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Non-timber forest products and their contribution to healthcare and livelihood security among the Karbi tribe in Northeast India

Puranjoy Mipun[1*], Nazir Ahmad Bhat[1], Dipankar Borah[2] and Yogendra Kumar[1]

Abstract

Introduction: Non-timber forest products (NTFPs) have been an essential source for food, medicine, and handicraft products among the indigenous populations living in forested areas for millennia. Scientific research on the restoration of the importance of NTFPs and their value addition could potentially guide the development of new nutraceutical products in the future. The present study aims to investigate the diversity of non-timber forest products of the Karbi Anglong District of Assam in Northeast India.

Methods: Multistage sampling technique was used for the study. A total of 70 respondents from 7 randomly selected villages were interviewed with a well-developed semi-structured questionnaire to explore the utilisation of NTFPs. Data analysis was done using four quantitative indices: (a) use report (UR), (b) use value (UV), (c) informant consensus factor (ICF), and (d) fidelity level (FL).

Results: A total of 138 plant species belonging to 59 families distributed in 110 genera were recorded and identified as NTFPs of 1 type or the other. These include 42% having ethnomedicinal use, 33% as edible forest products, 15% as household building materials and utensils, 6% as spices and condiments, and 4% as herbal dyes. Among the medicinal plant species, *Abroma augustum* (L.) L. f., *Amaranthus spinosus* L, and *Geophila repens* (L.) I. M. Johnst. showed the highest ICF and FL.

Conclusions: The present study confirms that NTFPs have played an essential role in the healthcare and livelihood of the indigenous people of the Karbi tribe throughout their generations and continue to do so. Also, the species with high value for both ICF and FL could be used for the development of new, cheap, effective, and eco-friendly herbal formulations for healthcare management leading to economic and social benefits to the indigenous tribe. However, anthropogenic pressure and overexploitation of NTFPs may lead to the loss of this precious natural resource from this area.

Keywords: East Karbi Anglong, Ethnobotany, Forest income, NTFPs, Wildlife sanctuary, Quantitative study, Medicinal plants

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Introduction

All biological products, other than timber or products of animal origin, that are harvested from forests and manipulated for human and animal use, are described as non-timber forest products (NTFPs) (Ros-Tonen et al. 1995). NTFPs play a vital role in supporting livelihood security, development, and poverty reduction, especially for the rural communities living around forest areas (Cocks and Wiersum 2003; Cocksedge 2006; Endamana et al. 2016). It also has substantial cultural significance and value for various ethnic groups around the world. However, the importance of NTFPs tends to be underestimated as they are not traded through organised markets and do not appear in national economic statistics even though millions of forest dwellers harvest large quantities of NTFPs for both subsistence and commercial use, either regularly or as an emergency (Shaanker et al. 2004).

In India, 90% of the plants supplied to the international market are from the wild stock (Mishra et al. 2009). It is therefore essential to develop a systematic and rigorous data collection system in all the developing countries for better utilisation of NTFPs. Moreover, if the government and stakeholders take the initiative to

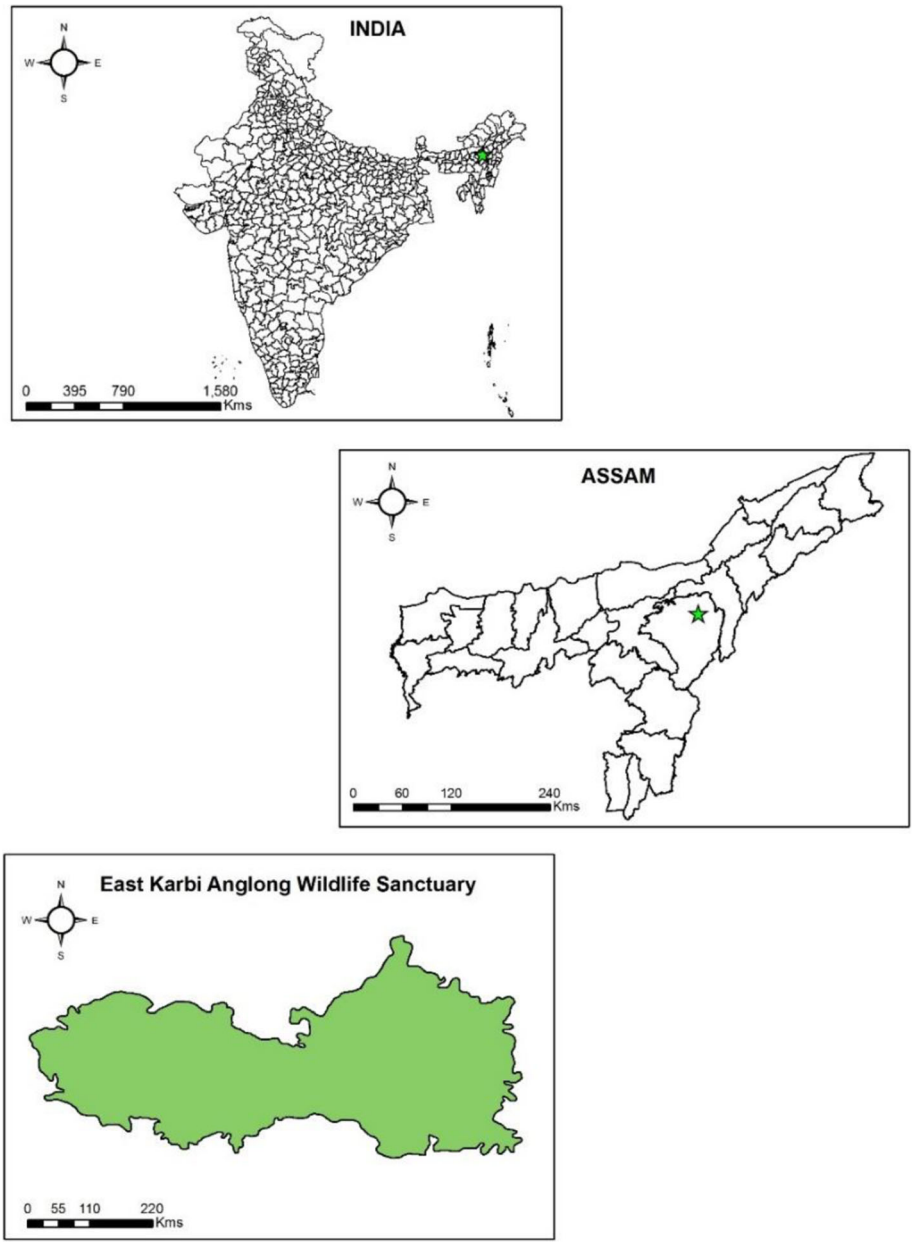

Fig. 1 Map of East Karbi Anglong Wildlife Sanctuary, Assam, indicating selected area for study

Table 1 Demographic characteristics of informants for NTFPs surveys in East Karbi Anglong Wildlife Sanctuary

Villages	Borpung	Tarapung	Noralangso	Phanglangso	Langtuk hanse	Langpratlangso	Kanduwa bosti
Male	7	6	7	8	7	8	6
Female	3	4	3	2	3	2	4
Total households	10	10	10	10	10	10	10
Total respondents	10	10	10	10	10	10	10

prioritise the sustainable use of NTFPs, the economic and social well-being of communities living in and around forest lands could be enhanced substantially (Agrawal et al. 2013). The increasing threat of large-scale deforestation and degradation of the natural habitat poses a significant hazard to various forest resources, particularly NTFPs. Therefore, it is important to urgently develop appropriate management strategies and practical plans before these elements are lost forever (Pandey and Saini 2007).

Northeast India spreads over an area of 255,088 km^2, constituting 7.7% of the total geographical area of the country. A large number of different indigenous communities in this region are traditionally dependent on forest products, especially on NTFPs, which play a significant role in the maintenance of subsistence and provision of food and medicine. It is estimated that 60–94% of the tribal population in states like Arunachal Pradesh, Nagaland, Manipur, and Tripura are dependent on forest resources for various purposes (Dattagupta and Gupta 2016). Earlier studies of NTFPs in Assam are minimal in comparison to other Indian states (Sarma et al. 2016). One research has shown that forest dwellers of the Inner Line Reserve Forest of Cachar District in the Barak Valley region collect 67 plant species as NTFPs of 40 families (Dattagupta et al. 2010, 2014). Another study on the commercial uses of forest products in Karbi Anglong District of Assam has shown that the forest remains the backbone of the economy for the people living in this area (Timunpi 2017).

Quantitative ethnobotany is the application of quantitative techniques to direct analysis of contemporary plant use data (Phillips and Gentry 1993). This approach aims to describe the variables quantitatively and analyse the observed patterns to test different hypotheses about the relationship between plant species and humans (Höft et al. 1999; Reyes-García et al. 2006). One advantage of using this method, in addition to the systematic quantification, is that it helps to produce quality information, which in turn supplies substantially to resource conservation and development (Hussain et al. 2018). Quantitative ethnobotanical indices have so far been able to measure the various uses of plants whether as food, veterinary medicine, remedies for human disease, or economic value (Pieroni 2001; Upadhyay et al. 2011; Kim and Song 2013; Reyes-García et al. 2006). Although a few relevant ethnobotanical studies among the Karbi tribe have been conducted (Sankar and Chowdhury 2000; Kar and Borthakur 2008; Teron and Borthakur 2012; Teron and Borthakur 2013; Phongchopi et al. 2014; Terangpi et al. 2014; Teronpi et al. 2015; Singh 2017), none of

