Indian Journal of Traditional Knowledge
Vol 22(1), January 2023, pp 30-39
DOI: 10.56042/ijtk.v22i1.43088

Ethnopedological knowledge of upland *Karbi* Community: A case study from Dima Hasao District of Assam, North-Eastern Himalaya, India

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Received 18 November 2020; revised & accepted 15 March 2023

This paper describes the ethnopedological knowledge of indigenous upland *Karbi* farmers inhabiting a hilly area of Assam, India. Semi-directive interviews, focused group discussion and joint field visit methods were used for eliciting information on soil from key knowledge holders identified through chain referrals. Soil was classified into eight folk types based on fertility which were determined via its physical properties *viz*., colour, texture, water retention capacity and compactness. This classification helped them in land-use and crop-selection related decisions and some other uses. Plant species *viz*., *Albizia* spp., *Imperata cylindrica, Lantana camara* and *Schima wallichii* indicating soil fertility were valued for identification of most suitable *jhum* sites. To minimize soil erosion, indigenous techniques like inverted 'U' shaped channels, maintaining standing trees and cut stumps, and placing horizontal wooden logs across shifting agricultural fields on steep slopes were employed. The laboratory analysis of physico-chemical parameters *viz*., bulk density, colour, texture, water holding capacity, pH, soil organic carbon and total nitrogen support the ethnopedological knowledge of the farmers. Study may help in preservation and protection of local knowledge on soil which is eroding fast under the influence of modernity.

Keyword: Crop suitability, Fertility management, Folk soil taxonomy, Indicator species, *Karbi*, Traditional knowledge

IPC Code: Int Cl.[23]: G01N 33/00

Local pedological knowledge helps indigenous farmers in classifying soils into various folk types, playing a vital role in land-use planning, soil fertility management, crop selection in traditional agroecosystems and determining other uses such as in making traditional pottery and decorations, house construction, and ethnoveterinary practices[1-5]. Finding congruity between folk and formal soil taxonomies has emerged as an important research area for developing sustainable agriculture and local land use patterns[3,6-8].

The folk soil taxonomy of the indigenous communities inhabiting the North-Eastern Himalayan region of India, which falls in the Indo-Burma global biodiversity hotspot, plays an important role in sustainability of traditional farming practices where shifting cultivation is not only the core economic activity but also embedded in their cultural way of life[9]. However, as elsewhere, the indigenous knowledge systems are eroding fast in the North-Eastern Himalayas[10-12]. The documentation and validation not only help in the preservation and protection of such knowledge and practices but may also benefit soil and agricultural scientists in formulating their research strategies and making appropriate interventions locally[2,13]. However, only few attempts have so far been made to understand the folk soil taxonomy and how it helps in determining the agricultural and other land use choices of indigenous communities of the region[14-17]. With this backdrop, the present study was carried out to document the folk soil taxonomy of the *Karbi* community, its soil management practices in arable lands, use of soil for other household purposes, and find scientific evidences behind the documented knowledge and practices.

Material and Methods

Socio-economic profile of the Karbi community

Karbi is one of the major indigenous communities of North-East India inhabiting East Karbi Anglong, West Karbi Anglong and few pockets of Dima Hasao, Kamrup, Morigaon, Nagaon, Sonitpur districts of Assam and Ri-Bhoi district of Meghalaya state[18]. The population of the community in Assam is 430,452[19]. A majority of the people among the *Karbis* follow

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Hinduism while a few have embraced Christianity and speak *Karbi* dialect. They celebrate a number of cultural festivals such as *Chosun, Rongker, Chokk-eroi, Chomangkanour,* etc., related to their farming practices from sowing to harvesting. *Mei* is the traditional village council of the *Karbis* that regulates the socio-cultural life of the community.

Shifting cultivation (*Jhum*) in the upland and settled wet rice cultivation in the lowland are the major livelihood activities of *Karbi* people. In addition to agriculture, they collect a range of wild edibles from the forests which not only provide nutraceutical benefits to them but also contribute to part of their household income[11]. The upland *Karbi* farmers select shifting cultivation sites in their village forests as allotted by the village headman. The farmers clear the vegetation from the site in November-December followed by drying and burning of the dried biomass *in situ* before the onset of the monsoon in April. Rice (*Oryza sativa*) and maize (*Zea mays*) are the major staple crops while ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), taro (*Colocasia spp.*), perilla (*Perilla frutescens*) and sesame (*Sesamum indicum*) are the cash crops for the upland *Karbi* community. Seed sowing of most of the crops is completed by the end of May and harvesting of crops is done sequentially which starts from September and is completed by mid-December. After cultivation of the same land for 2-3 consecutive years, when the soil fertility starts diminishing, the land is fallowed for regeneration of the vegetation[9]. As in other parts of the region, till a few decades ago, the fallow period used to be 15-20 years long but it has come down to 4-5 years in recent years due to population pressure coupled with simultaneous changes in the socio-economic spheres of the *Karbi* community[10].

