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Economic significance of wild bioresources to rural communities in the Eastern Himalayan state of Assam, Northeast India

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ABSTRACT

Wild bioresources are indispensable for the survival and sustenance of ethnic and rural communities, especially those of Northeast (NE) India which has a rich heritage of indigenous traditional knowledge on biodiversity and bioresources. This study investigates the trade of wild bioresources throughout the Eastern Himalayan state of Assam along with the socioeconomic attributes of the communities involved in the trade system. Surveys and interviews were executed in local markets and village households. Interviews were carried out with vendors and consumers in 30 weekly markets, and with household heads in 550 households using open-ended structured questionnaires. A systematic database on species diversity, distribution, use pattern, availability, local market economics and community details was assembled, from which standard values of commodities were computed to facilitate uniformity of market values. The study recorded 5 species of wild edible mushrooms, 158 species of wild plants and 11 species of animals available in local markets. Among these 78.7% are consumed as food, while 77 of the total species are medicinal. In some markets, products of species like *Amaurornis phoenicurus, Canarium strictum, Elaeocarpus ganitrus, Hystrix indica, Lentinus polychrous*, L. *squarrosulus, Ocimum basilicum, Piper longum* and *Termitomyces* sp., were sold at a high price of 6.5–65 USD/kg. It was observed that trading wild bioresources contributes 5–75% to the total income at a majority of the households. The present study highlights that wild bioresources are indeed significant for the subsistence of rural communities in Assam, with the potential of improving local economies and promoting community development. Through effective policies and conservation strategies, local communities should be encouraged and empowered to sustainably manage biodiversity and bioresources in the wake of climate change.

1. Introduction

Human well-being has traditionally been governed by biological diversity, ecosystem functioning and ecosystem services. According to the Convention on Biological Diversity (CBD), the flow of biological resources provided by healthy biodiversity provides for 40 percent of the world's economy and 80 percent of the needs of the poor. Biological resources have been historically managed and sustainably used by indigenous communities of the world for their survival, sustenance and livelihood (The World Bank, 2008; WRI, 2005). Especially for communities dwelling in rural and remote places, wild bioresources fulfill majority of their needs and serve as an insurance against risk in terms of food security, health and environmental hazards (CBD, 2010). Furthermore, their cultures evolve with their subsistence demands on wild bioresources and amass in the form of traditional ecological knowledge which is passed on to successive generations.

In recent decades, biodiversity and bioresources have been subjected to habitat loss and changing ecologies due to climate change, coupled with anthropogenic activities such as irrational resource extraction and unsustainable land use practices (Kafoutchoni et al., 2018; Vranken et al., 2011). Exploitation of the ecosystems harboring wild bioresources may negatively affect the biodiversity health, food security and rural livelihoods, and may even provoke conflicts and civil unrest. Consequently, this erodes the traditional socio-ecological knowledge system of local communities which rely on wild bioresources for revenues (Ituarte-Lima et al., 2012). Therefore, it is imperative to study the distribution, use and trade of wild bioresources at local and regional scales in order to achieve their sustainable utilization, conserva-

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tion and livelihood security (Dobbertin and Nobis, 2010; Sundriyal and Sundriyal, 2004).

India's northeast is nestled between two biodiversity hotspots- the Eastern Himalayas and the Indo-Burma region, and is home to over 200 diverse ethnic communities which constitutes about one-fourth of the population of the region (NERLP 2012). The north-eastern state of Assam has a heterogeneous population from diverse ethnic communities having wide range of socio-cultural backgrounds. Ethnic and other rural communities hold a rich indigenous traditional knowledge on biodiversity and bioresources for their subsistence (Sarma et al., 2010). Most of these communities thrive on the availability of wild bioresources in their vicinity for their dietary, healthcare, energy, crafts and utilitarian items, cultural, economic and other day-to-day requirements. Certain wild edible bioresources also act as food supplements when conventional, cultivated crops become inaccessible during natural disasters such as the perennial floods in Assam (Borthakur, 1996).

Although modernization and industrialization have paved a way to the use of agricultural and animal produce, wild bioresources remain an integral component of the livelihood and economic security of financially marginal communities. Most of these communities target the local markets to sell their wild products which they collect from nearby natural habitats like community or reserve forests, water bodies and other landscapes. The local trade gives them an opportunity to raise their income and provides a stepping stone to enter the cash economy, especially in rural areas with limited options for wage labor (Meinhold and Darr, 2019).

In Assam, studies and reports on bioresources are exclusively focused on the use of wild edible and medicinal plants by different ethnic communities (Kar and Borthakur, 2008; Kar et al., 2008; Medhi and Borthakur, 2012; 2013; Medhi et al., 2014; Sarma et al., 2010; Teronpi et al., 2015). A number of studies have also touched upon the contribution of wild bioresources or non-timber forest products (NTFPs) to the livelihoods of indigenous communities (Komor and Devi, 2016; Mipun et al., 2019). However, these investigations were confined within certain fragmented areas of the state. In the light of this scenario, the present study attempts to systematically investigate the trade of wild bioresources throughout Assam, while also documenting the socioeconomic attributes of the communities involved in the trade system.

2. Materials and methods

2.1. Study area

The north-eastern state of Assam is sandwiched between the foothills of the Eastern Himalayas and the Patkai and Naga Hill Ranges, and extends between 24°07′ to 28°00′ North latitude and 89°42′ to 96°02′ East longitude. It has a total geographical area of 78,438 sq. km. (2.39 percent of the total area of India), of which 98.4 percent are rural areas. Rich alluvial plains punctuated by tributaries, hills and hillocks lying between the Brahmaputra and the Barak river valleys form the uneven topography of the state. The climate is influenced by the southwest monsoons and high humidity. The annual rainfall ranges between 1500 mm to 3800 mm with maximum precipitation during June and July, and the annual temperature varies from 5 ^{0}C to 32 ^{0}C. The vegetation of the state consists of tropical evergreen and deciduous forests, subtropical broadleaf and pine forests, littoral and swamp forests, grasslands and savannahs. The recorded forest area is 26,832 sq. km., which accounts for 34.21 percent of the total geographical area (ISFR 2019). The soil type is alluvial and laterite with highly decomposed humus, and is strongly acidic with a pH of 4.2–5.8.