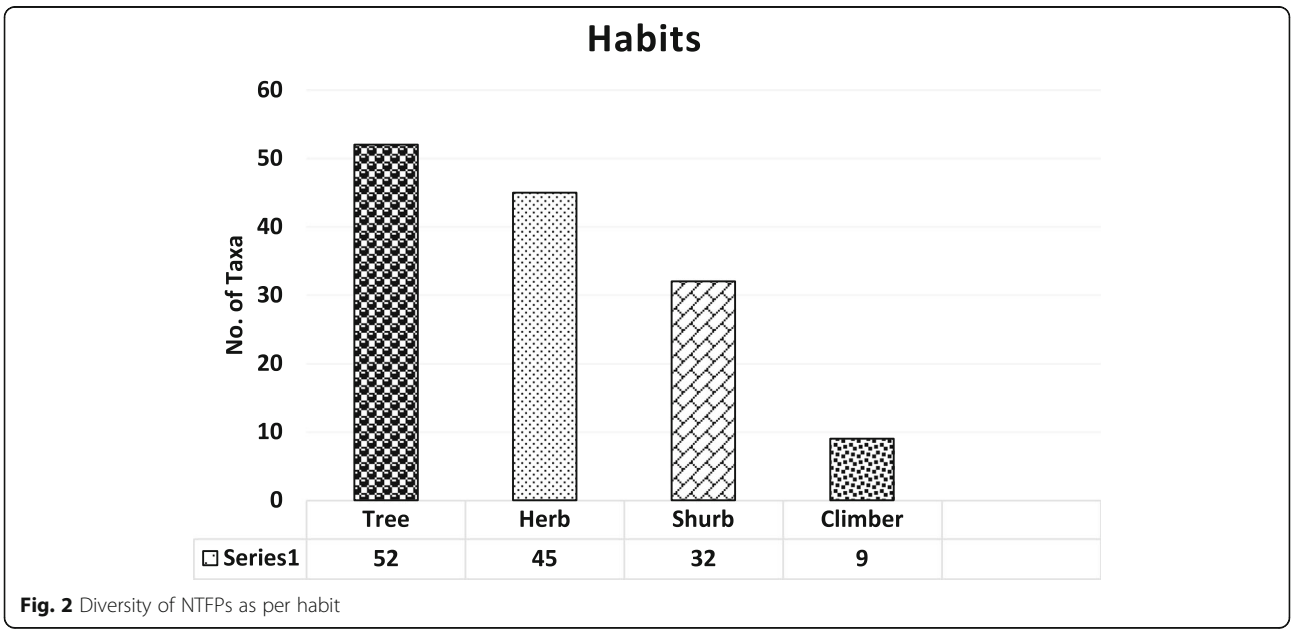

Fig. 2 Diversity of NTFPs as per habit

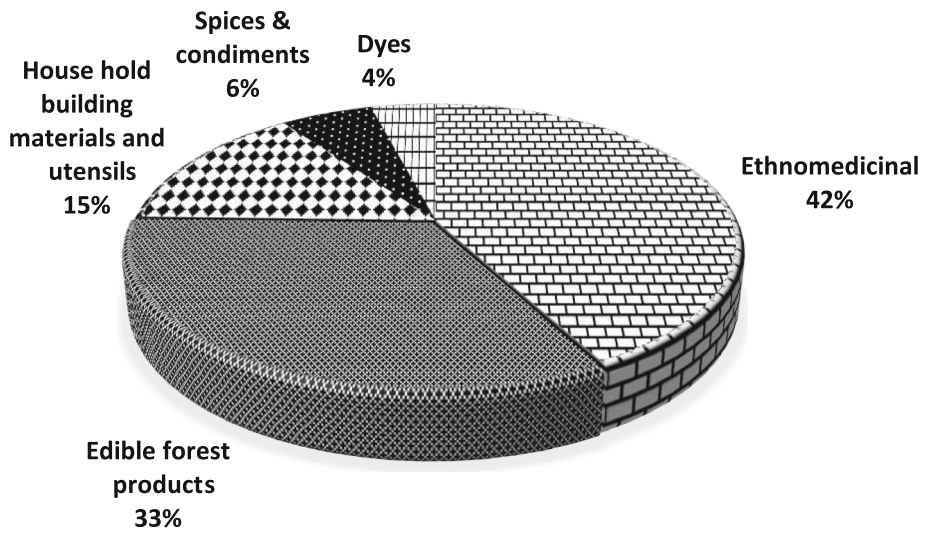

Fig. 3 Categories of non-timber forest products collected from East Karbi Anglong Wildlife Sanctuary

them have been able to document those studies using quantitative ethnobotanical techniques. Ethnobotanical studies using quantitative approach have a significant potential to enhance the indicative value of ethnobotanical studies and can enhance the factual information available for conservation and development of the existing resources.

Apart from some plant diversity studies carried out in Karbi Anglong District, no extensive study has been carried out to evaluate the exact wealth of the hilly terrains present in the area. This study explores NTFPs used by the indigenous Karbi community, evaluates different ethnobotanical indices, and examines the dependence of the forest dwellers on this existing resource in East Karbi Anglong Wildlife Sanctuary in the Karbi Anglong District of Assam.

Methods

Study area

The present study was carried out in East Karbi Anglong Wildlife Sanctuary of Karbi Anglong District of Assam, which is one of the primary forests of the state covering an area of 221.81 km^2 (Fig. 1). It is situated between 24° 33′ N to 26° 35′ N latitude and 92° 10′ E to 93° 50′ E longitude and is 80–600 m asl. It is an essential component of the Karbi Anglong-Kaziranga landscape. The topography of the study site ranges from undulating hills to wide valleys and steep gorges with rivers and creeks, as well as annual and perennial streams. The wildlife sanctuary holds different forest types ranging from moist semi-evergreen, moist mixed deciduous to miscellaneous type with scattered pure or mixed patches of bamboos. Some of the prominent tree species found in the sanctuary are Hoong (*Dipterocarpus macrocarpus*), Mekai (*Shorea assamica*), Nahar (*Mesua ferrea*), Sia-nahar (*Keyea assamica*), Sissoo (*Dalbergia sissoo*), Khair (*Acacia catechu*), Helika (*Terminalia chebula*), etc. The soil is well-drained, sandy loamy to clayey loamy, and the climate is warm and humid with an annual rainfall of 1800 mm. The average maximum temperature is around 30 °C in August, and the minimum goes down to 6.5 °C in winter.

Participatory rural assessment

The present field survey was carried out from 2015 to 2017, mainly in the villages surrounding the sanctuary.

Table 2 Details of villages surveyed in investigations of the NTFPs in East Karbi Anglong Wildlife Sanctuary

Sl. no.	Villages	Population	Latitude (N) (DMS)	Longitude (E) (DMS)	Altitude (m)
1	Borpung	2132	26° 23′ 21.6564″ N	93° 28′ 17.8932″ E	340
2	Tarapung	1752	26° 28′ 07.396″ N	93° 30′ 1.688″ E	300
3	Noralangso	960	26° 27′ 25.088″ N	93° 27′ 56.627″ E	344
4	Phanglangso	1172	26° 22′ 23.761″ N	93° 20′ 14.985″ E	440
5	Langtuk hanse	720	26° 26′ 7.0476″ N	93° 27′ 49.6404″ E	456
6	Langpratlangso	1183	26° 24′ 22.9″ N	93° 26′ 39.073″ E	540
7	Kanduwa bosti	1240	26° 22′ 34.1868″ N	93° 21′ 22.1868″ E	458

Source: local headmen of respective villages

Table 3 Enumeration of medicinal plant species used by the Karbi tribe in East Karbi Anglong Wildlife Sanctuary

Botanical name	Local name	Habit	Parts used	Medicinal uses	Used type	Mode of application
Abroma augustum (L.) L.f. (Malvaceae)	*Korai*	S	R	1. Amenorrhea, dysmenorrhoea	O	1. Decoction of root
Abrus precatorius L. (Fabaceae)	*Chuselok*	C	R, L	1. Malaria 2. Fever, cold, cough	O O	1. Decoction of root 2. Decoction of leaf
Acacia pennata (L.) Willd. (Fabaceae)	*Khemra*	T	B, L, R	1. Cut, wound, antidote against insect bites 2. Stomach ache, dyspepsia	T O	1. Paste of bark and leaf 2. Decoction of root
Aegle marmelos (L.) Correa (Rutaceae)	*Thepli*	T	L, F,	1. Stomach ache 2. Dysentery, constipation, haemorrhoids, cure weak health	O O	1. Mixture of leaf and fruits with water 2. Juice of fruits
Alocasia macrorrhizos (L.) G.Don (Araceae)	*Henchala*	H	L, St, Cr	1. Antidote against insect bites 2. Diarrhoea, stomach ache	T O	1. Paste of leaf and stem 2. Corm decoction
Alpinia nigra (Gaertn.) Butt (Zingiberaceae)	*Tara*	H	Rh	1. Stomach ache, sore throat 2. Headache, lumbago	O T	1. Juice of rhizome 2. Paste of rhizome
Alternanthera sessilis (L.) R. Br. Ex DC. (Amaranthaceae)	*Utokreng*	H	Wp,	1. Urinary disorder, haematuria	O	1. Decoction of whole plant
Alternanthera philoxeroides (Mart.) Griseb. (Amaranthaceae)	*Utokreng*	H	L, Wp	1. Skin allergies 2. Urinary disorder	T O	1. Paste of fresh leaf 2. Infusion of whole plant
Amaranthus spinosus L. (Amaranthaceae)	*Dido*	H	Wp, L	1. Antidote against insects bite 2. Nosebleed	T N	1. Juice of whole plant 2. Juice of leaf
Amblovenatum opulentum J.P. Roux (Thelypteridaceae)	*Babkeso*	S	Wp	1. Ectoparasitic control in poultry	T	1. Whole plant is applied directly
Annona reticulata L. (Annonaceae)	*Longle jangphong*	T	F, L	1. Diarrhoea, dysentery 2. Helminthiasis	O O	1. Direct feeding of fruits 2. Decoction of leaf
Annona squamosa L. (Annonaceae)	*Longle jangphong*	T	L	1. Ectoparasitic control in poultry	T	1. Whole plant is applied directly
Azadirachta indica A. Juss. (Meliaceae)	*Neem*	T	L, R	1. Skin acne 2. Fever 3. Skin acne in cattle, ectoparasitic control in cattle	T O T	1. Paste of leaf 2. Decoction of root 3. Paste of leaf, decoction of root and leaf
Baccaurea ramiflora Lour. (Phyllanthaceae)	*Dampijuk*	T	F	1. Scurvy 2. Skin infection	O T	1. Direct consumption of fruits 2. Juice of fruits
Bauhinia racemosa Lam. (Fabaceae)	*Ingku*	T	R, Fl	1. Stomach ache 2. Cold, cough	O O	1. Decoction of root 2. Decoction of flower
Bauhinia variegata Linn. (Fabaceae)	*Ingku-ke er*	T	R, B, Bu, Fl	1. Cut, wound 2. Vomiting, nausea 3. Tonsils, thyroid problem 4. Dysentery in cattle	T O O O	1. Paste of root 2. Powder of dry buds and root 3. Decoction of bark for gargle 4. Infusion of flower
Bridelia retusa (L.) Spreng. (Phyllanthaceae)	*Pleple*	T	B	1. Burns, skin acne, cut, wound 2. Bronchitis	T O	1. Paste of bark 2. Decoction of bark
Bridelia tomentosa Blume (Phyllanthaceae)	*Thebihi-arong*	T	L, B	1. Stomach ache	O	1. Decoction of bark and leaf
Capsicum annuum L. (Solanaceae)	*Inglong abirik*	H	L, F	1. Dyspepsia, sore throat 2. Rheumatism 3. Laryngitis	O T O	1. Direct consumption of fruits 2. Paste of fruits and leaf 3. Decoction of fruits for gargle
Careya arborea Roxb. (Lecythidaceae)	*Loring*	T	B	1. Cure dysentery in cattle	O	1. Juice of the bark
Centella asiatica (L.) Urb. (Apiaceae)	*Chong amok*	H	L, Wp	1. Cut, wound, itches, sore eyes, sinusitis 2. Gastric problem, cold, cough 3. Haemorrhoids	T O O	1. Juice of leaf 2. Infusion of leaf 3. Juice of whole plant
Cheilocostus speciosus (J.Koenig) C.D. Specht (Costaceae)	*Ai-upo*	H	Rh	1. Helminthiasis, bronchitis 2. Skin acne	O T	1. Juice of rhizome 2. Paste of rhizome
Cissampelos pareira L. (Menispermaceae)	*Tubuki-lota*	C	L, R, St	1. Skin acne, cut, wound, antidote against insect bite 2. Helminthiasis, diarrhoea, dysentery, dysmenorrhoea	T O	1. Paste of leaf and root 2. Infusion of leaf and stem