Study area

The study was carried out in the western part of Dima Hasao district of Assam state in North-Eastern India where *Karbi* is one of the dominant communities (Fig. 1). The vegetation of the study area is characterized by tropical wet evergreen and tropical semi-evergreen forest types[20]. Soil of the study area is largely ultisol with dark grayish brown to yellowish red in colour, fine to coarse loamy in texture, strongly to moderately acidic, and high organic content[21]. The area experiences sub-tropical monsoon climate and as per the recorded data of last four decades (1981-2017), receives an average annual rainfall of 1226 mm. About 74% of the total rainfall occurs during May through September. During winter season (November-January) the temperature ranges from 7°C to 12°C while it remains between 23°C and 32°C in summer (June-September) season[22]. After a

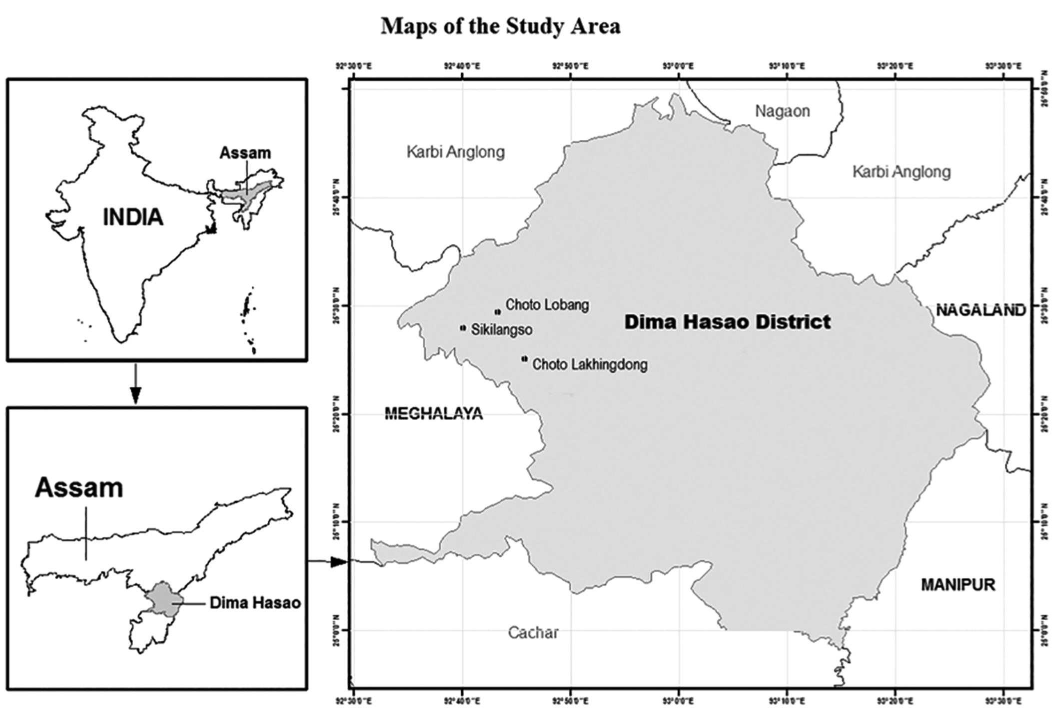

Fig. 1 — Location of the villages in the map of the study area

Table 1 — Demographic profiles and number of key knowledge holders (KKHs) identified in the study villages in Dima Hasao district of Assam

Village	No. of households	Population	Sex ratio (F:M)	Number of KKHs		
				Male	Female	Total
Chotolakhingdong	72	382	94:100	16	7	23
Chotolobang	32	194	92:100	9	6	15
Sikilangso	70	354	98:100	18	8	26

reconnaissance survey, three representative *Karbi* villages *viz*., Sikilangso, Chotolakhingdong and Chotolobang were selected for the present study. The total population of the villages is 354, 382 and 194, respectively (Table 1).

