract or pulp is extracted for consumption.	Oral ingestion
Terminalia bellirica (Gaertn.) Roxb.	Bahera	Tree	Combretaceae	Fruits	Wild	Diarrhea, allergy, malaria, inflammation and anti-carcinogenic.	The fruit is eaten raw or preserved as powder or dried.	Oral ingestion
Tetrapilus dioicus (Roxb.) L.A.S.Johnson	Poreng	Tree	Oleaceae	Fruit,leaves & bark	Wild	Digestive, cough, respiratory, anti-inflammatory & antiseptic problems	Fruit can be consumed raw, made into a juice, leaves crushed as a powder & bark powdered.	Oral and also topical.
Zanthoxylum nitidum (Roxb.) DC.	Tejmuri	Climber	Rutaceae	Root	Cultivated	Pneumonia, Body pain and Malaria	The root is crushed into paste or boiled	Oral ingestion and topical application
Zingiber officinale Roscoe	Ada	Herb	Zingiberaceae	Roots, leaves	Wild	Fight off chronic diseases like high blood pressure, heart disease, diseases of lungs, and promote healthy aging.	The rhizome is used for consumption as extract or raw pieces with or without other remedies.	Oral ingestion
Ziziphus mauritiana Lam. [579]	Bogori	Tree	Rhamnaceae	Leaves, fruits, seeds & flowers	Wild	Digestive, anti-inflammatory, respiratory, skin conditions, sedative & antioxidant	Leaves & flowers boiled or ground into a paste, fruits can be juiced, seeds or leaves dried and powdered for use.	Oral and also topical.

Discussion

Socio-economic status

The socioeconomic and demographic characteristics of a household are the primary determinants of a household's dependence on the forest (Jain & Sajjad 2016; Garekae *et al.* 2017). It is essential to recognise that the majority of households, especially those in poverty, rely on multiple sources of income for survival. Sunderlin *et al.* (2004) stated that it is crucial to quantify the extent to which people depend on forests in order to know the effectiveness of poverty alleviation measures that are based on forests. This is especially important in countries where there is a significant amount of tropical deforestation and forest degradation and where the local populace substantially relies on forests. There is a correlation between household size and dependence on forests. The larger the family, the greater its dependence on forest resources for subsistence (Mamo *et al.* 2007). In the present study, household size range from 1 to 9 members. Similarly, there is a positive correlation between the aged old individuals (60 years and above) of the household and forest dependence, although the frequency of visit and harvesting of bioresources decreases after reaching a particular age due to physical strength (Soe *et al.* 2019). However, the elderly head of the household may possess a wealth of environmental knowledge about the ecosystem in their immediate surroundings, which could lead to higher probability of them depending on forest resources (Hussain *et al.* 2019). Harvesting forest products is a labour-intensive way of subsistence for forest dwellers that rely on forests. These activities demand significant time and effort (Angelsen *et al.* 2014; Fisher *et al.* 2005; Pattanayak & Sills 2001). Hence, when deforestation and forest degradation occur, they suffer the greatest losses, making them important and large stakeholders (Nerfa *et al.* 2020). Poor households in rural areas have extremely limited income-generating activities leading to little income from these activities. However, more affluent households depend on forest resources for their subsistence than do rural communities (Angelsen *et al.* 2014; Charlery & Walelign 2015). Several studies have demonstrated that variations in the reliance of rural livelihood on forest resources is a result of differences in demographic factors, socioeconomic conditions, beliefs, and community standards (Adam & El Tayeb 2014; Ali & Rahut 2018; Berkes 2013; Bijaya *et al.* 2016; Jain & Sajjad 2016 Keleman *et al.* 2010; Lepetu *et al.* 2009).