The present study was conducted within the physiographic regions of Brahmaputra valley and Central Assam Hills, from Goalpara district (bordering with the state of Meghalaya in the south) to Dhemaji and Tinsukia districts (bordering with the state of Arunachal Pradesh in the east). The locations of the markets surveyed in the present study are shown in Fig. 1.

2.2. Methods

For the purpose of the current study, plant and animal resources which are found ~~living~~ under natural conditions (in forest lands, natural water bodies or even growing naturally alongside cultivated crops in agricultural lands), and are used by ethnic and rural communities for their provisioning and cultural purposes were considered as 'wild' bioresources. To conduct the study, due permission was obtained from the Principal Chief Conservator of Forests & Head of Forest Force, Assam and local authorities such as market committees and village councils. All respondents were kept in full light of the objectives of the research and its possible outcome, and interviews were conducted with their consent while also maintaining confidentiality of identities and information shared. Through interviews, basic information such as local name of product, collection site/habitat, use of product, mode of consumption, price, quantity sold per day, any medicinal importance, etc. were noted (Questionnaire provided in Table S1). After careful observation of vendors in the market and items with them for sale, only those vendors selling local and/or wild products were interviewed for the purpose of the study. Through interviews, basic information such as local name of product, collection site/habitat, use of product, mode of consumption, price, quantity sold per day, any medicinal importance, etc. were noted (Questionnaire provided in Table S1). Surveys were also conducted at households' level in Darrang, Dhemaji, Lakhimpur, Sonitpur and Udalguri districts (Questionnaire provided in Table S2). For this, 10 forest-fringe villages were randomly selected from each district where households are dependent on forest products for their livelihoods. Voucher specimens of plant and animal resources were collected only for those species which the authors couldn't identify in situ. The rest of the species which are common and readily identifiable and is well known to the authors were identified on the spot and recorded. Collected specimens are brought to the institution (Eastern Himalayan Botanic Ark, Balipara Foundation, Assam) and voucher specimens are maintained in the laboratory for future reference and study. Based on the interviews with vendors, consumers and household heads (mostly elders in the household) using open-ended structured questionnaires (Sundriyal and Sundriyal, 2004; Termote et al., 2012), a systematic database on species diversity, distribution, use pattern, availability, local market economics (quantities collected, bought or sold and price) and community details such as age, gender, occupation, annual income was assembled. From the database, standard values of commodities (quantities sold per week, unit price and income earned per week) were computed to facilitate uniformity of market values. The profitability or added values of each wild bioresource was calculated as the difference between the price the vendor sells the product for and the price they pay for the product. Thus, added value = quantity traded (selling price per unit of product - buying price per unit of product) (Termote et al., 2012), where losses due to perishability and/or self-consumption were not taken into account. All monetary estimations were converted from the current rates of the Indian Rupee into the United States Dollar (1 INR = USD 0.013).

3. Results

3.1. Diversity of wild bioresources available in local markets of Assam

The products of wild bioresources recorded in the present study comprised of 5 species of fungi (wild edible mushrooms) belonging to 4 genera and 4 families, 143 species of plants (belonging to 115 genera and 57 families) and 11 species of animals (spread across 11 genera and 11 families). Furthermore, products of an additional 15 ethnospecies of plants and 1 species of animal (snail) were also encountered during the survey; however the identification of those species were limited to local names only (See supplementary material Table S3).