Data collection

The process of data collection was taken up between December 2016 and September 2018. Considerable time was spent with villagers without hampering their day-to-day activities to convey about the objectives of the study and to develop a thorough trust with the community. Key elements of participatory research were followed during the survey *viz*., (a) as per National Biological Diversity Act (2002) and Rules (2004), secured prior informed consent from the Assam State Biodiversity Board for conducting the research, (b) remained sensitive to community's social customs and norms, and (c) with the help of local translators depended more on verbal responses with minimal requirement of responding via writing/reading to ensure smooth communication. Keeping the aforesaid elements constantly in mind, a total of 64 Key Knowledge Holders (hereafter referred as KKHs; 43 male and 21 female) of different age groups (35-80 years) which included farmers, headmen of the villages, executive members of the traditional institution (*Mei*), church committees and local NGOs were identified through "Chain Referral" method[23].

Based on secondary literature and with the help of KKHs, we documented the details of the ethnopedological knowledge and traditional land management practices in the study area using discovery-oriented semi-structured interviews (for invoking free flowing discussions), focused group discussions and collaborative fieldwork methods with the KKHs[23]. The responses of the KKHs were noted down with the help of local field associates who helped in translating their tape-recorded responses as well. Besides, soil samples of all the folk soil types were collected from representative sites for laboratory analysis. Three replicate samples of each soil type from different representative sites were collected up to 30 cm depth with the help of soil corer. The replicate soil samples of each soil type were mixed to make a composite sample and brought to the laboratory. Soil samples were air-dried and sieved with 2 mm sieve for analysis of soil physico-chemical properties.

Laboratory analysis

Soil colour was determined by Munsell soil colour chart[24] and soil pH by digital pH meter (Control Dynamics, Model APX 175 E/C) with 1:2.5 soil-water ratio. Soil texture was analyzed by Bouyoucos soil hydrometer[25], soil bulk density by core method[26], water holding capacity by Keen-Raczkowski Box Method[27], soil organic carbon by rapid titration method[28] and total nitrogen (N) by semi micro Kjeldahl method using KELPLUS-KES 12 L for digestion and KELPLUS Distyl-EMBA for distillation[29]. Least significant difference ($p=0.05$) test was applied using SPSS 16.0 to compare mean values of the physico-chemical properties *viz*., bulk density, pH, texture, organic carbon and total N contents of different folk soil types.

Results

Folk soil taxonomy

The KKHs in the studied villages reported a total of eight folk soil types *viz*., *longlei-angpi, longlei-enghan, longlei-etso, longlei-phorsonoi, longlei-sangtei, longlei-pi, longlei-sangtei-ki-ek* and *tiplong-enghan* based on their traditional criteria using the colour, texture, stickiness, water retention capacity, and fertility of the soils (Table 2). In the folk taxonomy of the *Karbi* community, *longlei-angpi* symbolizes the reddish coloured soil where *longlei* means 'soil' and '*angpi*' means red. Similarly, *longlei-enghan* means the sticky soil, *longlei-etso* the yellow soil, *longlei-pi* the fabulous soil, *longlei-sangtei* the sandy soil, *longlei-sangtei-ki-ek* the blackish sandy soil, and *tiplong-enghan* the soil of the termite mounds (Table 2).

As per the KKHs, the vernacular name of individual folk soil type indicated about some of its salient features. Accordingly, they characterized *longlei-angpi*

Table 2 — Folk taxonomy and farmers' perceptions on soil characteristics and crop suitability.

Folk Soil Type *(Folk Taxonomy)*	Colour	Stickiness	Compactness	Texture	Water retention capacity	Fertility	Crop suitability
Longlei-angpi (*Longlei*-Soil, *Angpi*-Red)	Reddish	Less	Less	Not sandy	High	High	Good for vegetables cultivation
Longlei-enghan (*Longlei*-Soil, *Enghan*- Sticky)	-	High	High	Less sandy	High	Very High	Good for all crop cultivation
Longlei-etso (*Longlei*-Soil, *Etso*- Yellow colour)	Yellowish	Less	Less	Not sandy	High	High	Good for all crop cultivation
Longlei-phorsonoi (*Longlei*-Soil, *Phorsonoi*-useless)	-	Very less	High	-	Very less	Very less	Not good for any crop
Longlei-pi (*Longlei-pi*- fabulous soil)	Dark grey	High	High	Not sandy	High	Very high	Good for all crops
Longlei-sangtei (*Longlei*-Soil, *Sangtei*-Sandy)	-	Very less	Very less	Very sandy	Very less	High	Not good for cultivation
Longlei-sangtei-ki-ek (*Longlei*-Soil, *Sangtei*-Sandy, *Ki-ek*- Black colour)	Blackish	Very less	Less	Sandy	Less	High	Good for vegetable cultivation
Tiplong-enghan (*Tiplong*-termite mound, *Enghan*-Sticky)	-	Very high	Less	Not sandy	Very high	High	Good for cultivation of cucurbits