Table 3 Enumeration of medicinal plant species used by the Karbi tribe in East Karbi Anglong Wildlife Sanctuary *(Continued)*

Botanical name	Local name	Habit	Parts used	Medicinal uses	Used type	Mode of application
Citrus assamensis R.M.Dutta & Bhattacharya (Rutaceae)	*Tumeng*	S	F	1. Dyspepsia 2. Antidote against insect bite 3. Malaria	O T O	1. Juice of fruits 2. Juice of fruits 3. Juice of fruits
Clerodendrum infortunatum L. (Verbenaceae)	*Phlek ik*	S	L, Tw, R	1. Diarrhoea, dysentery 2. Dandruff	O T	1. Infusion of root and twigs 2. Infusion of leaf
Curcuma longa L. (Zingiberaceae)	*Tharmit*	H	Rh	1. Dyspepsia, gastric problem 2. Rheumatism, cut, wound, bruise, burns	O T	1. Juice of rhizome 2. Paste of rhizome
Datura metel L. (Solanaceae)	*Hepi chumprak*	H	L, S	1. Pain reliever 2. Asthma and bronchitis	T I	1. Paste of roasted leaf 2. Vapour of boil leaf
Dendrocalamus strictus (Roxb.) Nees (Poaceae)	*Chek arong*	S	L	1. Arthritis, fever	T	1. Paste of leaf
Drymaria cordata (L.) Willd. ex Roem. & Schult. (Caryophyllaceae)	*Nonrongman*	H	Wp, L	1. Cut, wound, bruise, burns 2. Cold, cough, sinusitis	T I	1. Paste of whole plant 2. Vapour from boil leaf
Ficus benghalensis L. (Moraceae)	*Cheri hanthor*	T	L, La	1. Diarrhoea, dysentery 2. Haemorrhoids	O O	1. Infusion of leaf buds 2. Direct consumption of a few drops of latex with milk
Ficus hispida L. (Moraceae)	*Ingthum*	T	R, F, B	1. Skin acne, itches 2. Jaundice, stomach ache 3. Increase lactation in lactating woman	T O O	1. Powder of dried root bark 2. Decoction of fruits and bark 3. Direct consumption of ripe fruits
Ficus racemosa L. (Moraceae)	*Cheri*	T	B, La, F	1. Mouth infection 2. Ears infection 3. Urinary disorder	O T O	1. Decoction of bark for gargle 2. Paste of latex 3. Powder of dried peel of its fruits
Geophila repens (L.) I.M. Johnst. (Rubiaceae)	*Chong*	H	Wp, F	1. Skin infection, skin acne, allergies	T	1. Paste of whole plant
Habenaria dentata (Sw.) Schltr. (Orchidaceae)	*Bomu*	H	Wp	1. Skin acne, cut, wound	T	1. Paste of whole plant
Hedyotis scandens Roxb. (Rubiaceae)	*Bi akengkung*	H	R	1. Sprains in goats	T	1. Paste of rhizome
Hibiscus cannabinus L. (Malvaceae)	*Hanserong*	H	L, Fl, S	1. Cold, cough *2.* Muscle fatigue 3. Gastric problem, stomach ache	O T O	1. Infusion of leaf 2. Paste of leaf and stem 3. Juice of flower mixed with sugar
Hibiscus sabdariffa L. (Malvaceae)	*Hanserong ke-er*	H	S, L	1. Urinary incontinence, dyspepsia 2. Antidote against insect bite 3. Food poisoning in cattle	O T O	1. Decoction of seed 2. Paste of leaf 3. Decoction of seed
Hydrocotyle sibthorpioides Lam. (Apiaceae)	*Chong amok*	H	L	1. Dysentery, gastric problem, stomach ache	O	1. Juice of leaf
Ichnocarpus frutescens (L.) W. T. Aiton (Apocynaceae)	*Parok hanthor*	C	Wp, S, L	1. Bleeding gums 2. Fever, cough, dysentery 3. Cut, wound, headache	O O T	1. Juice of whole plant 2. Decoction of stem and leaf 3. Paste of leaf
Kaempferia galanga L. (Zingiberaceae)	*Bithiphaknur*	H	Rh	1. Fever in cattle	O	1. Juice of rhizome
Leea indica (Burm. F.) Merr. (Vitaceae)	*Gangma-chi*	S	R, L, Fl	1. Diarrhoea, dysentery 2. Skin ache	O T	1. Decoction of root 2. Paste of leaf and flower
Leucas aspera (Willd.) Link (Lamiaceae)	*Han phulok*	H	L, Fl	1. Sinusitis 2. Helminthiasis 3. Antidote against insect bite	N O T	1. Juice of leaf 2. Decoction of leaf and flower 3. Paste of leaf
Lippia alba (Mill.) N.E.Br. ex Britton & P.Wilson (Verbenaceae)	*Naga alopong*	S	L	1. Conjunctivitis 2. Fever, stomach ache	T O	1. Juice of leaf 2. Infusion of leaf
Magnolia hodgsonii (Hook.f. & Thomson) H.Keng (Magnoliaceae)	*Parokbithi-arong*	T	B, Fl	1. Dysmenorrhoea, stomach ache, dyspepsia 2. Asthma, coughing	O O	1. Decoction of bark 2. Decoction of flower
Mangifera indica L. (Anacardiaceae)	*Tharve*	T	S, L	1. Diarrhoea, haemorrhoids 2. Throat infection	O O	1. Powder of dried seed 2. Direct consumption of

Table 3 Enumeration of medicinal plant species used by the Karbi tribe in East Karbi Anglong Wildlife Sanctuary *(Continued)*

Botanical name	Local name	Habit	Parts used	Medicinal uses	Used type	Mode of application
						young leaf
Moringa oleifera Lam. (Moringaceae)	*Sondon*	T	B	1. Kill maggots in cattle	T	1. Paste of bark
Murraya koenigii (L.) Spreng. (Rutaceae)	*Thengsakso*	S	L	1. Gastric problem, dysentery, vomiting	O	1. Juice of leaf
Nyctanthes arbor-tristis L. (Oleaceae)	*Hawali*	T	L, Fl	1. Malaria, constipation, helminthiasis	O	1. Juice of leaf and flower
Ocimum gratissimum L. Lamiaceae)	*Tulsi*	H	L	1. Indigestion 2. Ectoparasitic in cattle	T T	1. Infusion 2. Leaf is applied directly
Oroxylum indicum (L.) Vent. (Bignoniaceae)	*Napak ban*	T	Fl, R, S, B	1. Helminthiasis 2. Diarrhoea, dysentery 3. Cut, wound, boils 4. Tonsil	O O T T	1. Decoction of flower 2. Decoction of root 3. Paste of young seed 4. Paste of bark for gargle
Oxalis corniculata L. (Oxalidaceae)	*Wothung-mekbok*	H	Wp, L	1. Helminthiasis, scurvy 2. Antidote against insect bite, burns, skin allergies 3. Sore eyes	O T T	1. Infusion of whole plant 2. Paste of leaf 3. Juice of leaf
Phlogacanthus tubiflorus (Buch.-Ham. ex Wall.) Nees (Acanthaceae)	*Jok-aan*	S	I, L	1. Helminthiasis 2. Cold, cough, asthma	O O	1. Juice of inflorescence 2. Decoction of leaf
Phyllanthus emblica L. (Phyllanthaceae)	*Thilu kame*	T	B, F	1. Nausea, vomiting 2. Dysentery	O O	1. Powder of fruits 2. Decoction of fruits
Physalis peruviana L. (Solanaceae)	*Nihang bokbok*	H	L	1 Arthritis, headache 2 Malaria	T O	1. Paste of leaf 2. Decoction of whole plant
Pseudocaryopteris foetida (D.Don) P.D.Cantino (Lamiaceae)	*Pherklum alo*	S	Wp	1. Ectoparasitic control in poultry	T	1. Whole plant is applied directly
Sarcochlamys pulcherrima Gaudich. (Urticaceae)	*Bikbik*	T	L, F	1. Diarrhoea, dysentery 2. Skin ache	O T	1. Decoction of leaf 2. Juice of leaf and fruits
Senna alexandrina Mill. (Fabaceae)	*Taw-eit*	S	L	1. Constipation, release kidney stone 2. Skin acne, cut, wound	O T	1. Powder of dried leaf mixed with hot water 2. Powder of dried leaf mixed with oil
Sida acuta Burm.f. (Malvaceae)	*Bijang*	S	Wp, L, R	1. Fever, dyspepsia 2. Dysentery, diarrhoea 3. Bleeding gum, toothache	O O T	1. Decoction of whole plant 2. Infusion of leaf 3. Paste of root
Sida rhombifolia L. (Malvaceae)	*Bijangnai*	H	Wp	1. Chicken pox, burns, skin allergies	T	1. Paste of whole plant
Solanum indicum L. (Solanaceae)	*Hepi sokran*	H	F, L	1. Helminthiasis 2. Fever, cold, cough	O O	1. Direct consumption of fruits 2. Decoction of fruits and Leaf
Solanum torvum Swartz (Solanaceae)	*Hipi kumbong*	S	F, L	1. Helminthiasis 2. Skin infections, cut, wound	O T	1. Direct consumption of fruits 2. Paste of the leaf
Stemona tuberosa Lour. (Stemonaceae)	*Nune hiru*	C	F	1. Kill ingro (lice) in dogs	T	1. Paste of fruits
Syzygium cumini (L.) Skeels (Myrtaceae)	*Jangmi*	T	S, F	1. Asthma, bronchitis 2. Haemorrhoids	O O	1.Paste of fruits and seed kernel 2. Direct consumption of fruits
Tabernaemontana divaricata (L.) R.Br. ex Roem. & Schult. (Apocynaceae)	*Mir herai*	S	R, L, Fl	1. Diarrhoea, stomach ache 2. Cough 3. Sore eyes	O O T	1. Decoction of root 2. Infusion of leaf 3. Juice of flower
Tephrosia purpurea (L.) Pers (Fabaceae)	*Mith- arong*	S	Wp, L	1. Jaundice 2. Toothache	O T	1. Decoction of whole plant 2. Paste of leaf
Terminalia arjuna Wight and Arn. (Combretaceae)	*Arjungos*	T	B	1. Food poisoning 2. Bone fracture 3. Bone fracture in cattle	O T T	1. Infusion of bark 2. Paste of the bark 3. Paste of the bark
Terminalia bellirica (Gaertn.) Roxb. (Combretaceae)	*Logio-asing*	T	F, B	1. Diarrhoea, dysentery 2. Leucodermia	O T	1. Direct consumption of the pulp from raw fruits 2. Paste of bark
Tragia involucrata L. (Euphorbiaceae)	*Bab*	H	R	1. Cure helminthiasis in dogs	O	1. Paste of rhizome