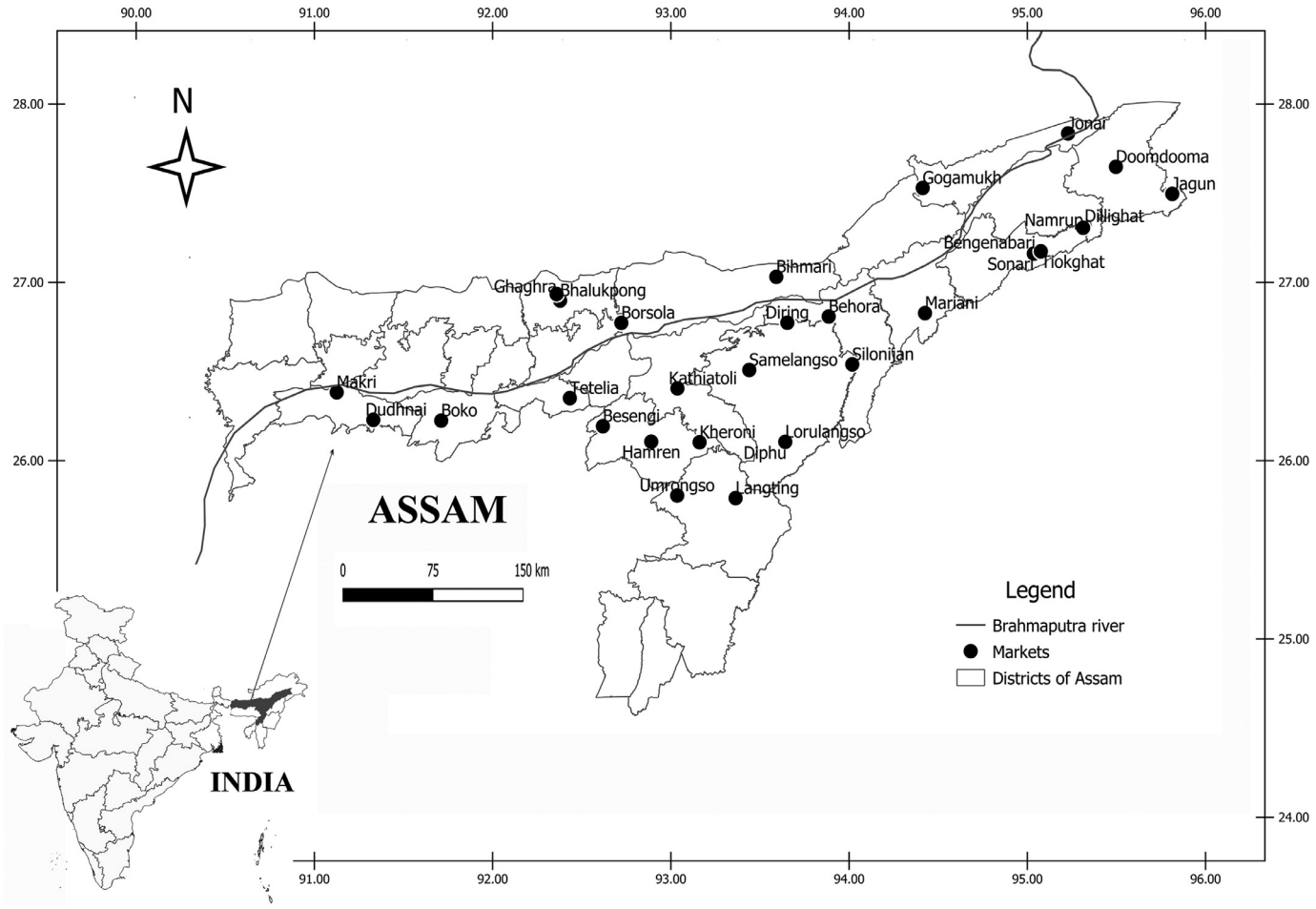

Fig. 1. Map depicting locations of the surveyed weekly markets and household areas in Assam, NE India.

The five species of wild edible mushrooms are *Auricularia delicata* (Mont.) Henn, *Lentinula edodes* (Berk.) Pegler., *Lentinus polychrous* Lev., L. *squarrosulus* (Mont.) and *Termitomyces* sp. Among the wild plant species, there were 2 species of gymnosperms, i.e. *Gnetum gnemon* L. and *Pinus kesiya* Royle ex. Gordon, while the other 141 species were angiosperms. Some of the wild bioresources had multiple species of the same genus, i.e., there were four species each of *Colocasia, Musa, Solanum* and *Terminalia*, three species each of *Bambusa* and *Garcinia* and two species each of *Albizia, Artocarpus, Calamus, Cinnamomum, Dendrocalamus, Elaeocarpus, Ficus, Lentinus, Passiflora, Phyllanthus*, and *Zizyphus* (See supplementary material Table S3).

While considering the highest number of species that falls under a specific family, it was deduced that 10 species belong to Fabaceae, followed by Araceae, Lamiaceae and Poaceae with 8 species each, Asteraceae with 6 species, and Arecaceae, Moraceae, Musaceae and Zingiberaceae with 5 species each. Among the others, Combretaceae, Rutaceae, and Solanaceae had 4 species each, while Acanthaceae, Amaranthaceae, Clusiaceae, Cucurbitaceae, Lauraceae, Malvaceae, Phyllanthaceae and Rhamnaceae had 3 species each. Ten families had 2 species each, while forty-two families had 1 species only (See supplementary material Table S3).

Most of the wild bioresources documented in the present study have been harvested or collected from village/community forests, reserve forests and hill forests and foothills of Arunachal Pradesh, Meghalaya and Nagaland bordering the state of Assam. Some of the wild bioresources have also been brought from water bodies such as ponds, *beels* (lake-like wetlands) and mighty rivers like the Subansiri and the Brahmaputra. The products that are available in the markets are either collected by the vendor from wild habitats or bought from other people or suppliers.

3.2. Use pattern of the products

The diverse wild bioresources documented in the present study were available in the form of 184 products in local markets. Based on usage, these products were broadly divided into 7 categories: food (including local beverages, spices and condiments), firewood, timber, utilitarian items (agricultural tool, brooms, materials for crafts and construction), and miscellaneous items (comprising of amulets, incense, lac, ointment for external use, traditionally prepared oral medicine and resin) (Fig. 2). Seventy-eight-point seven percent of the wild bioresources are consumed as food (raw, pickled, fermented, or cooked) across a wide range of fruits, vegetables, leafy greens and mushroom. Twenty tree species were sold for timber (as furniture) and ten species as firewood. Seventy-seven species are known to be of medicinal value as analgesic, antibiotic, antioxidant, antipyretic, digestive, laxative, etc., or used as anti-hairfall, anti-venom, aphrodisiac, astringent, blood coagulant, health supplement, stimulant, for weight loss, against skin diseases and other therapeutic purposes (See supplementary material Table S3).

The most widely sold parts of the edible bioresources were leaf (45 percent), fruit (18 percent) and flower/inflorescence (7 percent) while bark, tuber/rhizome, root, seed, shoot or in whole were also available (Fig. 3). For certain species, several parts of the plant were used for different purposes and available in market e.g., bark and roots (for wine) and leaf (as edibles) of *Acacia pennata* (L.) Willd., young shoot (as edibles) and culm (for handicraft items) of *Bambusa bambos* (L.) Voss

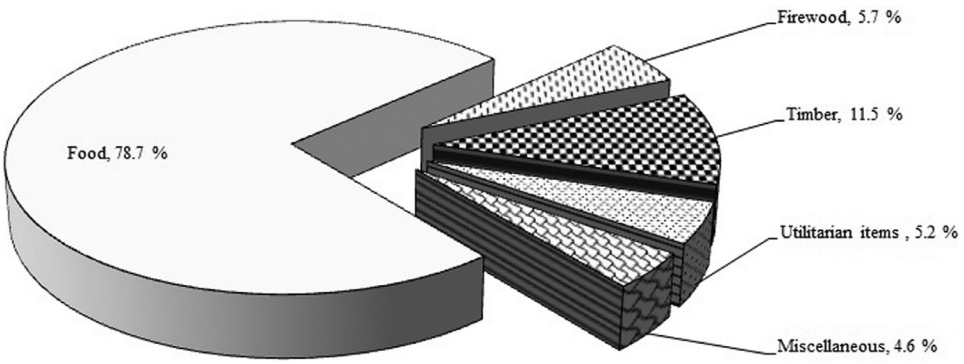

Fig. 2. Use pattern (percent) of different wild bioresources available in local markets of Assam, NE India.