soil type as reddish in colour, less sticky and fertile; *longlei-enghan,* the blackish or dark in colour, sticky, fertile with high water retention capacity; *longlei-etso,* yellowish in colour and lower of sand; *longlei-phorsonoi,* the loose and less fertile with low water retention capacity; *longlei-sangtei,* the dark to light grey in colour, loose soil with higher proportion of sand and much lower water retention capacity; *longlei-pi*, the compact, blackish to reddish in colour turning sticky when comes in the contact of water and hence high water retention capacity; and *longlei-sangtei-ki-ek* as fertile sandy soil and blackish or dark in colour. The soil of termite mounds called *Tiplong-enghan marked* by reddish to yellowish in colour with stickiness and high-water retention capacity.

Soil properties and crop selection

Owing to years of experiences, the *Karbi* farmers could easily ascertain the potential yields of various traditional crops under different soil conditions. The farmers believed that the dark, compact and sticky soils (*longlei-enghan* and *longlei-pi*) are the most suitable for growing rice, maize, sesame and a range of vegetables. The *longlei-pi* soil which is compact, blackish in colour, retains high moisture and becomes sticky when comes into contact with water was the most preferred for growing rice, maize and vegetables (such as brinjals, chillies, cucurbits, ladyfingers, taros, etc.) in shifting cultivation fields. The *longlei-enghan* was also considered as fertile soil for rice and maize cultivation. However, it was mostly preferred for rice cultivation on the wet terraces due to its greater moisture retention property. The farmers preferred to grow *Sok-et, Prank* and *Sok-jube* landraces of rice in *longlei-pi* and *longlei-enghan* soils for higher grain yield. Despite preference for fertile soil types, sometimes limited land resources forced them to grow crops in less fertile soils such as *longlei-sangtei-ki-ek*, *longlei-etso* and *longlei-angpi* as well. As per the KKHs, the yield of rice in these soils was 12-15% less compared to when grown in *longlei-pi* and *longlei-enghan* soils. Besides rice, farmers grew maize, sesame and vegetables on fields where *longlei-sangtei-ki-ek*, *longlei-etso* and *longlei-angpi* soil types were found. About 57% of KKHs reported that the yield of maize was comparatively higher in *longlei-sangtei-ki-ek* soil than the other soil types while the remaining (43%) could not differentiate the differential yields of the maize in other soil types. The farmers accorded *longlei-enghan* and *longlei-pi* soils bearing *longduk* (a sub soil underneath the top soil) good for banana and sugarcane plantations owing to their higher water retention capacity. The termite mounds were common in the shifting cultivation fields during the fallow phase and homestead gardens of the study area. The farmers, after partially dismantling the termite mounds, preferred growing cucurbits specifically pumpkins in the *tiplong-enghan* soil, due to their better growth and yield compared to when grown in other soil types.

Longlei-sangtei soil was less preferred for cultivation due to its low water retention capacity. According to knowledge holders, the soil easily loses moisture during dry winter and under sunny day conditions in summer season resulting into wilting of the crop plants. Among the eight folk soil types, the farmers avoided *longlei-phorsonoi* soil for cultivation and even for using it for other purposes.

Biological indicators of soil fertility

The *Karbis* use *Albizia* spp., *Imperata cylindrica, Lantana camara* and *Schima wallichii* as indicators plants for assessing soil fertility during selection of shifting cultivation fields. Overwhelming number (94%) of upland farmers accorded forest areas dominated by *Albizia* spp (locally called *Koroi* trees) as most suitable sites for shifting cultivation as they believed that soils in such forests are highly fertile bearing *longlei-pi* and *longlei-enghan* soil types. However, forest sites dominated by *Schima wallichii* (*Amsong* trees) are generally not preferred by (58%) farmers considering them less fertile due to the prevalence of *longlei-phorsonoi* and *longlei-sangtei* soil types in such forest areas (Fig. 2). About 52% of the KKHs reported that the shifting cultivation fallows dominated by *Lantana camara* have comparatively fertile soil than those dominated by other weeds e.g., *Chromolaena odorata*, *Clerodendrum* sp and *Melastoma malabathricum*. About 88% farmers did not select shifting cultivation fields where they see preponderance of the graminoid *Imperata cylindrica* in the peripheral forest area. They perceived that at the time of maturity when the leaves of *I. cylindrica* turn reddish, these harbour pathogens (bacteria) causing leaf blight locally called *Pretam* in it, which enhanced chances of the spread of the disease into their rice crop (Fig. 2).