Forest bioresource dependency

Given that it is the poorest who are mostly collecting resources from the forest for their direct use, restricting people's access to these resources would have significant effects on the security of people's livelihoods and increase income inequality (Abdullah *et al.* 2015). However, in our study, we found that the villagers are dependent on the forest products irrespective of their income status. The practice of collecting plant bioresources by the villagers is deeply rooted in tradition and is a time-honoured custom which plays a pivotal role in sustaining livelihood and preserving biodiversity while holding cultural and historical significance. However, the villagers claim that there is a sharp decline in the resource availability in the forest due to various reasons. The respondents have identified several threats to the forest, including increased human settlements, illegal poaching, mining and destruction of trees by herds of elephants. These problems have affected availability of the plant bioresources in the area. Integrating ethnobotanical practices into biodiversity conservation offers dual benefits: protecting cultural heritage and preserving ecosystems. Species crucial to local livelihoods may be prioritized for conservation programs, especially in community-managed landscapes (Gadgil *et al*. 1993). In the present study, it was observed that several agricultural fields grow rice variety like Masuri, Bora, Dharia and Ranjit. Edible fruits like papaya, sugarcane, amla, coconut, as well as edible plants like brinjal, chilli pepper, mustard, peas, cabbage, lentils, common bean, yardlong beans and sweet potatoes, are grown in the fields for both consumption and market purposes. However, various factors significantly impact agricultural production. These factors include elephant attacks during harvesting, crop loss caused by pest infestations, fruits and tender plants being consumed by animals and birds before harvesting, and difficulties associated with harvesting.

Ethnobotanical Knowledge and its Significance

This study emphasizes the vital role of traditional ethnobotanical knowledge in maintaining rural livelihoods and preserving biodiversity in the Eastern Himalayas. The results demonstrate that the villagers relied on forest bioresources like medicinal plants and wild foods. This shows how important it is to keep a strong repository of indigenous ecological knowledge. Similar research in comparable settings have highlighted the significance of ethnobotanical knowledge in enhancing community resilience and biodiversity management (Berkes *et al.* 2000; Turner *et al*. 2000). Our findings contribute to demonstrating the interaction between local resource utilization and cultural practices. The research highlights that the transfer of ethnobotanical knowledge, especially among the elderly and forest guards within the community, predominantly occurs via oral tradition and practice. Our findings correspond with the study conducted by Reyes-Garcia et al. (2009) that emphasizes oral transmission as fundamental to the preservation of traditional ecological knowledge in indigenous communities. Nonetheless, our findings also indicate that generational disparities and urban migration provide considerable threats to the oral transmission. Integrating formal and informal educational initiatives may facilitate the elimination of these gaps. From our study, the villagers indicated that they replaced specific medicinal plants with more readily available alternatives as forest accessibility altered owing to conservation limitations or resource depletion. *Aloe vera* (L.) Burm.f. is increasingly utilized instead of *Acmella paniculata* (Wall.ex DC.) due to its prevalence in natural habitats and homes gardens, as well as its accessibility. It is utilized for the treatment of cuts, sunburns, and skin allergies. This adaptability illustrates the dynamic nature of traditional knowledge systems, as indicated by adaptive co-management frameworks (Folke *et al*. 2004) which highlight the significance of biodiversity protection.