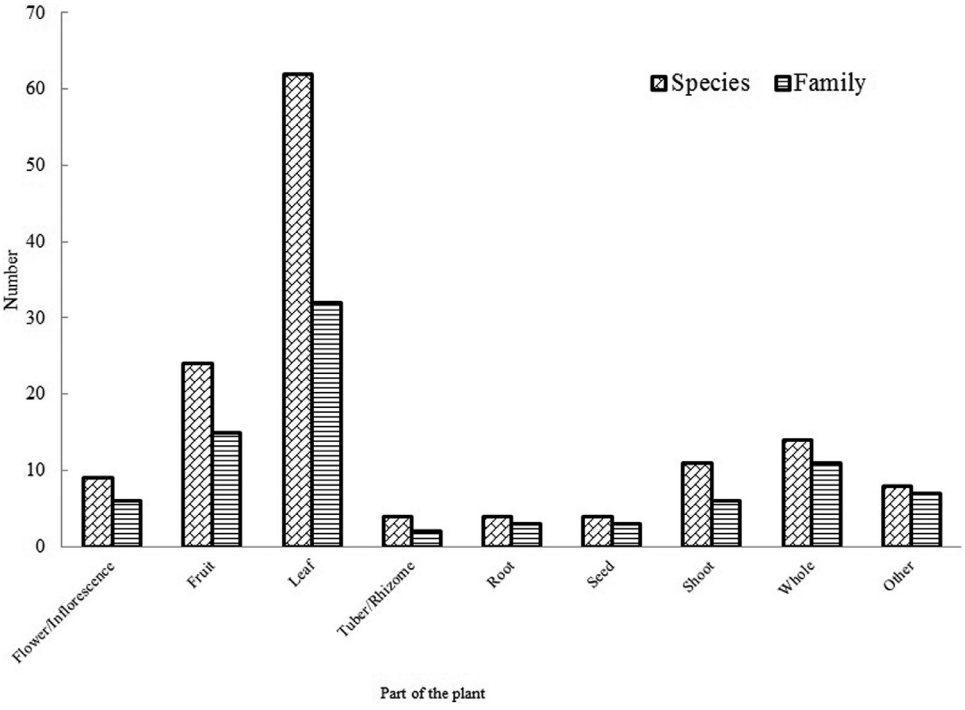

Fig. 3. Different plant parts available as wild edible bioresources in local markets of Assam, NE India.

and *Calamus tenuis* Roxb., leaf (as edibles) and roots (for amulets) of *Murraya koenigii* (L.) Spreng., and fruit (as edibles) and trunk (for timber) of *Terminalia chebula* Retz. Some tree species, like *Bombax ceiba* L., *Lagerstroemia parviflora* Roxb., *Mesua ferrea* L. and *Shorea robusta* Gaertn.provide good quality of firewood and timber. Cut stems and small pieces of logs of *Pinus kesiya* Royle ex. Gordon were sold as incense and as timber.

Besides a myriad of fruits, vegetables and leafy greens, some other notable plants products that were available in the markets were: (a) traditional wine prepared from the bark of *Acacia pennata* (L.) Willd., (b) incense prepared from the resin of *Canarium strictum* Roxb. (c) amulets made from seeds of *Elaeocarpus ganitrus* Roxb. ex G.Don and *Terminalia arjuna* (Roxb. ex DC.) Wight & Arn., (d) leaves and stem of *Livistona jenkinsiana* Griff. and *Phragmites karka* (Retz.) Trin. ex Steud. for use as housing material, (e) green, pink and yellow coloured inflorescences of different species of bananas, (f) a traditional cooking soda prepared from the root of *Musa balbisiana* Colla, (g) oral medicines prepared from *Piper longum* L., (h) soap made from seeds of *Sapindus mukorossi* Gaert., etc. to name a few. *Boesenbergia rotunda* (L.) Mansf., *Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm, *Cinnamomum verum* J.Presl and *Ocimum basilicum* L., were also sold as spices and condiments (See supplementary material Table S3).

The products of animal species that were observed in the local markets includes honey/honeycombs (produced by *Apis cerana indica* F.), crabs (*Barytelphusa guerini* (H.Milne Edwards, 1853)), water snails (*Bellamya bengalensis* (Lamarck, 1882), *Melanoides tuberculata* (Müller, 1774) and *Pila globosa* (Swainson, 1822), lac (produced by lac insects *Kerria lacca* Kerr.), weaver ants (*Oecophylla smaragdina* Fabricius, 1775) and meat of white-breasted water hen (*Amaurornis phoenicurus* P.), fallow deer (*Cervus dama* L.), Indian crested porcupine (*Hystrix indica* Kerr.) and wild boar (*Sus scrofa* Linnaeus, 1758) (See supplementary material Table S3).

3.3. Market characteristics and economy

Most products were put on display as bundles or packets weighing around 100–500 g. The total number of species of wild bioresources sold, was higher in the markets of Lorulangso (49 species in total), Diphu (35 species), Gogamukh (30 species) and Kheroni (27 species) (Table 1). Wild edible species were available in all markets except for Behora and Borsola. Next to edibles, the most commonly available products were brooms and timber, which were sold in 22 and 16 markets, respectively.

The sale of timber products depended on orders which were placed much ahead of the market day; hence timber products have been excluded from economic valuation. From the estimation of total volume

Table 1
Valuation of wild bioresources sold in local markets of Assam, NE India. Quantity sold per week = weight of one unit of a product sold by the vendor * total units of the product sold; Revenue raised = (Selling price of a product /weight of one unit of the product)*quantity sold per week.