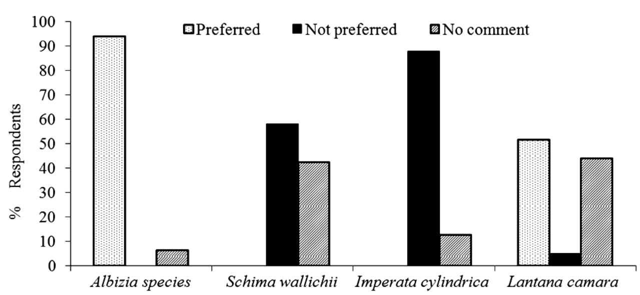

Fig. 2 — Farmers' preference on presence and absence of the indicators species in selecting shifting cultivation fields in the studied villages in Dima Hasao district of Assam, India

Soil conservation and fertility management

Despite suitable topographical and climatic conditions for practicing shifting agriculture in the North-Eastern Himalayan region, these are not immune to soil erosion during the rainy season[9]. The farmers reported that topsoil loss and seed displacement through surface runoff during seed sowing (monsoon season) affected the yield of the crops. To minimize the erosion and displacement of *in situ* seeds, farmers constructed inverted 'U' shaped channels locally called '*longor*' (with width ranging from 35-45 cm and depth 20-30 cm) before sowing around the margins of the shifting cultivation fields on steep slopes (Fig. 3 a-b). Such channels helped divert the excess runoffs from the top hills laterally. In addition, farmers maintained few standing trees (6%) and did not uproot the large cut stumps (28%) in the shifting cultivation fields which they believed help reduce the soil erosion (Fig. 3 b-c, Fig. 4).

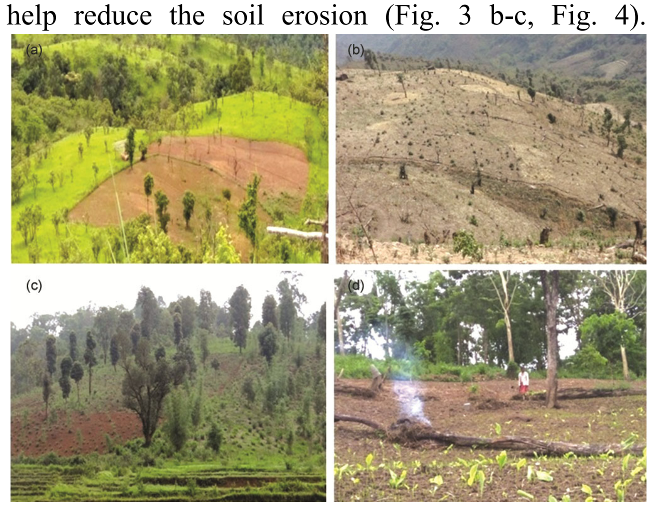

Fig. 3 — Traditional shifting cultivation fields showing (a) inverted 'U'-shaped channel in the boarder of the field (b) cut -stamps, wooden logs and water channels (c) standing trees and (d) horizontal wooden logs

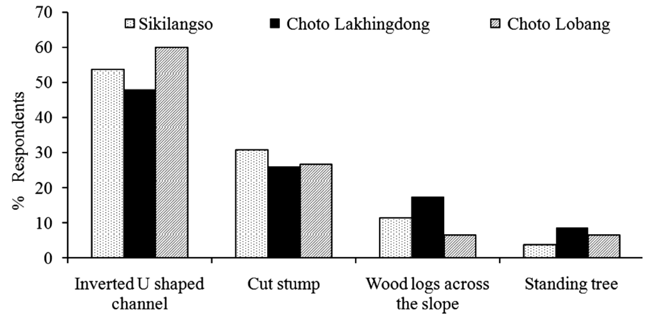

Fig. 4 — Traditional measures of soil erosion control used by the *Karbis*

Construction of channels in shifting cultivation fields was the most preferred soil erosion control measure practiced by about 54% farmers in the studied villages (Fig. 4). Among the KKHs, 26% reported lying of wooden logs horizontally across steep shifting cultivation fields in order to reduce the amount of surface runoff and increase infiltration to maintain soil moisture for a longer period of time post monsoon season. It was the most favoured soil erosion control method for 17% of farmers in Chotolakhingdong, 12% in Sikilangso and 7% in Chotolobang villages (Fig. 3d, Fig. 4).