Climate change perception

To ascertain the changes in respondents' perceptions of climate change over time, it is necessary to examine their age distribution. During the survey, respondents of age groups 41-60, 61-80 and 81-100 were interviewed about their perceptions of how the climate in the area has changed over the past 30 years with respect to the present scenario. The Chi-Square indicated that there is a significant association between age group and perception of climate change, $\chi 2(2, N=86) = 12.76, p<0.05$. It was revealed that individuals in different age groups perceive climate change differently, with individuals above 61 years experiencing considerable change in climate compared to those in the age group of 41 to 60 years. In Fig. 5, 60% of the respondents in the age group 41-60 expressed the belief that their local climate is changing. Some people may not experience an immediate connection with the matter if they do not perceive its effects as directly affecting their daily existence. A significant majority of individuals in the age group 61-80 (75%) and 79% of the age group 81-100 clearly experience that the local climate of the region has undergone noticeable changes over the past 30 years. Most of them claim to have lived in the region for a long time and witnessed a multitude of alterations in the climatic conditions. When evaluating the effects of climate change on human and ecological systems, it is crucial to consider the magnitude of the stresses caused by changes in climatic conditions such as temperature, precipitation, and severe storms. Additionally, it is important to assess the level of vulnerability of individuals and systems to these changes. Some of the changes that have been found are changes in the frequency and timing of the rainfall, more erratic occurrences of thunder and lightning events, occurrences of hail, sleet, and gaupel, temperature changes resulting in longer summers and shorter winters, more frequent and intense floods and erosion, and alternation in the flowering and fruiting periods of various plant species (Figure 5). Overall, 73% of the respondents in the survey agree that the climate is changing, and this change is affecting their means of livelihood. In this way, even the smallest changes in weather conditions, such as the frequency or severity of storms or fluctuations in mean temperature, can significantly affect people and systems that are highly sensitive to them. The extent of sensitivity differs depending on the duration of exposure to the change and the coping ability of the people and the system to adapt (Kasperson & Kasperson 2012). In the present study, the older age group experienced more pronounced climate change compared to the younger age group. This is because they have been experienced more drastic change over time. As men and women are affected by climate change in varying degrees, gender vulnerability is an important aspect of resource dependency and climate change impact studies. The detrimental effects of climate change have profoundly jeopardised the security of people's livelihood in this region, posing serious risks to their health, natural security, and occupation (Sharma *et al.* 2009). There were various observations related to climate change claimed by the respondents. According to their observations, there has been a decline in tree fruiting, infrequent sightings of uncommon birds, the decline in agricultural productivity, increased severity of hailstorms, decreased toad and frog populations, diminished bird nesting, and a decrease in firefly occurrences.

The majority of households in the studied five villages primarily depend on subsistence agriculture for their livelihood, which tends to be an insufficient source of sustenance, especially due to reduced water availability caused by climate change. A community's dependence on forest resources directly influences its economic status. High forest dependency and poverty may be indicative of limited access to alternative livelihoods or possibly a contributing factor to poverty, as many forest products have poor economic value and generate low income (Angelsen & Wunder 2003). However, forests serve as safety nets for the rural poor during unexpected famines or as gap fillers during regular seasonal shortages (Angelsen & Wunder 2003; Paumgarten 2005; Shackleton & Shackleton 2004). While it may address the issue of food security, it will not provide adequate security for people's livelihoods. As a result, they are confronted with severe financial constraints while managing to deal with natural disasters such as droughts, landslides, and earthquakes, as well as cultivating human capital and ensuring nutritional security. In this context, it is imperative to implement livelihood diversification as a means to reduce the risks associated with natural disasters and poverty. To sustain their livelihoods and economic activities in the face of changing climatic conditions, people also need to engage in possible non-agricultural activities that are resilient to climate impacts and that provide alternative income sources with market links. This will contribute to the overall resilience of the community (Barua *et al.* 2014).