Sl. No.	Name of market (name of district within parentheses) See Fig. 1	Total no. of species sold*	No. of vendors	Percentage of female vendors (%)	Quantity Sold Per Week (kg/week)#	Revenue raised (USD/week)#
1	Begenabari (Charaideo)	11	8	75	0.5–4	0.26–2.60
2	Behora (Golaghat)	5	6	0	6.0	6.50
3	Besengi (Karbi Anglong)	16	30	93.3	0.6–500	0.39–65.00
4	Bhalukpong (Sonitpur)	20	15	93.3	0.3–700	0.26– 273.00
5	Bihmari (Biswanath)	4	3	100	5.0–62.5	5.20–162.50
6	Boko (Goalpara)	21	40	100	0.3–212.5	0.26–208.00
7	Borsola (Darrang)	3	3	0	10.0–250	5.20 –390.00
8	Dillighat (Dibrugarh)	8	14	100	0.5–80	0.13–15.60
9	Diphu (Karbi Anglong)	35	32	100	0.1–70	0.13 –182.00
10	Diring (Golaghat)	6	11	9.1	0.5–100	0.39 –156.00
11	Doomdooma (Tinsukia)	24	37	64.9	0.5–100	0.20–39.00
12	Dudhnai (Goalpara)	21	41	34.1	0.3–150	0.65– 65.00
13	Ghaghra (Udalguri)	7	6	66.7	0.1–6.3	0.91–7.80
14	Gogamukh (Dhemaji)	30	31	54.8	0.2–100	0.13–234.00
15	Hamren (Karbi Anglong)	16	29	86.2	0.5–250	0.65 –65.00
16	Jagun (Tinsukia)	22	23	100	0.2–75	0.20–39.00
17	Jonai (Dhemaji)	21	24	91.7	0.5–120	0.65–13.00
18	Kathiatoli (Nagaon)	12	36	22.2	2.0–150	1.30 –26.00
19	Kheroni (Karbi Anglong)	27	27	66.7	0.3–300	0.33–13.00
20	Langting (Dima Hasao)	16	27	74.1	0.2–120	0.26–168.35
21	Lorulangso (Karbi Anglong)	49	68	92.6	0.1–120	0.13–78.00
22	Makri (Goalpara)	11	11	72.7	0.3–16	0.33–13.00
23	Mariani (Jorhat)	15	28	0	0.5–400	0.65–156.00
24	Namrup (Dibrugarh)	14	17	29.4	0.2–20	0.07–6.50
25	Samelangso (Karbi Anglong)	14	13	76.9	0.5–3	0.39–1.30
26	Silonijan (Golaghat)	14	12	41.7	0.7–10	0.26–7.80
27	Sonari (Charaideo)	15	10	30	0.3–500	0.39–130.0
28	Tetelia (Kamrup)	23	16	62.5	0.6–75	0.65 –117.00
29	Tiokghat (Charaideo)	6	8	75	0.4–10	0.26 –5.20
30	Umrongso (Dima Hasao)	15	14	50	0.6–5	0.65–3.12

*includes both of plant and animal species,.
#excluding timber products.

of products sold in each market, it was seen that 100–200 kg/week of 17 species were sold in 12 markets, while 201–400 kg/week of 6 species were sold in 7 markets. The highest quantity was sold in the market of Bhalukpong (700 kg/week of *Melanoides tuberculata*) and Sonari (500 kg/week of tender shoot of *Calamus tenuis* and fruit of *Phyllanthus emblica* L.) (See Table 1 and supplementary material Table S3). Furthermore, 56 species (including 4 animal products) were sold at a unit price of Rs. 100–200 (USD 1.30–2.60) per kg and 12 species (including 4 other animal products) at the rate of Rs. 201–400 (USD 2.61–5.20) per kg. The wild edible mushrooms *Lentinus polychrous*, L. *squarrosulus* and *Termitomyces* sp. were priced between Rs. 100–666 (USD 1.30–8.67) per kg. Other highly priced species were *Canarium strictum* at Rs. 480 (USD 6.24) per kg sold at the market of Diring, *Elaeocarpus ganitrus* at Rs. 2000 (USD 26) per kg at Tetelia, *Ocimum basilicum* at Rs. 500 (USD 6.50) per kg at Diphu, and *Piper longum* at Rs. 500–600 (USD 6.50–7.80) per kg at Gogamukh and Tetelia. Meat of *Amaurornis phoenicurus* was sold at Rs. 2666–2800 (USD 34.8–36.4) per kg at Langting and that of *Hystrix indica* at Rs. 5000 (USD 65) per kg at Jagun (See supplementary material Table S3).

Most vendors have acknowledged earning lucrative incomes from the sale of wild bioresources. Twenty-five percent of species had brought in Rs. 500–2500 (USD 6.5–32.5) per week, 5 percent was sold for Rs. 2501–5000 (USD 32.51–65) per week and 3 percent was sold for Rs. 5001–10,000 (USD 65.01–130) per week. Some vendors had earned between Rs. 10,000–30,000 (USD 130–390) by selling plant species such as *Canarium strictum, Phyllanthus emblica* and *Piper longum*, and animal species such as *Cervus dama* and *Melanoides tuberculata*. The highest revenue was earned from selling 250 kg of *Canarium strictum* for Rs. 30,000 (USD 390) in the market of Borsola. Moreover, there was also profit (added value) ranging between Rs. 40 and Rs. 7000 (USD 0.5– 91.0) for 49 species across 17 markets (See supplementary material Table S3).

3.4. Community characteristics

Sixty-seven percent of the vendors selling wild bioresources in local markets of Assam were womenfolk (Table 1), with all-women vendors in 5 markets, i.e. Bihmari, Boko, Dillighat, Diphu and Jagun. Vendors of diverse age groups; < 15 years (0.2 percent), 15–24 years (1.3 percent), 25–54 years (84.1 percent), 55–64 years (12.8 percent), > 65 years (1.7 percent) and eighteen ethnic communities were found to be involved in the local trade (Fig. 4). Apart from the Assamese and Bengali, there were also individuals of some of the major ethnic communities of Assam, such as Adivasi, Ahom, Bodo, Dimasa, Kachari, Karbi, Koch, Mishing, Rabha and Sonowal. People from neighboring states of Arunachal Pradesh (Adi and Nyishi), Meghalaya (Garo and Khasi) and Nagaland (Naga) are also involved in trading.

From interviews conducted at households across 49 villages in Assam, it was observed that 68% of the households use wild bioresources for food, fodder and fuel-wood, which are collected from forests and grasslands. Some of these forests are in the vicinity of protected areas such as national parks or reserve forests, while some others are community forests. 47.8% of the collectors were women-folk, 43.7% were male and 8.4% were children. In addition to thriving on wild bioresources, the households also depend on agriculture and non-agricultural occupations. While 19% of those households have annual incomes ≤ Rs. 1 lakh (≤ 1318.96 USD) per annum, 72% earn between Rs. 1–2 lakhs (1318.96–2637.91 USD) p.a. and 8% have incomes ≥ Rs. 2 lakhs (≥ 2637.91 USD) p.a. For a majority of the households, the selling of wild bioresources has contributed between 5% and 75% to the total income. Further details on the wild bioresources recorded from households are given in Table 2.