Use of soils for other purposes

The *Karbis* selected suitable soil types for other traditional uses such as applying soil paste on the mud floors of their traditional houses, constructing traditional hearths and preparing mud pellets. The *Karbi* women often used *longlei-sangtei* soil for applying its paste on the earthen floor for maintaining hygiene as it does not develop cracks after drying and thus helps controlling dust in and around their dwelling places. Besides, paste made of sticky soils such as *longlei-enghan, longlei-pi* and *tiplong-enghan* can also be utilized for preserving cleanliness and making the traditional hearths but required mixing with fresh cow dung to prevent developing cracks after drying. Occasionally, they smeared mud paste of *longlei-angpi* soil for the purpose of cleanliness as well as providing reddish tone to their traditional floors for enhanced aesthetics. The *tiplong-enghan* was preferred for preparing mud pellets for their bows and catapults to scare the crop-raiding birds and wild animals. The soil was fancied for its hardness, compactness and smoothness for pellet making. If *tiplong-enghan* was not available, they used *longlei-enghan* or *longduk* soils for the purpose alongside for making clay toys.

Physico-chemical properties of the folk soil types

Various physico-chemical characteristics of the folk soil types is given in Table 3. The colour of different soil types i.e., *longlei-angpi, longlei-enghan, longlei-etso, longlei-phorsonoi, longlei-sangtei, longlei-pi, longlei-sangtei-ki-ek* and *tiplong-enghan* determined as Reddish Brown, Grayish Brown, Yellowish Brown, Pale Brown, Grayish Brown, Brown, Brown and Dark Yellowish Brown, respectively, with different hue and chroma. The bulk density of the soil samples ranged from 0.48 g/cm^3 for *tiplong-enghan* to 1.31 g/cm^3 for *longlei-sangtei*s oil type. Bulk density varied significantly ($p<0.05$) across majority of soil types except between *longlei-angpi, longlei-enghan, longlei*-etso*, longlei-pi* soils and also between *longlei-sangtei* and *longlei-phorsonoi* soils (Table 3). Texture analysis showed that *longlei-angpi, longlei-enghan, longlei-pi* and *tiplong-enghan* were predominantly clayey soils while *longlei-etso* and *longlei-phorsonoi* were clay loam soils. *Longlei-sangtei* and *longlei-sangtei-ki-ek* were found as sandy loam and sandy clay loam soils, respectively. Across the soil types, highest percentage of clay was recorded in *tiplong-enghan* (61.3%) followed by *longlei-pi* (46.8%) soil while highest proportion sand was recorded in *longlei-sangtei* (58.1%) followed by *longlei-sangtei-ki-ek* (52.0%) soil. Water holding capacity was recorded maximum for *tiplong-enghan* (75%) followed by *longlei-pi* (69%) and minimum in *longlei-sangtei* (35%) soil. The water holding capacity of the soil types differed significantly ($p<0.05$) except between *longlei-enghan, longlei-etso* and *longlei-pi* soils. In general, all soils were found acidic to highly acidic in nature. Highest pH (5.53) was recorded in *longlei-sangtei* and lowest in *longlei-pi* (4.46) soil. The *longlei-enghan* soil contained the highest amount (2.46%) of soil organic carbon followed by *longlei-pi* (2.17%) and least in (0.19%) *longlei-phorsonoi* soil. Organic carbon content of *longlei-angpi* did not differ significantly ($p>0.05$) with *longlei-sangtei* and *tiplong-enghan* soils, and also of the *longlei-enghan* with *longlei-etso, longlei-phorsonoi*, *longlei-pi* and *longlei-sangtei-ki-ek* soil types. Similarly, total N was recorded highest (0.45%) in *longlei-enghan* followed by *longlei-pi* (0.34%) and lowest (0.16%) in *longlei-phorsonoi* soil. The total N content differed significantly among various soil types ($p<0.05$) except between *longlei-angpi* with *longlei-sangtei* and *tiplong-enghan,* and *longlei-etso* with *longlei-pi* and *longlei-sangtei-ki-ek* soils (Table 3).

Table 3 — Physico-chemical properties of the folk soil types.