Research Gaps and Future Directions

The conducted study indicates that despite their potential medical benefits, a diverse range of medicinal and edible plants remain underutilized. More comprehensive research may investigate the biochemical and pharmacological potential of these underutilized species. This would be a step forward that could aid bioprospecting initiatives (Prance *et al.* 1987). Identifying plant species with notable therapeutic qualities presents chances for additional study into new pharmacological substances. For instance, the villagers recognize the pharmacological benefits of limited use of species such as *Calamus erectus* Roxb. and *Euphorbia hirta* L. Similar research (Ved et al. 2017; Bussmann & Sharon 2018) shows that cultural preferences, ecological constraints, and limited market access make it harder for more people in rural India to use valuable bioresources. AS a result, future studies could adopt participatory approaches to find out why these plants are underutilized and to explore their potential for enhancing local livelihoods through bioprospecting initiatives or value-added products. Another critical area for exploration is the mode of knowledge transmission across generations. While aged traditional members serve as primary custodians of ethnobotanical knowledge, the mechanisms of how this knowledge is shared or potentially lost between younger generations remain underexplored (Cámara-Leret *et al.* 2019). This research may provide solutions for revitalizing and preserving traditional traditions. Additionally, gender dynamics in ethnobotanical knowledge constitute an intriguing study field. This study observed disparities in plant utilization knowledge between male forest guards and older female villagers. While the forest guards undoubtedly possessed an in-depth knowledge of plant bioresources inside the forests and their utilisation, older female villagers were equipped with traditional knowledge of plants with high medicinal values. Understanding the influence of gender on knowledge systems may reveal how social structures contribute to the continuation of cultural legacy (Howard 2003). Addressing these gaps would allow future research to improve the discourse on ethnobotany, especially regarding its significance for biodiversity conservation, cultural heritage, and sustainable lifestyles. Furthermore, integrating ethnobotanical knowledge into biodiversity conservation frameworks may improve the efficacy of existing initiatives by aligning them with community goals. Future studies may investigate how community-oriented conservation strategies might reconcile ecological preservation with sustainable resource utilization.

Conclusion

The findings of the present study establish the villagers' dependence on the forests, highlighting the strong connection that exists between communities and the natural environment. The ethnobotanical plants found in the Soraipung range inside the Dehing Patkai National Park play a crucial role for the villagers, since they significantly contribute to their livelihoods and cultural practices. This research highlights the critical role of ethnobotanical traditions in the Eastern Himalayas of India, where they protect cultural heritage, conserve biodiversity, and sustain livelihoods. Traditional knowledge systems possess underutilized ecological and medicinal knowledge. When these traditional knowledge systems combined with modern scientific methods, these knowledge sources can generate transformative solutions. The findings indicated that the impacts of climate change have threatened the availability of the bioresources. It was found that changes in the weather conditions by examining people's perceptions showed variations in the climate not only pose a substantial threat to the sustainability of the local ecosystem but also jeopardize the traditional way of living. While analyzing these processes in a global context, the results of the present study demonstrate the global importance of conserving biodiversity and ethnobotanical knowledge. These findings highlight the need of integrated climate resilience strategies that protect indigenous knowledge systems. We can use this information to informed global conservation and sustainable development strategies. This inquiry not only clarifies the challenges encountered by the villagers of Dehing Patkai National Park, but it also contributes to a deeper understanding of the vital interrelationships between human cultures and their natural surrounding environment on a global scale.

Moving forward, interdisciplinary collaborations between ethnobotanists, pharmacologists, environmental scientists, and sociologists could deepen our understanding of the cultural, ecological, and biochemical significance of these practices. Such collaborations would not only validate traditional knowledge but also strengthen its role in achieving global sustainability goals. This study could serve as a foundation for future work aimed at bridging local ethnobotanical practices with global conservation and development agendas.

Declarations

List of abbreviations: The article does not contain abbreviations.

Ethics approval and consent to participate: Permission was sought from the concerned village headmen of all the villages in study. Verbal informed consent to participate and consent to publish were obtained from all the individual respondents and they signed a form of consent. This work was supported by the Department of Science and Technology (DST), Government of India under grant ID DST/CCP/CoE/182/2019(G).

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Author contributions: Sweeta Sumant, Shilpa Baidya and Dipshikha Singha collected the data. Sweeta Sumant analyzed and drafted the manuscript Shilpa Baidya performed the statistical tests for the work. Bijay Thakur and Anubhav Bhuyan created the map of the study area. Ashalata Devi, Amit Prakash and Nirmali Gogoi read and corrected the final draft of the manuscript. Ashalata Devi read and improved the final version of the manuscript.

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