Table 2
Wild bioresources used at households in 5 districts in Assam, NE India.

Sl. No.	Name of species [family name within brackets]	Part used/sold	Use	Specific medicinal properties	Households engaged in collection (%)	Average quantity collected per month (kg)	Households involved in selling (%)	Average quantity sold (kg)	Average unit price (USD)
1	*Aborichthys elongatus* Hora [Nemacheilidae]	Whole	Food	Nutritive	0.5	30	0.5	25	1.56 per kg
2	*Aegle marmelos* (L.) Correa [Rutaceae]	Fruit	Food	Digestive	0.2	50	0.2	40	0.13 per fruit
3	*Albizia lebbeck* (L.) Benth [Fabaceae]	Branch	Fuelwood	–	3.2	2120	3.2	700	0.26 per bundle
4	*Alocasia cucullata* (Lour.) G.Don[Araceae]	Whole	Food	Anti-rheumatic	0.7	500	0.7	400	0.26 per part
5	*Azadirachta indica* A.Juss [Meliaceae]	Leaf	Fodder	For skin diseases	0.1	80	–	–	–
6	*Baccaurea ramiflora* Lour [Euphorbiaceae]	Fruit	Food	Digestive	1.1	50	1.1	40	0.52 per packet
7	*Bombax ceiba* L. [Malvaceae]	Branch	Fuelwood	–	3.1	55.7	3.1	600	0.26 per 0.5 kg
8	*Cassia fistula* L. [Fabaceae]	Leaf	Fodder, fuelwood	For skin diseases	3.4	48	–	–	–
9	*Channa barca* Hamilton. [Channidae]	Whole	Food	Nutritive	0.2	80	0.2	60	1.56 per kg
10	*Channa punctata* Bloch. [Channidae]	Whole	Food	Nutritive	0.2	200	0.2	150	1.3 per kg
11	*Chrysopogon aciculatus* Trin. [Poaceae]	Whole	Fodder	–	2.2	85.7	–	–	–
12	*Clerodendrum glandulosum* Coleb. [Lamiaceae]	Leaf	Food	Anti-malarial	0.5	200	0.5	100	0.52 per bundle
13	*Colocasia esculenta* (L.) Schott [Araceae]	Whole	Food	Anti-hairfall	0.9	100	0.9	70	0.07 per part
14	*Colocasia* sp. [Araceae]	Whole	Food	Nutritive	1.4	200	1.4	100	0.13 per part
15	*Cynodon dactylon* (L.) Pers. [Poaceae]	Whole	Fodder	–	2.8	41.8	–	–	–
16	*Dillenia indica* L. [Dilleniaceae]	Fruit	Food	Astringent	2.5	378.5	2.5	360	0.13 per fruit
17	*Diplazium esculentum* (Retz.) Sw. [Dryopteridaceae]	Whole, young fronds	Food	–	2.8	300	2.8	204	0.26 per bundle
18	*Ensete superbum* (Roxb.) Cheesman [Musaceae]	Fresh stem pith, whole	Fodder, food	Laxative	1.1	20	–	–	–
19	*Flacourtia jangomas* (Lour.) Raeusch. [Flacourtiaceae]	Fruit	Food	Digestive	0.2	1000	0.2	990	0.78 per packet
20	*Garcinia mangostana* L. [Clusiaceae]	Fruit, leaf	Food	Analgesic	0.5	50	–	–	–
21	*Garcinia pedunculata* Roxb. [Clusiaceae]	Fruit	Food	Digestive	0.5	50	0.5	40	0.26 per fruit
22	*Gmelina arborea* Roxb. ex Sm. [Verbenaceae]	Branch, leaf	Fodder, fuelwood	Anthelmintic	6.8	511.7	6.8	741.1	0.26 per bundle of fuelwood
23	*Heteropneustes fossilis* Bloch [Heteropneustidae]	Whole	Food	Iron supplement	0.4	80	0.4	70	4.16 per kg
24	*Holmskioldia sanguinea* Retz. [Verbenaceae]	Leaf	Fodder	Analgesic	1.6	20	–	–	–
25	*Lagerstroemia speciosa* (L.) Pers. [Lythraceae]	Branch	Fuelwood	–	0.8	518.5	0.8	400	0.26 per bundle
26	*Mallotus nudiflorus* (L.) Kulju & Welzen [Euphorbiaceae]	Branch	Fuelwood	–	0.2	500	–	–	–
27	*Melia azedarach* L. [Meliaceae]	Branch, leaf	Fodder, fuelwood	Anti-diarrhoeal	3.9	81.04	3.9	40	0.13 per bundle of fuel-wood
28	*Mikania micrantha* Kunth [Asteraceae]	Leaf	Fodder	–	2	15	–	–	–
29	*Morus alba* L. [Moraceae]	Fruit, leaf	Fodder, food	Antipyretic	1.5	15	–	–	–
30	*Neolamarckia cadamba* (Roxb.) Bosser [Rubiaceae]	Branch	Fuelwood	–	2.1	391.1	2.1	600	0.26 per bundle
31	*Phyllanthus emblica* L. [Phyllanthaceae]	Fruit	Food	Anti-hairfall	2.9	400	2.9	300	0.52 per kg
32	*Potentilla indica* (Andr.) Wolf [Rosaceae]	Fruit	Food	Diuretics	0.7	5	–	–	–
33	*Puntius sophore* F. Hamilton [Cyprinidae]	Whole	Food	Nutritive	0.2	1350	0.2	1343	1.3 per kg

(*continued on next page*)

Table 2 (*continued*)

34	*Shorea robusta* Gaertn. [Dipterocarpaceae]	Branch	Fuelwood	–	1.5	178.4	1.5	400	0.26 per bundle
35	*Stereospermum chelonoides* (L.f.) DC. [Bignoniaceae]	Branch	Fuelwood	–	1.9	878.1	1.9	733.3	0.26 per bundle
36	*Streblus asper* Lour. [Moraceae]	Leaf	Fodder	Sedative	2.4	50	–	–	–
37	*Tectona grandis* L.f. [Lamiaceae]	Branch	Fuelwood	–	3.8	177.34	3.8	550	0.26 per bundle
38	*Terminalia chebula* Retz. [Combretaceae]	Fruit	Food	Antibiotic	3.9	1000	3.9	900	0.26 per 250 g
39	*Tetrameles nudiflora* R. Br. [Tetramelaceae]	Branch	Fuelwood	–	1.5	373	1.5	300	0.26 per bundle
40	*Ziziphus jujuba* Mill. [Rhamnaceae]	Branch, Fruit	Food, fuelwood	Laxative	1.9	80.6	1.9	50	0.26 per 250 g of fruits

4. Discussion

Flanked between two biodiversity hotspots and the Brahmaputra River as its lifeline, India's northeastern state of Assam has a huge repertoire of wild resources. The present study is a comprehensive documentation of a wide variety of wild bioresources which are used by different rural communities in Assam. The study shows how wild bioresources are integral for the food security and subsistence of these communities, while also being an essential part of the rural household economy.