Soil Type	Colour	Texture (C, S and Si) *	Bulk density (gm/cm^3)	Water Holding Capacity (%)	pH	Organic Carbon (%)	Total Nitrogen (N)
Longlei-angpi	Reddish Brown (5YR/5/3)	Clay (C: 45.9%, S: 31.6%, Si: 22.5%)	0.89±0.12^{bcd}	62.28±1.08^{c}	5.09±0.04^{a}	1.23±0.10^{d}	0.27±0.01^{cd}
Longlei-enghan	Grayish Brown (2.5 Y/5/2)	Clay (C: 46.3%, S: 36.5%, Si: 17.1%)	0.83±0.01bcde	67.60±1.69^{b}	5.32±0.03^{a}	2.46±0.49^{ac}	0.45±0.01^{a}
Longlei-etso	Yellowish Brown (10 YR/5/4)	Clay loam (C: 31.8%, S: 34.3%, Si: 34.0%)	0.80±0.10^{cd}	67.34±1.75^{b}	5.49±0.03^{a}	2.13±0.47^{abc}	0.29±0.01^{b}
Longlei-phorsonoi	Pale Brown (10 YR/6/3)	Clay loam (C: 33.5%, S: 34.1%, Si: 32.4%)	1.21±0.11^{a}	43.41±1.12^{e}	5.37±0.03^{a}	0.19±0.09^{e}	0.16±0.01^{e}
Longlei-pi	Brown (2.5 Y/5/3)	Clay (C: 46.8%, S: 31.7%, Si: 21.5%)	0.93±0.07^{bc}	69.06±1.50^{b}	4.96±0.01^{a}	2.17±0.10^{bc}	0.34±0.01^{b}
Longlei-sangtei	Grayish Brown (10 YR/5/1)	Sandy loam (C: 17.9%, S: 58.1%, Si: 24.0%)	1.31±0.10^{a}	34.98±1.33^{f}	5.53±0.02^{a}	1.44±0.35^{d}	0.25±0.01^{d}
Longlei-sangtei-ki-ek	Brown (10 YR/5/3)	Sandy clay loam (C: 33.3%, S: 52.0%, Si: 14.7%)	0.76±0.13^{d}	52.73±2.73^{d}	5.60±0.06^{a}	2.02±0.08^{abc}	0.32±0.01^{b}
Tiplong-enghan	Dark Yellowish Brown (10 YR/4/4)	Clay (C: 61.3%, S: 25.1%, Si: 14.7%)	0.48±0.06^{e}	74.59±1.91^{a}	4.82±0.98^{a}	1.22±0.21^{d}	0.24±0.01^{d}
LSD values	-	-	0.12	2.97	1.04	0.34	0.03

*C- Clay, S- Sand and Si- Silt
Means followed by the same superscript alphabet(s) are not significantly different ($p>0.05$) across the soil types and ± value indicates standard error of the mean

Discussion

Like other indigenous communities of the world, the pedological knowledge of the *Karbis* is based on physical/morphological properties of the soils such as colour, texture, stickiness, compactness and waterholding/moisture retention capacity[3,5,30-32]. Traditionally, soil colour is the key property to differentiate among the *longlei-angpi, longlei-etso, longlei-enghan, longlei-pi* and *longlei-sangtei-ki-ek* soils while soil texture and water holding capacity are the key properties considered by the farmers for classifying the *longlei-sangtei, tiplong-enghan* and *longlei-phorsonoi* soils that help them determining the most suitable land-use practices, selecting crops in traditional agroecosystems and also for other purposes. With sound knowledge of soil quality, *Karbi* farmers maintained sustainable yields in their upland fields and socio-cultural practices since generations as also prevalent in other indigenous peoples around the globe[2-3,5,8]. In the present study, cultivation of *Sok-et, Prank* and *Sok-jube* landraces of rice in *longlei-pi* and *longlei-enghan* soil and maize in *longlei-sangtei-ki-ek* soil with better physico-chemical properties helped the *Karbi* farmers in achieving 12-15% higher yields than in other soil types indicating their well acquired knowledge on crop-soil interactions. At the same time, banana and sugarcane cultivation in *longlei-pi* and *longlei-enghan* soils bearing *longduk* sub soil type underneath could be linked with high water/moisture holding capacity of these soils. Similar soil conditions for growing sugarcane and banana have also been reported by Van Asten[33] and Mauri[34]. We analyzed soil physical properties *viz*., colour, texture and water holding capacity which agree with the farmers' folk soil knowledge. Higher clay contents i.e., 61.3%, 46.8% and 46.3%, respectively, in *tiplong-enghan, longlei-pi* and *longlei-enghan* soils helped these to exhibit higher water holding capacity and organic carbon content. The prominent role of soil texture in determining water holding capacity and organic carbon content in arable soils has also been highlighted by Brown[35] and Adugna[36]. Higher sand content (58%) in *longlei-sangtei* reduced its water holding capacity often resulting in wilting of the crops under erratic climatic conditions as also observed in sandy soils by Chamen[37].