Table 3 Enumeration of medicinal plant species used by the Karbi tribe in East Karbi Anglong Wildlife Sanctuary *(Continued)*

Botanical name	Local name	Habit	Parts used	Medicinal uses	Used type	Mode of application
	kangsam					
Zanthoxylum armatum DC. (Rutaceae)	*Jajur*	S	L	1. Cure helminthiasis in cattle	O	1. Paste of leaf
Zingiber chrysanthum Roscoe (Zingiberaceae)	*Sobleksin*	H	Rh	1. Ear infection, boils, skin acne, cut, wound	T	1. Paste of rhizome
Zingiber officinale Rosc. (Zingiberaceae)	*Hanso*	H	Rh	1. Haemorrhoids, constipation 2. Dysmenorrhoea, stomach ache 3. Bleeding gums and ear infection 4. Indigestion in cattle	O O T O	1. Juice of rhizome 2. Decoction of rhizome 3. Paste of rhizome 4. Decoction of rhizome
Zizyphus xylopyrus (Retz) Willd. (Rhamnaceae)	*Bukuri arong*	T	F, S, L	1. Diarrhoea 2. Headache, fever 3. Skin burn and infection in cattle	O T T	1. Powder of seed 2. Paste of leaf 3. Paste of leaf

Seven out of the 14 villages were selected for the study, namely Borpung, Tarapung, Noralangso, Phanglangso, Langtuk hanse, Kanduwa bosti, and Langpratlangso (Table 1). These villages were purposively selected for their high tendency to use non-timber forest resources from the sanctuary. Selection of respondents was done through purposive stratified sampling from those villagers who accepted the request for an interview of their own free will. A total of 70 respondents (49 males and 21 females) from 70 households, i.e. 1 respondent from each house, were interviewed for the study. Two male forest officials were also included among the 49 male respondents, and they were from 1 of the selected villages (Borpung) representing 2 households from the village. The interviewed respondents were mainly the eldest persons in the household. Information regarding NTFPs harvested and their quantities, together with demographic details of the collector, was collected from the sample households through interviews by participatory interaction method supplemented by group discussions and semi-structured questionnaire (Martin 1995; Alexiades and Sheldon 1996).

Collection and identification of NTFPs

Collection of NTFPs was done in the company of respondents. Collection, pressing, and preparation of herbarium specimens were done following the methods suggested by Jain and Rao (1977) with suitable modifications. The collected specimens were identified with the help of available published literature (Kanjilal et al. 1939; Balakrishnan 1983; Haridasan and Rao 1987), as well as in consultation with experts from the herbarium housed at the Botanical Survey of India, Eastern Circle, Shillong (ASSAM), and the herbaria of the Department of Botany, North-Eastern Hill University. The scientific names were validated using the International Plant Names Index (IPNI) and an online resource, The PlantList (TPL).

Data analysis

Data collected was analysed using four quantitative indices: use report (UR), use value (UV), informant consensus factor (ICF), and fidelity level (FL). Whenever a plant was mentioned as being used for a particular purpose, it was considered to be one UR (Amiguet et al. 2005). The relative importance was analysed using the use value (UV), a quantitative measure for the relative importance of a species, which is based on the number of uses and the number of people that cite a given plant indicating the species that are considered most important by a given population (Phillips and Gentry 1993).

UV is calculated using the following formula:

$$\mathrm{UV} = U/n$$

where U is the number of use reports cited by every respondent for a given species and n is the total number of respondents interviewed. The UV is high when there are many use reports for a given species, which implies that the taxa are important. When there are few reports related to its use, the UV decreases.

The informant consensus factor (ICF) was calculated as:

$$\mathrm{ICF} = (Nur - \mathrm{Ns})/(Nur - 1)$$

where 'Nur' is the number of use reports for a particular use category and 'Ns' is the number of species used, for each category mentioned by all respondents (Trotter and Logan 1986). ICF was used to test the homogeneity of knowledge about the plants. Before performing the analysis, all the ailments were broadly classified into various categories following Hussain et al. (2018). ICF gives information about the consensus of respondents regarding the utilisation of a certain use category. The data of this factor ranges from 0 to 1. Values close to 1 indicate high consensus agreement among the respondents for the use of the particular plant while a value close to 0 indicates least consensus agreement.

Table 4 Enumeration of edible plants used by the local people in East Karbi Anglong Wildlife Sanctuary

Scientific name	Local name	Habit	Parts used	Form of use or eaten
Aegle marmelos (L.) Corrêa (Rutaceae)	*Thepli*	T	F	Ripe fruits are eaten directly.
Alocasia macrorrhiza Schott (Araceae)	*Hensoksu*	H	Rh	Rhizomes are eaten, baked, or roasted.
Alpinia nigra (Gaertn.) Butt (Zingiberaceae)	*Tara*	H	St	Stems are cooked as curry.
Amaranthus spinosus L. (Amaranthaceae)	*Dido*	H	Sh	Shoots are made as curry.
Amorphophallus bulbifer (Roxb.) Blume	*Hensarku*	H	P	Petioles are eaten, roasted, or boiled.
Artocarpus chama Buch.-Ham. (Moraceae)	*Phong*	T	F, S	Ripe fruits are eaten directly and seeds are roasted.
Artocarpus heterophyllus Lam. (Moraceae)	*Jangphong*	T	F, S	Ripe fruits are eaten directly and seeds are boiled.
Artocarpus lacucha Buch.-Ham. (Moraceae)	*Arong*	T	F	Ripe fruits are eaten directly.
Averrhoa carambola L. (Oxalidaceae)	*Torte*	T	F	Fruits are eaten directly or by making curry.
Annona reticulata L. (Annonaceae)	*Longle jangphong*	T	F	Ripe fruits are eaten directly.
Baccaurea ramiflora Lour. (Phyllanthaceae)	*Dampejuk*	T	F	Ripe fruits are eaten directly.
Calamus erectus Roxb. (Arecaceae)	*Theng*	S	F	Ripe fruits are eaten directly.
Castanopsis indica (Roxb. ex Lindl.) A.DC. (Fagaceae)	*Phongrong*	T	S	Seeds are eaten raw or roasted.
Choerospondias axillaris (Roxb.) B.L.Burtt & A.W.Hill (Anacardiaceae)	*Thesili*	T	F	Ripe fruits are eaten directly.
Coix lacryma-jobi L. (Poaceae)	*Tumdak*	H	S	Seed are roasted.
Colocasia esculenta (L.) Schott (Araceae)	*Henru ke-ik*	H	Tu	Tubers eaten as boiled and curry.
Cucumis melo L. (Cucurbitaceae)	*Thoithe suri*	H	F	Ripe fruits are eaten directly.
Dendracalamus hamiltonii Nees et Arn. ex Munro (Poaceae)	*Kaipho*	B	Sh	Fermented shoots are eaten as curry.
Dillenia indica L. (Dilleniaceae])	*Plum-plam*	T	F	Fruits are eaten as curry.
Dillenia pentagyna Roxb. (Dilleniaceae)	*Cherimpi*	T	F	Fruits are eaten directly.
Dioscorea alata L. (Dioscoreaceae)	*Ruichin*	H	T	Tubers eaten as boiled and curry.
Engelhardtia spicata Lechen ex Blume (Juglandaceae)	*Marloo*	T	F	Ripe fruits are eaten directly.
Garcinia pedunculata Roxb. ex Buch.-Ham.(Clusiaceae)	*Pranpre*	T	F	Ripe fruits are eaten directly.
Gnetum gnemon L.(Gnetaceae)	*Hanthu*	S	L, S	Leaves are eaten as curry and seeds are fried.
Hibiscus sabdariffa L.(Malvaceae)	*Hanserong ke-er*	S	F	Fruits are eaten as curry.
Hodgsonia macrocarpa (Blume) Cogn.(Cucurbitaceae)	*Hanthar*	C	S	Seeds are eaten raw or roasted.
Melastoma nepalensis Lodd. (Melastomataceae)	*Bik bik*	S	F	Ripe fruits are eaten directly.
Murraya koenigii (L.) Spreng. (Rutaceae)	*Thengsakso*	S	L	Leaves are eaten as curry.
Musa paradisiaca L.(Musaceae)	*Lothe*	H	F, In	Ripe fruits are eaten directly, unripe fruits and inflorescence are eaten, roasted, or boiled.
Musa balbisiana Colla(Musaceae)	*Lobong*	H	F, In	Ripe fruits and inflorescence are eaten as boiled or curry.
Mussaenda isertiana DC. (Rubiaceae)	*Vosopeban*	S	L	Tender leaves are eaten with meat.
Olax acuminata Wall, ex Benth. (Olacaceae)	*Hanboka*	S	L	Leaves are eaten boiled.
Oreocnide integrifolia (Gaudich.) Miq.(Urticaceae)	*Thehoi*	S	In	Inflorescences are cooked with meat or fish.
Oroxylum indicum (L.) Kurz (Bignoniaceae)	*Nopakban*	T	Fl, Sh	Flowers and shoots mixed with dried fish to make chutney.
Paederia foetida L. (Rubiaceae)	*Rikang menthu*	C	L	Leaves are cooked with fish or meat.
Parkia timoriana (DC.) Merr. (Fabaceae)	*Themuke*	T	F	Fruits are baked and eaten as chutney.