Among the 174 species documented in the present study, 79 percent are edible products and were available in most markets. This exemplifies the high diversity of wild edibles consumed by most ethnic and other rural communities in Assam. Out of 3895 plant species found in Assam, 7.34 percent are wild edibles of ethno-medicinal importance (Sarma et al., 2010). Several studies have discussed the diversity of wild edible plants in Dima Hasao (83 species, Medhi and Borthakur, 2013), Karbi Anglong (51–57 species, Kar et al., 2008; Kar and Borthakur, 2008; Teronpi et al., 2015), and North Cachar hills (114 species, Medhi and Borthakur, 2012) at length, including parts consumed, medicinal properties as well as their local market values. Medhi et al. (2014) have enlisted 168 species of wild edible plants and fungi which are used by over 10 ethnic groups in Dima Hasao, of which 66 species have been semi-domesticated and protected by the communities since ages. Komor and Devi (2016) have presented 143 species of edible wild, semi-wild and other bioresources available in the local markets of Central Assam. Some other studies have documented wild edible fruits, vegetables (Baro et al., 2015; Barua et al., 2007; Borgohain, 2017; Bose et al., 2018; Brahma et al., 2013) and wetland plants (Pagag and Borthakur, 2012) from several districts in Assam.

Besides being important sources of nutrition, wild edibles are abundantly available and easily accessible. Most wild edibles are consumed during lean periods of the year as a substitute for other cultivated food (Sundriyal et al., 2004). Especially during adverse situations such as the current COVID-19 pandemic which has challenged the food security of the urban and rural population alike, wild edible bioresources may serve as a handy option to fall back on. Value of wild edibles is relatively lower than their commercial counterparts because of limitations in connectivity and access to mainstream market economies (Medhi and Borthakur, 2012). However, the consumption of wild edibles by rural communities has decreased over the years, as most of the food re-

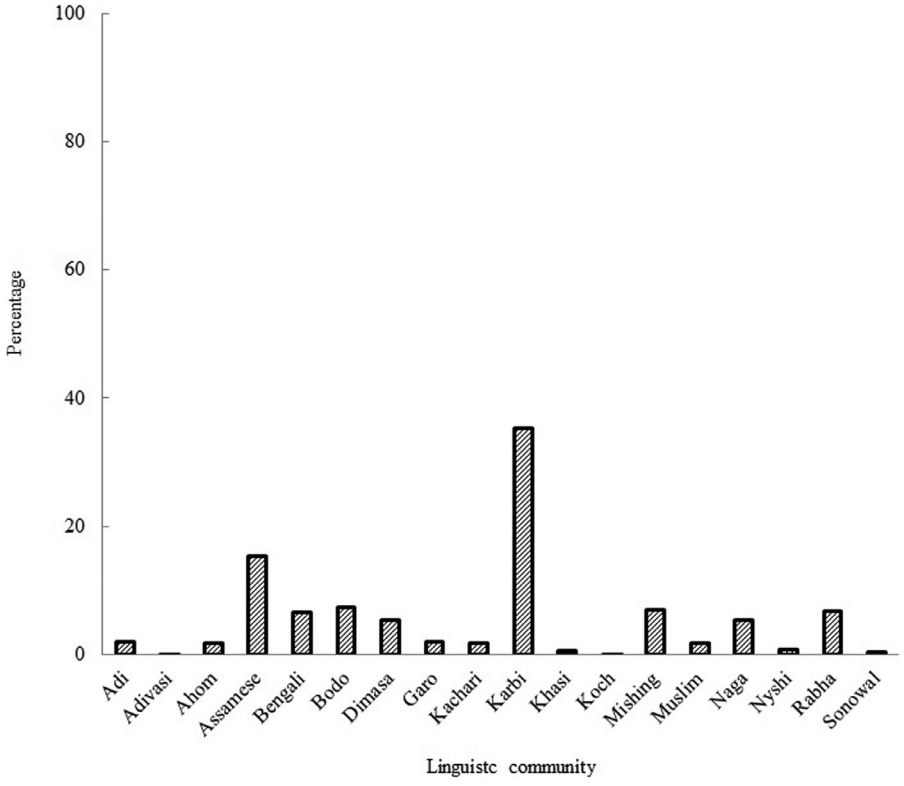

Fig. 4. Diversity of communities selling wild bioresources in local markets of Assam, NE India.

quirements are met from agricultural produce or commercially available products.

Socioeconomic conditions of rural communities govern local market economies and the frequency of market days (Sundriyal and Sundriyal, 2004). Vendors had informed that market availability and quantities of wild bioresources have come down over the years, while prices have increased. Availability of products in the markets is also strongly related to the time of the year and associated socio-cultural practices of the communities, such as food habits, festivals, traditional practices, illnesses, etc. Certain products of the same species were observed to have varying prices in different markets. This may be because of differences in demand of the products, labor costs and income of local inhabitants (Kar et al., 2008). High variety of wild bioresources was reported from the districts of Dhemaji, Goalpara, Kamrup, Karbi Anglong, Sonitpur and Tinsukia, which may be due to the proximity to forest areas with neighboring states of Arunachal Pradesh and Meghalaya. The rich forest resources of Karbi Anglong has been emphasized by previous studies (Komor and Devi, 2016; Sarma, 2007; Timungpi, 2017). It was also observed that women were the primary collectors in households and as vendors in the local markets. When children and young people are engaged in the exploration and collection of wild bioresources, it maintains the flow of traditional ecological knowledge across generations. Of late this flow of traditional knowledge is fading away fast with changes in socio-cultural structure, economic status, religious or spiritual values as well as erosion of ethnic languages and extinction of dialects.