Farmers considered dark colour and sticky soils as the most fertile soil in the study area which could be corroborated from the comparatively higher amount of organic carbon (2.46% and 2.17%), total N (0.45% and 0.34%) and higher water holding capacity (67.6% and 69.0%), respectively, in *longlei-enghan* and *longlei-pi* soils. Studies from different parts of the world support peoples' perceptions on black or dark coloured soils often linked to high organic matter content[38-39]. Low organic carbon (0.19%), total N (0.16%) and water holding capacity (43%) in *longlei-phorsonoi* soil support the farmers' preference of avoiding this soil type for cultivation. Soils with low organic carbon (<0.50%) and total N content in the range of 0.1-0.2% were regarded as not suitable for crop cultivation[40].

Use of local flora and fauna as biological indicators for soil fertility by local communities helps not only in sustainable land management practices among indigenous communities across the world but also in maximizing the crop yields[41]. *Karbis* used *Albizia* spp., *Schima wallichii* and *Lantana camara* as indicator species for assessing soil fertility to select suitable sites for shifting cultivation. The abundance of *Albizia* trees in forests is an indicator of the most fertile soil which is being leguminous species fix nitrogen in the soil. Similarly, farmers' perception on *Lantana camara* as a fertility enhancer in fallow lands is supported by the findings of earlier workers[42]. Lands covered by *Lantana camara* help in maintaining higher soil moisture and nutrients (N, P and K) and rate of N-mineralization[42]. Farmers preferred less *Schima wallichii,* which is one of the pioneer species in fallows and degraded lands, dominated forests for cultivation as the abundance of this species indicates the early successional state of the forests often poor in soil nutrients[20,43,44]. Besides, farmers also avoided selecting cultivation sites infested with *Imperata cylindrica* as it hosts pathogen of leaf blight disease which they believed may infect their rice crop.

The traditional soil management practices of the *Karbis* such as maintaining standing trees, wood logs across slopes, avoidance of uprooting large cut stumps and constructing inverted 'U' shaped channels around shifting cultivation fields on steep slopes helped them in minimizing soil erosion and maintaining fertility. Standing trees in the agricultural lands play important roles in fertility sustenance as they constitute an important source of organic matter inputs in the soil[39]. The erosion of topsoil carries away about 75% of vital plant nutrients N, P, K and Ca which affects crop production in agricultural fields[45]. However, maintaining cut stumps and laying wooden logs across slopes in a staggered manner practiced by *Karbi* farmers help in minimizing soil erosion during the rainy season.

Conclusion

The physical properties based traditional criteria of the *Karbi* farmers for soil classification have been found effective in assessing the soil quality for sustainable land use, efficient selection of crops and determining other day-to-day uses of the soil. The laboratory analysis of the physico-chemical parameters of the folk soil types lends some support to the ethnopedological knowledge of the farmers. Mechanisms are needed for evidence-based integration of elements of the ethnopedology in formal soil conservation and management approaches that may help to make them more efficient, cost-effective and locally nuanced. Further studies are warranted for generating sound scientific evidence behind the ethnopedology in general and for assessing the effectiveness of local practices related to the use of plant indicators of soil fertility, and measures taken for minimizing soil erosion in particular.

Acknowledgements

We acknowledge the Assam State Biodiversity Board for their logistic support and Regional Meteorological Centre, India Meteorological Department, Guwahati Assam for providing meteorological data. Financial assistance from the Department of Science and Technology, Govt. of India (Grant numbers: PAC-SES-DST-12141219-863) under National Mission for Sustaining the Himalayan Ecosystem (NMSHE) is acknowledged. We are also thankful to Dr. R.L. Semwal for his critical comments and suggestions that greatly helped us in analyzing the soil samples and in improving the manuscript.

Conflicts of Interest

Authors declare that there are no conflicts of interest.

Authors' Contributions

N B and S C G conceived the ideas and designed methodology; N B collected the data; N B and P L analyzed the data; N B and S C G led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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