Table 4 Enumeration of edible plants used by the local people in East Karbi Anglong Wildlife Sanctuary *(Continued)*

Scientific name	Local name	Habit	Parts used	Form of use or eaten
Passiflora foetida L. (Passifloraceae)	*Thevu-um*	H	F	Ripe fruits are eaten directly.
Phlogacanthus curviflorus (Wall.) Nees (Acanthaceae)	*Jok an*	S	In	Inflorescences are eaten boiled or baked.
Phlogacanthus thyrsiflorus Nees (Acanthaceae)	*Jok-an*	S	In	Inflorescences are boiled with dried fish or baked and eaten as chutney.
Phyllanthus acidus (L.) Skeels (Phyllanthaceae)	*Takiri thelu*	T	F	Fruits are eaten directly.
Phyllanthus emblica L. (Phyllanthaceae)	*Thelu kame*	T	F	Fruits are eaten raw.
Physalis peruviana L. (Solanaceae)	*Bokbok*	H	F	Ripe fruits are eaten directly.
Piper thomsonii (C. DC.) Hook. f. (Piperaceae)	*Hanbithi*	C	L, S	Leaves are cooked with rice flour and eaten as curry, dried seeds are added to curry to give flavour.
Polygonum microcephalum D. Don (Polygonaceae)	*Delap*	H	L	Leaves are cooked with fish.
Rhynchotechum ellipticum (Wall, ex Dietr.) A. DC. (Gesneriaceae)	*Mehek*	H	L	Leaves are eaten as boiled or curry.
Sauropus androgynus (L.) Merr. (Phyllanthaceae)	*Hanvoti*	T	L	Leaves cooked as curry.
Sesamum abbreviatum Merxm. (Pedaliaceae)	*Nempo*	H	L, S	Leaves and seeds are used for making curry.
Solanum indicum Linn. (Solanaceae)	*Hepi sokran*	S	L	Leaves are eaten as curry.
Sterculia villosa Roxb. (Malvaceae)	*Jintekong*	T	S	Roasted seeds are eaten.
Streblus asper Lour. (Moraceae)	*Cheri theso*	T	F	Ripe fruits are eaten directly.
Syzygium cumini (L.) Skeels, (Myrtaceae)	*Jangmi*	T	F	Ripe fruits are eaten directly.
Trevesia palmata (Roxb. ex Lindl.) Vis. (Araliaceae)	*Kokterak*	S	In	Inflorescences are boiled and eaten as chutney.
Zanthoxylum rhetsa (Roxb.) DC (Rutaceae)	*Arioso hanjor*	T	L, Sh	Leaves and shoots are used to make curry.
Zingiber chrysanthum Rosc. (Zingiberaceae)	*Sobleksin*	H	F	Fruits are eaten as fried.
Zingiber rubens Roxb. (Zingiberaceae)f	*Phree kangnek*	H	Sh	Shoots are cooked with dried fish.
Zingiber zerumbet (L.) Rose, ex Seem. (Zingiberaceae)	*Vorek hanso*	H	L, In	Leaves and inflorescences are cooked with dried fish.
Zizyphus xylopyrus (Retz) Willd. (Rhamnaceae)	*Bukuri arong*	T	F	Fruits are cooked as curry.

Fidelity level (FL) was calculated as:

$$\mathrm{FL}\ (\%) = \mathrm{Np}/N\mathrm{x}100$$

where 'Np' is the number of respondents that claim to use a plant species for treating a particular disease and N is the number of respondents that use the plants as a medicine to treat any given disease (Alexiades 1996).

Analysis of percentage contribution of NTFPs to household income

Household income from the 70 respondents was calculated as the sum incomes of all the members of a particular household. It includes income from off-farm activities, agricultural incomes, and forest incomes (Endamana et al. 2016).

The mathematical presentation is as follows:

$$\mathrm{THI} = \mathrm{OFI} + \mathrm{AI} + \mathrm{FI}$$

where THI = total household income, OFI = off-farm income, AI = agricultural income, and FI = forest income. The per capita household income (monthly) was calculated with the total gross household income divided by the total number of family members residing together under the same house.

Analysis of NTFP collector's percentage based on gender typology

The percentage of gender categorisation regarding the collection of NTFPs was calculated from the total respondents interviewed, both male and female. It is based on their practice of collection of edible forest products, ethnomedicines, household building materials and utensils, spices and condiments, and herbal dyes from the study site.

Table 5 Enumeration of household building materials and utensils used by the Karbi tribe in East Karbi Anglong Wildlife Sanctuary

Scientific name	Local name	Habit	Parts used	Uses
Abrus precatorius L. (Fabaceae)	*Chuselok*	S	S	Seeds are used to make eyes of birds in the traditional wood craft *Jambili Athon.*
Areca catechu L. (Arecaceae)	*Kove*	T	St	Wood is used for making *harpi*, a weaving implement.
Artocarpus chama Buch.-Ham. (Moraceae)	*Phong*	T	St	Wood is used for making *long*, a traditional wooden mortar.
Bambusa afjinis Munro (Poaceae)	*Inghin*	B	St	Roof of house
Bambusa pallida Munro (Poaceae)	*Chek duk*	B	St	Used for roofing and also used as knife handle
Bambusa tulda Roxb. (Poaceae)	*Artungso*	B	St	Used for roofing and as fishing rod
Bauhinia variegata L. (Fabaceae)	*Ingku*	T	St	Used as post for making house
Calamus erectus Roxb. (Arecaceae)	*Theng*	S	St	Stem with bamboo are used to make various basket.
Callicarpa arborea Roxb. (Lamiaceae)	*Arhi*	T	St	Used as post for making house
Careya arborea Roxb. (Lecythidaceae)	*Loring*	T	St	Used as post for making house
Cassia fistula L. (Fabaceae)	*Honaru*	T	St	Used as post for making house
Castanopsis indica (Roxb. ex Lindl.) A.DC. (Fagaceae)	*Phongrong*	T	St	Used as post for making house
Dalbergia sisso Roxb. (Fabaceae)	*Subin rikang*	T	St	Stem is used for *anghoi* (base) of baskets.
Dendracalamus hamiltonii Nees et Arn. ex Munro (Poaceae)	*Kaipho*	B	St	Stem split called *jintak* is used for making various crafts.
Dipteris wallichii (R. Br.) T. Moore (Dipteridaceae)	*Lodiphlir*	S	L	Used for thatching hut in rearing domestic animals
Garuga pinnata Roxb. (Burseraceae)	*Timur*	T	St	Used as post for making house
Hibiscus sabdariffa L. (Malvaceae)	*Hanserong*	S	B	Used as fibre in building house
Livistona jenkinsiana Griff. (Arecaceae)	*Jasera*	T	L	Used for thatching houses
Mangifera indica L. (Anacardiaceae)	*Therve*	T	St	Wood is used for making *long*, a wooden mortar.
Mesua ferrea L. (Calophyllaceae)	*Mir charne*	T	St	Wood is used for making knife handle.
Phrynium pubinerve Blume (Marantaceae)	*Loru*	H	L	Used for packing kitchen items
Sterculia villosa Roxb. (Malvaceae)	*Jintekong*	T	B	Used as fibre
Terminalia myriocarpa Van Heurck & Müll. Arg. (Combretaceae)	*Turtung*	T	St	Used as post for making house
Trema orientalis (L.) Blume (Cannabaceae)	*Rampak*	T	B	Used as fibre
Wrightia coccinea (Roxb. ex Hornem.) Sims (Apocynaceae)	*Bengwoi Ke-er*	T	St	Stem is used for making a woodcraft *Jambili Athon.*

Results

A total of 138 NTFPs plant species belonging to 59 families and 110 genera were collected from the East Karbi Anglong Wildlife Sanctuary. The highest number of NTFPs was extracted from trees (38%), followed by herbs (32%) and shrubs (23%), and the least was from climbers (7%) (Fig. 2). Out of the reported 138 NTFPs, 72 species (42%) had ethnomedicinal importance, 57 species (33%) are used as edible forest products, 25 species (15%) account for household building materials and utensils, 10 species (6%) are used as spices and condiments, and 7 species (4%) are used as herbal dyes (Fig. 3) (Tables 2, 3, 4, 5, 6, 7, 8, and 9). Several species used in traditional medicine and as edible food are in high demand in the local markets (Table 10). These include *Aegle marmelos*, *Alocasia macrorrhiza*, *Alpinia nigra*, *Averrhoa carambola*, *Baccaurea ramiflora*, *Citrus assamensis*, *Dendracalamus hamiltonii*, *Dillenia indica*, *Dioscorea alata*, *Gnetum gnemon*, etc.

The statistical evaluation report of ethnomedicines was classified into 2 major categories and 25 sub-categories with regard to various ailments:

a) Traditional medicine for human ailments

The sub-categories are as follows: cephalalgia; blood and circulatory problems; cold and cough; cuts and wounds; dermatological infections; ENT diseases; eye disease; fever; gastrointestinal disease; liver diseases; malaria; menstrual problems; dental and gum problems; muscle, bones, and joints; insect stings and bites; urinary tract and kidney problems; deworming; respiratory problems; and health tonic.

Table 6 Enumeration of spices and condiments used by the Karbi tribe in East Karbi Anglong Wildlife Sanctuary

Scientific name	Local name	Habit	Part used	Uses
Aralia armata (Wall. ex G.Don) Seem. (Araliaceae)	*Tengnang*	S	L	Aromatic leaves are cooked with meat or fish.
Boesenbergia rotunda (L.) Mansf. (Zingiberaceae)	*Tiha*	H	R	Tuberous roots are used as traditional spice in most of the dishes.
Clinopodium umbrosum (M.Bieb.) Kuntze (Lamiaceae)	*Berai*	H	Sh	Shoots are cooked with fishes.
Citrus assamensis R.M.Dutta & Bhattacharya (Rutaceae)	*Tumeng*	S	L	Leaves are added to flavour meat.
Piper nigrum L. (Piperaceae)	*Ahom birik*	C	F	Dried fruits are added in many dishes as spice.
Dendracalamus hamiltonii Nees et Arn. ex Munro (Poaceae)	*Kaipho*	B	Sh	Fermented shoots called *upthor* are used to flavour meat and fish delicacies.
Murraya koenigii (L.) Spreng. (Rutaceae)	*Thengsakso*	S	L	Leaves are added to flavour meat and fishes.
Sesamum abbreviatum Merxm. (Pedaliaceae)	*Nempo*	H	S	Seeds are the most common condiment, powder seeds are eaten with meat and fish.
Zingiber officinale Rosc. (Zingiberaceae)	*Hanso*	H	Rh	Rhizomes are made as a paste to flavour meat or fish curry.
Zanthoxxlum rhetsa (Roxb.) DC (Rutaceae)	*Arioso hanjor*	T	Sh, L	Shoots and tender leaves are used to flavour dishes, particularly meat items.

b) Ethnoveterinary medicines

The sub-categories are as follows: ectoparasitic control, deworming, dermatological infections, gastrointestinal disease, fever, and muscle, bones, and joints.