Provisioning ecosystem services are especially important for most rural communities and households of low financial profile, limited livelihood options from land or non-land resources and poorer infrastructure (Njwaxu and Shackleton, 2019; You-Kai et al., 2004). Angelsen et al. (2014) have analyzed that wild bioresources such as non-timber forest products (NTFPs) may contribute to 28% of household income on an average world-wide, which may even be at par or exceed agricultural income in certain households. In the present study, it was deduced from the responses of vendors during the interviews, that 5–75% of the incomes of nearly half of the households are secured from selling wild bioresources. Similar results were found by Mipun et al. (2019) from their detailed investigation of the contribution of NTFPs to healthcare and livelihood security among the Karbis, where 20–50 percent of the households earn from less than 20–90 percent of their income from the sale of NTFPs. Even though most vendors acknowledged making lucrative incomes, there was no stability in the business as it depends on the access to wild bioresources.

During the household survey, it was learnt that the cover of the source forests has gradually declined in the past decade due to landuse changes and tree-felling for fuel-wood or timber. Unhealthy harvesting of wild bioresources for subsistence use or for trade may have disastrous effects on the resilience of species or the ecosystems harboring them (Oldfield, 2012). To ensure the judicious use and conservation of wild bioresources that are indispensable to the communities, governments, scientists, policy-makers and stake-holders must reassess existing policies and strategies while also roping in community participation through provisions for incentives or through programmes like tourism and REDD+ ((International Union for Conservation of Nature and Resources, 2002); Raudsepp-Hearne et al., 2010). Such opportunities may help deviate unemployed people toward a different source of livelihood instead of banking on exploitation and erosion of natural resources of an area (Komor and Devi, 2016).

Economically important wild bioresources such as bamboos and rattans, *Canarium strictum, Phyllanthus emblica*, wild species of *Musa*, mushroom species, spices, etc., or those of ethno-medicinal significance should be brought into *ex situ* conservation schemes through cultivation in homesteads and other traditional agroforestry systems (Kar et al., 2008; Medhi and Borthakur, 2012; Sundriyal and Sundriyal, 2004) along with apiculture and fisheries. With the help of community elders or traditional healers, medicinal plants may be selected for further biochemical analysis to evaluate their nutritional value and potential drug development (Mipun et al., 2019). Domestication of wild plants increases diversity of cultivars, encourages organic agriculture, enhances biodiversity and ecosystem health and generating more revenues to rural communities (Teronpi et al., 2015). To bring the trade of wild bioresources at par with their commercial counterparts in urban markets, new marketing opportunities should be identified and implemented with women at the forefront as they are the primary collectors and sellers (You-Kai et al., 2004).

A more meticulous analysis of seasonal differences in availability, demand, prices and quantities of the different wild bioresources sold in local markets of Assam, along with the various social factors associated with livelihood resources of the communities would substantially help to assess the contribution that this trade makes to the overall economy of the region. Although Assam and the northeastern states of India are unique in abundance of natural resources and socio-cultural diversity, the region has a long way to go before attaining economic prosperity because of weak infrastructural facilities, poor entrepreneurial ventures and lingering civil unrest (Chawii, 2007). Livelihoods of rural communities are transitioning from a need-based system which depended on natural resources and community labor, to commercial agricultural and non-agricultural system, to the organized sector. In order to diversify sources of income of rural communities and manage natural resources, the government is making endeavors toward strengthening traditional governance and community decision-making (Chawii, 2007; (NER Version 2020)).

5. Conclusions

Previous investigations on wild bioresources of Assam have concentrated on inventories and market economies of species that are consumed or are traditionally used by a number of ethnic communities in certain parts of the state. The present study recorded 174 species of wild bioresources in Assam which are significant for the subsistence and livelihoods of various indigenous communities through a rich traditional knowledge system. The most common use of bioresources as food supplement highlights the diverse culinary practices of the people of this region. The study documented a few costly animal bioresources, for example the meat of *Amaurornis phoenicurus* and *Hystrix indica,* although their quantities and occurrences were less frequent. Their higher prices stem from the fact that they are highly sought-after protein supplements but are rare to find in markets. Among plant bioresources, seeds of *Elaeocarpus ganitrus* used as amulet, fetched the highest prices and is identified as a potential economical bioresource. There is a scope to increase the economic stability of the sellers by increasing the quantity and availability of highly priced bioresouces. This work also highlights an interesting fact that womenfolk play a proactive role in both collection and trade of bioresources in this region. Therefore, imparting proper training to the womenfolk on bioresource collection, sustainable use and propagation becomes crucial as it can play a pivotal role in strengthening the rural economy by providing secondary source of income to the household.

The investigation throws light upon the significant role that wild bioresources play in improving local economies and promoting community development, thus serving as a baseline for similar future studies. However, an important aspect of the collection and trade of wild bioresources that should not go unaddressed is the unsustainable harvesting. This calls for effective policies and conservation strategies to revive and strengthen traditional management practices with modern sustainable planning. Such steps would also help enhance the livelihoods and food security of ethnic and other rural communities while empowering them to manage biodiversity and bioresources in the wake of climate change. This work providing first-hand information on the bioresource utilization and its economic importance to the rural communities of the Eastern Himalayan state of Assam is expected to apprise the policy makers to prioritize bioresource management policies for economic development of this remote region.

Authors' contributions

The work was conceptualised and designed by GD. The collection of primary data and voucher samples from the study areas has been done by MB, AFA, DB and RKS. CD has helped in identification of species and preparation of the map. Analysis and interpretation of the data has been done by GC, MB and GD. GC, MB, GD, NH, AD contributed equally towards writing, reviewing and editing the manuscript. The final manuscript has been read and approved by all the authors.

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Availability of data and materials

All data generated or analysed during this study are included in this published article.

Ethics approval and consent to participate

The authors declare that there were no violation of ethics and consent to participate.

Consent for publication

All respondents gave consent to publish the information included in this draft.

Declaration of Competing Interest

The authors declare that they have no competing interests.

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Supplementary materials

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