Use value (UV) of all the 138 reported species ranges from 0.014 to 0.128 (Table 11). The ICF value for traditional medicines varied from 0.11 to 0.95, with an average value of 0.53. Menstrual problems have the highest ICF value of 0.95 with 63 use reports for 4 species, followed by malaria (ICF = 0.93; 50 use reports, 4 species), ectoparasitic control (ICF = 0.91; 50 use reports, 5 species), insect stings and bites (ICF = 0.88; 63 use reports, 8 species), etc. (Table 8). The species responsible for the high consensus for menstrual problems are *Abroma augustum*, *Magnolia hodgsonii*, *Cissampelos pareira*, and *Zingiber officinale*. Similarly, species responsible for the high consensus for malaria are *Nyctanthes arbor-tristis*, *Abrus precatorius*, *Citrus assamensis*, *Physalis peruviana*, etc. (Table 3).

To determine the cultural importance of medicinal species in the society, the fidelity level (FL) of plants was calculated based on user reports for being used against a given ailment. The high value of fidelity level (%) is taken for selecting the most preferred plant species for each ailment category (Uddin and Hassan 2014). The results revealed that out of the 4 highest values of ICF species for treating menstrual problems, *Abroma augustum* (L.) L. f. is the most commonly used species in the study area (ICF = 0.95) with 63 use report and FL value (90%). Similarly, *Amaranthus spinosus* L. is the most widely used

Table 7 Enumeration of dye-yielding plants used by the Karbi tribe in East Karbi Anglong Wildlife Sanctuary

Scientific name	Local name	Habit	Parts used	Uses
Croton caudatus Geisel. (Euphorbiaceae)	*So-ik*	T	St	Dye obtained is used in the traditional wooden craft *Jambili Athon*.
Curcuma longa L. (Zingiberaceae)	*Thermit*	H	Rh	Yellow dye is used in weaving garment products.
Ehretia acuminata R.Br. (Boraginaceae)	*Chorsim*	T	F, L	Dye extracted from it is used in colouring *hijap* (hand fan), *tarso* (small mat), and *jambili* (traditional bags).
Garcinia xanthochymus Hook.f. ex T.Anderson (Clusiaceae)	*Tichamprang*	T	F	Yellow dye extracted is used in colouring yarns and garments.
Indigofer tinctoria L. (Fabaceae)	*Duli*	S	L, Fl	Both the parts are said to give brownish tinge to garments.
Strobilanthes cusia (Nees) Kuntze Brem. (Acanthaceae)	*Burot*	H	Tw	Indigo dye is obtained and used to dye various traditional clothes among the Karbi tribe.
Terminalia bellirica (Gaertn.) Roxb. (Combretaceae)	*Kuru*	T	F	Dye obtained are rubbed on fibres or ropes to give black colour.

T tree, *H* herb, *S* shrub, *C* climber, *L* leaves, *R* root, *B* bark, *F* fruits, *St* stem, *P* petioles, *Sh* shoot, *Rh* rhizome, *Wp* whole plant, *Fl* flower, *Bu* bud, *Tu* tuber, *Tw* twig, *In* inflorescence, *La* latex, *Co* corm, *O* oral, *T* topical, *N* nasal, *I* inhaling

Table 8 Consensus of agreement on the uses of medicinal plants among informants

Category of indigenous use	Sub-categories	Number of species (Ns)	Number of use report (Nur)	Consensus factor
Human	Cephalalgia	6	15	0.65
	Blood and circulatory problems	7	33	0.81
	Cold and cough	16	32	0.51
	Cuts and wounds	20	42	0.54
	Dermatological infections	33	61	0.46
	ENT problems	11	44	0.77
	Eye disease	10	52	0.81
	Fever	8	14	0.47
	Gastrointestinal disease	53	60	0.11
	Liver disease	2	4	0.67
	Malaria	4	50	0.93
	Menstrual problems	4	63	0.95
	Dental and gum problems	8	16	0.53
	Muscle, bones, and joints	8	39	0.81
	Insect stings and bites	8	63	0.88
	Urinary tract and kidney problems	6	11	0.50
	Deworming	10	21	0.5
	Respiratory problems	7	17	0.63
	Health tonic	2	5	0.75
Animals	Ectoparasitic control	5	50	0.91
	Deworming	2	6	0.80
	Dermatological infections	6	18	0.71
	Fever	2	5	0.75
	Gastrointestinal disease	6	25	0.80
	Muscles, bones, and joints	2	5	0.75

species for treating insect stings and bites with 62 use report and FL value (88.57%), followed by *Geophila repens* (L.) I. M. Johnst. with 61 use report and FL value (87.15%) for skin infections, *Aegle marmelos* (L.) Corrêa with 60 use report and FL value (85.72%) for dysentery, and *Abrus precatorius* L. with 50 use report and FL value (71.42%) for malaria (Table 9).

Percentage contribution of non-timber forest products to household incomes

The contribution of NTFPs to household incomes per month revealed that 50% of the respondents derived 50–90% of their total revenues from NTFPs, whereas about 30% derived 20–40% of their total household incomes from sales of NTFPs. While the remaining

Table 9 Fidelity level (FI %) of frequently cited plant species with major uses

Botanical name	Categories	Citation for particular disease (use report)	Fidelity level (%)
Abroma augustum (L.) L.f. (Sterculiaceae)	Menstrual disorder	63	90
Geophila repens (L.) I.M. Johnst. (Rubiaceae)	Skin infections	61	87.15
Aegle marmelos (L.) Correa (Rutaceae)	Dysentery	60	85.72
Abrus precatorius L. (Fabaceae)	Malaria	50	71.42
Cheilocostus speciosus (J.Koenig) C.D. Specht (Costaceae)	Helminthiasis	45	64.29
Baccaurea ramiflora Lour. (Phyllanthaceae)	Scurvy	40	57.15
Syzygium cumini (L.) Skeels (Myrtaceae)	Haemorrhoids	35	50
Amaranthus spinosus L. (Amaranthaceae)	Insect stings and bites	62	88.57

Table 10 Documented list of traded species in the markets locally available with prevailing price

Botanical name	Part(s) traded	Trade category		Market price in per unit (Indian rupees)
		Food	Medicine	Village market
Aegle marmelos (L.) Correa (Rutaceae)	Fruit	Available	Available	2–5 per fruit
Alocasia macrorrhiza Schott (Araceae)	Corm, stem	Available	Available	Corm 10–20 per kg Stem 10–15 per kg
Alpinia nigra (Gaertn.) Butt (Zingiberaceae)	Stem	Available	NA	10–15 per kg
Amaranthus spinosus L. (Amaranthaceae)	Tender shoot	Available	Available	5–10 per bundle (200–300 g)
Artocarpus heterophyllus Lam. (Moraceae)	Fruits	Available	NA	10 per kg
Averrhoa carambola L. (Oxalidaceae)	Fruit	Available	NA	10–15 per kg
Baccaurea ramiflora Lour. (Phyllanthaceae)	Fruit	Available	Available	20–30 per kg
Boesenbergia rotunda (L.) Mansf. (Zingiberaceae)	Rhizome	Available	NA	15–20 per kg
Choerospondias axillaris (Roxb.) B.L.Burtt & A.W.Hill (Anacardiaceae)	Fruit	Available	NA	15 per kg
Citrus assamensis R.M.Dutta & Bhattacharya (Rutaceae)	Fruit	Available	Available	2–4 per fruit
Colocasia esculenta (L.) Schott (Araceae)	Tuber	Available	NA	10 per kg
Dendracalamus hamiltonii Nees et Arn. ex Munro (Poaceae)	Shoots	Available	NA	15 per kg
Dillenia indica L. (Dilleniaceae)	Fruit	Available	NA	20 per kg
Dioscorea alata L. (Dioscoreaceae)	Tuber	Available	NA	10 per kg
Gnetum gnemon L. (Gnetaceae)	Leaves	Available	NA	10 per bundle (150–200 g)
Hibiscus sabdariffa L. (Malvaceae)	Fruit	Available	NA	10 per bundle (450–500 g)
Musa paradisiaca L. (Musaceae)	Fruit, inflorescence	Available	NA	5 per bundle 10 per inflorescence
Musa balbisiana Colla (Musaceae)	Fruit, inflorescence	Available	NA	5 per bundle 10 per inflorescence
Parkia timoriana (DC.) Merr. (Fabaceae)	Fruit	Available	NA	30 per kg
Phlogacanthus thyrsiflorus Nees (Acanthaceae)	Inflorescence	Available	Available	10 per bundle (150–200 g)
Phyllanthus acidus (L.) Skeels (Phyllanthaceae)	Fruit	Available	NA	10–20per kg
Phyllanthus emblica L. (Phyllanthaceae)	Fruit	Available	Available	10–20 per kg
Piper nigrum L. (Piperaceae)	Fresh seed	Available	NA	150–200 per kg
Piper thomsonii (C. DC.) Hook. f. (Piperaceae)	Fresh seed	Available	NA	40–50 per kg
Rhynchotechum ellipticum (Wall, ex Dietr.) A. DC. (Gesneriaceae)	Tender leaf	Available	NA	10 per bundle (150–200 g)
Sesamum abbreviatum Merxm. (Pedaliaceae)	Dry seed	Available	NA	80 per kg
Syzygium cumini (L.) Skeels, (Myrtaceae)	Fruit	Available	Available	20–25 per kg
Terminalia arjuna Wight and Arn. (Combretaceae)	Bark	NA	Available	15–20 per bundle (500–600 g)
Zanthoxylum rhetsa (Roxb.) DC (Rutaceae)	Tender shoot	Available	NA	10–15 per bundle (250–300 g)
Zingiber chrysanthum Rosc. (Zingiberaceae)	Fruit	Available	Available	25–30 per kg
Zingiber officinale Rosc. (Zingiberaceae)	Rhizome	Available	Available	20–25 per kg
Zingiber rubens Roxb. (Zingiberaceae)	Shoot	Available	NA	15–20 per kg
Zingiber zerumbet (L.) Rose, ex Seem. (Zingiberaceae)	Inflorescence	Available	NA	10–15 per bundle (350–400 g)
Zizyphus xylopyrus (Retz) Willd. (Rhamnaceae)	Fruit	Available	NA	15–20 per kg

NA the item is not available in the local market as food or as medicine

20% of the entire interviewed households raised less than 20% of their incomes from NTFP-based enterprises in the study, this shows that NTFPs constitute an essential component of the rural household economy in the study area.

Non-timber forest product collection based on gender typology

The gender typology for NTFPs collection in East Karbi Anglong Wildlife Sanctuary revealed that both men and women were involved in the collection of NTFPs.

Table 11 List of NTFPs with different categories of uses and their use value

Botanical name (voucher no.)	Medicinal uses	Wild edible uses	Household building materials and utensil	Spices and condiment uses	Dye uses	Use value (UV= U/n)
Abroma augustum (EKAWLS141)	+	–	–	–	–	0.028
Abrus precatorius (EKAWLS160)	+	–	+	–	–	0.057
Acacia pennata (EKAWLS179)	+	–	–	–	–	0.071
Aegle marmelos (EKAWLS200)	+	+	–	–	–	0.085
Alocasia macrorrhiza (EKAWLS221)	+	+	–	–	–	0.057
Alpinia nigra (EKAWLS199)	+	+	–	–	–	0.071
Alternanthera sessilis (EKAWLS222)	+	–	–	–	–	0.042
*Alternanthera philoxe*roides (EKAWLS240)	+	–	–	–	–	0.028
Amaranthus spinosus (EKAWLS142)	+	+	–	–	–	0.042
Amblovenatum opulentum(EKAWLS251)	+	–	–	–	–	0.014
Amorphophallus bulbifer (EKAWLS260)	–	+	–	–	–	0.014
Annona reticulate (EKAWLS159)	+	+	–	–	–	0.057
Annona squamosa (EKAWLS178)	+	–	–	–	–	0.014
Aralia armata (EKAWLS239)	–		–	–	–	0.014
Areca catechu (EKAWLS161)	–	–	+	–	–	0.014
Artocarpus chama (EKAWLS252)	–	+	+	–	–	0.042
Artocarpus heterophyllus (EKAWLS259)	–	+	–	–	–	0.028
Artocarpus lacucha (EKAWLS220)	–	+	–	–	–	0.028
Averrhoa carambola (EKAWLS162)	–	+	–	–	–	0.014
Azadirachta indica (EKAWLS180)	+	–	–	–	–	0.057
Baccaurea ramiflora (EKAWLS198)	+	+	–	–	–	0.042
Bambusa afjinis (EKAWLS238)	–	–	+	–	–	0.014
Bambusa pallida (EKAWLS158)	–	–	+	–	–	0.014
Bambusa tulda (EKAWLS201)	–	–	+	–	–	0.014
Bauhinia racemosa (EKAWLS224)	+	–	–	–	–	0.042
Bauhinia variegata (EKAWLS241)	+	–	+	–	–	0.128
Boesenbergia rotunda (EKAWLS177)	–	–	–	–	–	0.014
Bridelia retusa (EKAWLS143)	+	–	–	–	–	0.071
Bridelia tomentosa (EKAWLS181)	+	–	–	–	–	0.014
Calamus erectus (EKAWLS197)	–	+	+	–	–	0.028
Callicarpa arborea (EKAWLS202)	–	–	+	–	–	0.014
Capsicum annuum (EKAWLS237)	+	–	–	–	–	0.057
Careya arborea (EKAWLS157)	+	–	+	–	–	0.028
Cassia fistula (EKAWLS242)	–	–	+	–	–	0.014
Castanopsis indica (EKAWLS252)	–	+	+	–	–	0.028
Centella asiatica (EKAWLS163)	+	–	–	–	–	0.128
Cheilocostus speciosus (EKAWLS293)	+	–	–	–	–	0.042
Choerospondias axillaris (EKAWLS286)	–	+	–	–	–	0.014

Table 11 List of NTFPs with different categories of uses and their use value *(Continued)*

Botanical name (voucher no.)	Medicinal uses	Wild edible uses	Household building materials and utensil	Spices and condiment uses	Dye uses	Use value (UV= U/n)
Cissampelos pareira (EKAWLS225)	+	−	−	−	−	0.114
Citrus assamensis (EKAWLS176)	+	−	−	−	−	0.042
Clerodendrum infortunatum (EKAWLS288)	+	−	−	−	−	0.042
Clinopodium umbrosum (EKAWLS219)	−	−	−	−	−	0.014
Coix lacryma-jobi (EKAWLS144)	−	+	−	−	−	0.014
Colocasia esculenta (EKAWLS183)	−	+	−	−	−	0.014
Croton caudatus (EKAWLS196)	−	−	−	−	+	0.014
Cucumis melo (EKAWLS236)	−	+	−	−	−	0.014
Curcuma longa (EKAWLS243)	+	−	−	−	+	0.114
Dalbergia sisso (EKAWLS253)	−	−	+	−	−	0.114
Datura metel (EKAWLS287)	+	−	−	−	−	0.042
Dendracalamus hamiltonii (EKAWLS278)	−	+	+	+	−	0.042
Dendrocalamus strictus (EKAWLS203)	+	−	−	−	−	0.028
Dillenia indica (EKAWLS175)	−	+	−	−	−	0.014
Dillenia pentagyna (EKAWLS156)	−	+	−	−	−	0.014
Dioscorea alata (EKAWLS275)	−	+	−	−	−	0.014
Dipteris wallichii (EKAWLS218)	−	−	+	−	−	0.014
Drymaria cordata (EKAWLS226)	+	−	−	−	−	0.100
Ehretia acuminata (EKAWLS254)	−	−	−	−	+	0.028
Engelhardtia spicata (EKAWLS184)	−	+	−	−	−	0.014
Ficus benghalensis (EKAWLS244)	+	−	−	−	−	0.042
Ficus hispida (EKAWLS164)	+	−	−	−	−	0.071
Ficus racemosa (EKAWLS274)	+	−	−	−	−	0.042
Garcinia pedunculata (EKAWLS255)	−	+	−	−	−	0.014
Garcinia xanthochymus (EKAWLS258)	−	−	−	−	+	0.014
Garuga pinnata (EKAWLS235)	−	−	+	−	−	0.014
Geophila repens (EKAWLS196)	+	−	−	−	−	0.042
Gnetum gnemon (EKAWLS272)	−	+	−	−	−	0.028
Habenaria dentata (EKAWLS216)	+	−	−	−	−	0.042
Hedyotis scandens (EKAWLS204)	+	−	−	−	−	0.014
Hibiscus cannabinus (EKAWLS174)	+	−	−	−	−	0.071
Hibiscus sabdariffa (EKAWLS145)	+	+	+	−	−	0.085
Hodgsonia macrocarpa (EKAWLS185)	−	+	−	−	−	0.014
Hydrocotyle sibthorpioides (EKAWLS245)	+	−	−	−	−	0.042
Ichnocarpus frutescens (EKAWLS195)	+	−	−	−	−	0.100
Indigofer tinctoria (EKAWLS155)	−	−	−	−	+	0.028
Kaempferia galanga (EKAWLS205)	+	−	−	−	−	0.014
Leea indica (EKAWLS226)	+	−	−	−	−	0.042

Table 11 List of NTFPs with different categories of uses and their use value *(Continued)*

Botanical name (voucher no.)	Medicinal uses	Wild edible uses	Household building materials and utensil	Spices and condiment uses	Dye uses	Use value (UV= U/n)
Leucas aspera (EKAWLS234)	+	−	−	−	−	0.042
Lippia alba (EKAWLS261)	+	−	−	−	−	0.042
Livistona jenkinsiana (EKAWLS165)	−	−	+	−	−	0.014
Magnolia hodgsonii (EKAWLS217)	+	−	−	−	−	0.071
Mangifera indica (EKAWLS271)	+	−	+	−	−	0.057
Melastoma nepalensis (EKAWLS146)	−	+	−	−	−	0.014
Mesua ferrea (EKAWLS154)	−	−	+	−	−	0.014
Moringa oleifera (EKAWLS173)	+	−	−	−	−	0.014
Murraya koenigii (EKAWLS186)	+	+	−	−	−	0.085
Musa paradisiaca (EKAWLS194)	−	+	−	−	−	0.028
Musa balbisiana (EKAWLS233)	−	+	−	−	−	0.028
Mussaenda isertiana (EKAWLS262)	−	+	−	−	−	0.014
Nyctanthes arbor-tristis (EKAWLS269)	+	−	−	−	−	0.042
Ocimum gratissimum (EKAWLS206)	+	−	−	−	−	0.028
Olax acuminata (EKAWLS227)	−	+	−	−	−	0.014
Oreocnide integrifolia (EKAWLS257)	−	+	−	−	−	0.014
Oroxylum indicum (EKAWLS216)	+	+	−	−	−	0.128
Oxalis corniculata (EKAWLS246)	+	−	−	−	−	0.085
Paederia foetida (EKAWLS250)	−	+	−	−	−	0.014
Parkia timoriana (EKAWLS228)	−	+	−	−	−	0.014
Passiflora foetida (EKAWLS153)	−	+	−	−	−	0.014
Phlogacanthus tubiflorus (EKAWLS172)	+	−	−	−	−	0.057
Phlogacanthus curviflorus (EKAWLS268)	−	+	−	−	−	0.014
Phlogacanthus thyrsiflorus (EKAWLS232)	−	+	−	−	−	0.014
Phrynium pubinerve (EKAWLS166)	−	−	+	−	−	0.014
Phyllanthus acidus (EKAWLS193)	−	+	−	−	−	0.014
Phyllanthus emblica (EKAWLS187)	+	+	−	−	−	0.014
Physalis peruviana (EKAWLS215)	+	+	−	−	−	0.042
Piper nigrum (EKAWLS247)	−	−	−	−	−	0.014
Piper thomsonii (EKAWLS147)	−	+	−	−	−	0.028
Polygonum microcephalum (EKAWLS263)	−	+	−	−	−	0.014
Pseudocaryopteris foetida (EKAWLS292)	+	−	−	−	−	0.014
Rhynchotechum ellipticum (EKAWLS208)	−	+	−	−	−	0.014
Sarcochlamys pulcherrima (EKAWLS249)	+	−	−	−	−	0.042
Sauropus androgynus (EKAWLS231)	−	+	−	−	−	0.014
Senna alexandrina (EKAWLS264)	+	−	−	−	−	0.071

Table 11 List of NTFPs with different categories of uses and their use value *(Continued)*

Botanical name (voucher no.)	Medicinal uses	Wild edible uses	Household building materials and utensil	Spices and condiment uses	Dye uses	Use value (UV= U/n)
Sesamum abbreviatum (EKAWLS192)	−	+	−	−	−	0.042
Sida acuta (EKAWLS214)	+	−	−	−	−	0.085
Sida rhombifolia (EKAWLS148)	+	−	−	−	−	0.042
Solanum indicum (EKAWLS188)	+	+	−	−	−	0.057
Solanum torvum (EKAWLS167)	+	−	−	−	−	0.057
Stemona tuberosa (EKAWLS171)	+	−	−	−	−	0.014
Sterculia villosa (EKAWLS152)	−	+	+	−	−	0.028
Streblus asper (EKAWLS209)	−	+	−	−	−	0.014
Strobilanthes cusia (EKAWLS213)	−	−	−	−	+	0.014
Syzygium cumini (EKAWLS149)	+	+	−	−	−	0.057
Tabernaemontana divaricata (EKAWLS170)	+	−	−	−	−	0.057
Tephrosia purpurea (EKAWLS190)	+	−	−	−	−	0.028
Terminalia arjuna (EKAWLS212)	+	−	−	−	−	0.028
Terminalia bellirica (EKAWLS151)	+	−	−	−	+	0.042
Terminalia myriocarpa (EKAWLS191)	−	−	+	−	−	0.014
Tragia involucrata (EKAWLS168)	+	−	−	−	−	0.014
Trema orientalis (EKAWLS210)	−	−	+	−	−	0.014
Trevesia palmata (EKAWLS212)	−	+	−	−	−	0.014
Wrightia coccinea (EKAWLS150)	−	−	+	−	−	0.014
Zanthoxxlum rhetsa (EKAWLS229)	−	+	−	+	−	0.057
Zanthoxylum armatum (EKAWLS248)	+	−	−	−	−	0.014
Zingiber chrysanthum (EKAWLS256)	+	+	−	−	−	0.114
Zingiber officinale (EKAWLS230)	+	−	−	+	−	0.114
Zingiber rubens (EKAWLS211)	−	+	−	−	−	0.014
Zingiber zerumbet (EKAWLS189)	−	+	−	−	−	0.028
Zizyphus xylopyrus (EKAWLS169)	+	+	−	−	−	0.071

However, men were the most dominant extractors. Most of the collectors of edible forest products (90%), ethnomedicines (80%), household building materials and utensils (80%), spices and condiments (50%), and herbal dyes (40%) were men, while most of the women were engaged in the collection of herbal dye (80%), spices and condiments (70%), ethnomedicines (60%), edible forest products (50%), and household building materials and utensils (40%).

Discussion

The data generated from the respondents interviewed were from seven randomly selected rural and mountainous villages, covering the entire extent of the study area. The spatial variation in the area has therefore been adequately represented in our samples. The present study shows that NTFPs play a pivotal role in healthcare and livelihood security for the Karbi community. They are vital for maintaining the community at large for household uses, healthcare, and income generation as indicated by half the households arising 50–90% of their incomes of half from NTFPs collected from the sanctuary. Most of the revenue is generated by selling these products in the local markets in the form of wild vegetables and fruits. The stem of *Alpinia nigra*, shoot of *Dendracalamus hamiltonii*, fruit of *Dillenia indica*, tuber of *Dioscorea alata*, leaves of *Gnetum gnemon*, inflorescence of *Phlogacanthus thyrsiflorus*, seeds of *Piper nigrum*, etc. are commonly sold in the market. Other ways in which the NTFPs are used to generate incomes include selling as fibres, traditional wooden mortars, and weaving implements as well as various handicrafts (Fig. 4). The findings of the current study validate those of Timunpi

Fig. 4 **a**–**b** Informants. **c** Market with various forest products. **d** Bamboo shoots. **e** Basket made from bamboo and cane

(2017), who reported that forest is the backbone of the economy of the people living in this district.

The current study also highlights the diverse knowledge of ethnomedicinal plants exhibited by the Karbi community. Out of the 72 medicinal species recorded from the study area, the maximum number of species used as medicine was found in the family Fabaceae (6 species), followed by Malvaceae, Zingiberaceae, and Solanaceae (each with 5 species), while Rutaceae and Phyllanthaceae contribute 4 species each. Lamiaceae, Annonaceae, Moraceae, and Amaranthaceae each have 3 species, and Apiaceae, Apocynaceae, Verbenaceae, Rubiaceae, and Combretaceae have 2 species each while the remaining 18 families are monospecific. Plant species like *Abroma augustum*, *Geophila repens*, *Habenaria dentata*, *Magnolia hodgsonii*, *Pseudocaryopteris foetida*, *Sarcochlamys pulcherrima*, *Stemona tuberosa*, *Tephrosia purpurea*, *Tragia involucrata*, and *Zingiber chrysanthum* which have not been notified by earlier studies conducted elsewhere within the district among the Karbi tribe (Jain and Borthakur 1980; Teron and Borthakur 2012; Teron and Borthakur 2013; Terangpi et al. 2014; Teronpi et al. 2015) have been reported for their medicinal uses in this study. The present study along with the introduction of new medicinal plants also provides information of about the uses in treating 60 different types of ailments which include amenorrhea, dysmenorrhoea, dysentery, malaria, various skin infections, diarrhoea, bleeding gums cuts and wounds, helminthiasis, conjunctivitis, and constipation. This outcome supports the findings of Jain and Borthakur 1980 that ethnomedicines have always played a significant role in the healthcare system of the ethnic Karbis.

Data obtained using quantitative ethnobotanical studies have shown the significance of these plants among the Karbis. The plants (*Centella asiatica*, *Cissampelos pareira*, *Dalbergia sisso*, *Ichnocarpus frutescens*, etc.) with the highest UV are considered most important for the local people due to their multiple use reports and are therefore specifically conserved (Albuquerque et al. 2006). The ICF value for each of the 25 sub-categories ranged from 0.11 to 0.95. While sub-categories like malaria, menstrual problems, and ectoparasitic controls showed higher ICF values of ≥ 0.91, it is because only a few species for each category were used by the respondents. The plants associated with higher ICF value (*Abroma augustum*, *Amaranthus spinosus*, *Geophila repens*, *Aegle marmelos*, etc.) are used by a large portion

of the community, implying that the communities at large have significant uses of these few plants for treating different ailments. Moreover, the variation in ICF value might be due to the availability and diversity of medicinal plants within the particular locality and restriction in exchange of ethnobotanical knowledge through generations (Hossain and Rahman 2018).

Most of the respondents used specific species for particular ailments as shown by the eight species having FL above 50%. More work needs to be done on those particular plants which have high ICF and FL values to validate their uses as traditional medicines and to check their bioactive constituents for further drug development (Bibi et al. 2014). This type of study could open new paths for future pharmacological research, which can serve as a reference, especially for quantitative ethnobotanical investigations among diverse ethnolinguistic indigenous groups (Ong and Kim 2014). Research based on indigenous knowledge of various communities can yield a tremendous amount of cultural information which can potentially be utilised for economic and welfare benefits. Such information with proper scientific research could be beneficial in solving many modern-day problems, viz. food shortage, health issues, to curb famine, drought, and ways to manage and maintain sustainable utilisation of the natural wealth surrounding us. In recent decades, in many of the developing countries, there is an increasing demand for NTFPs for subsistence and cash income generation (Shackleton et al. 2011; Steele et al. 2015). Thus, NTFPs can play a significant role in commercial purposes which contribute to local economies and hence contribute to community development. In our study area, the NTFPs are mostly utilised for subsistence as well as for moderate cash income generation. However, inefficient utilisation of these resources due to insufficient knowledge could lead to overexploitation and depletion of these resources. These multiuse resources are being hampered by habitat destruction, overexploitation, unlimited grazing, change in land use pattern, and dominance of invasive species. Even so, the role of NTFPs in supporting livelihoods of rural communities is possible to continue as long as the resources are utilised sustainably (Solomon 2016).

Conclusion

Various ethnobotanical indices in the study have demonstrated and underscored the dependence of the forest dwellers on this living resource for their livelihood and subsistence. In addition to the use of the listed NTFPs, plants such as bamboo can support the local paper industries and other handicraft enterprises helping to augment their income. The informant consensus factors and fidelity level suggest that the ethnobotanical knowledge of the locals of this area is significantly diverse and useful. Inputs of these tribal experts should be given priority in bioassay and toxicity studies. From this study, we recommend *Abroma augustum*, *Amaranthus spinosus*, *Geophila repens*, *Aegle marmelos*, and *Abrus precatorius* for further ethnopharmacological studies, since these species have high ICF and FL values.

Moreover, UV data can be used to highlight those plants which need to be effectively conserved as they are resources which can sustain the indigenous population. Non-timber forest product management is a process involving harvesting, gathering, utilisation, and management of resources within the given ecological, economic, social, political, institutional, and legal frameworks. An effective NTFP policy is urgently required to link the provision of livelihood security as well as sustenance with biodiversity conservation. The high level of dependency on forest products by the different indigenous groups can affect the status of their forest. However, the efficient and eco-sensitive extraction of these forest products can not only add value to the forest product but also provide a proper incentive for conservation and sustainable forest management.

Abbreviations

EKAWLS: East Karbi Anglong Wildlife Sanctuary; FL: Fidelity level; ICF: Informant consensus factor; NTFPs: Non-timber forest products; UR: Use report; UV: Use value

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Authors' contributions

PM contributed to the collection of primary data from the study sites and to the analysis and interpretation of the data in the form of informant consensus factor and fidelity level. NAB contributed to the data calculation of all the plant species for all the four quantitative indices: (i) use report, (ii) use value, (iii) informant consensus factor, and (iv) fidelity level, and to the critical revision of the whole manuscript. DB contributed to the collection of primary data from the study sites and to the analysis and interpretation of all the data vitally. YK contributed to the design and drafting of the manuscript and to its critical revision. All authors read and approved the final manuscript.

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Availability of data and materials

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests
The authors declare that they have no competing interests.

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