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Research paper

Local soil knowledge of *Imperata* grasslands in Barak Valley, Assam, northeast India.

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Abstract: Local knowledge of farmers has great implications in present days for providing insight into soil characters and sustainable land management. The small scale farmers of rural regions have indeed conserved the indigenous and traditional facts since past generations that eventually redefined as local soil knowledge. Hence, keeping in view, the socioeconomic structure of Barak Valley region, the grassland managers of agricultural communities could be recognized as a great storehouse of traditional knowledge and synchronizing with scientific support further play a vital role towards various land recuperation processes. The study was carried out at Dargakona village, Barak Valley, Assam, northeast India with an objective to assess the database of farmers' nomenclature and information of soils in managed grassland sites; thereafter comparing local knowledge with analytical study of soils. The smallholder village people were interviewed with the aid of standard questionnaire who nomenclated four soil types ('*lal*', '*balu*', '*athail*' and '*citta*'). Further, the farmers' soil types corroborated the scientific observation of grassland soils. Bulk density of the soils studied increased progressively with the increase in depth of soil column in various sites. The textural class of *lal* and *balu* soils indicated variation from sandy loam to sandy clay loam. The *athail* and *citta* soils ranged from loam to clay loam and sandy clay loam to clay loam respectively. Water holding capacity recorded highest in *athail* and lowest in *balu* soils. The pH of soils revealed acidic nature irrespective of different soil types. Soil organic carbon content of top soils exhibited maximum values and gradually decline in the sub-soils across study area. As endorsed by farmers' statement, the strong soils were *athail* type with more organic carbon content. The study concluded that the farming society experienced diversification in their soils which is the consequence of definite basis of traditional wisdom. Hence, proper documentation of the folk knowledge systems with subsequent scientific validation is needed for better land use, management and rehabilitation of degraded soils.

Keywords: Local Soil Knowledge, *Imperata* Grassland, Farmer, Local people, Texture

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Introduction:

Indigenous knowledge of the local people is a process that gets mediated by the socio-economic and political background of the farmer (WinklerPrins, 2001). The study of local soil knowledge has been predominantly targeted at documenting how farmers classified their soils in contrast to understanding how such classificatory knowledge made use of in actually managing soils for sustained production (Talawar and Rhoades, 1998). It has become more and more apparent that the knowledge of people who have been interacting with their soils for a very long time can offer many insights about sustainable management of tropical soils rather than scientific information (Hecht, 1990; Osunade, 1992). According to Barrera-Bassols and Zinck (2002) local soil knowledge and their management constitute a complex wisdom system, with some universal principles and categories similar or complementary to those used by modern soil science. Huynh et al. (2020) in their statement supported the local soil knowledge systems for its significant role in sustainable soil management and agroecosystems.

Traditional subsistence farmers of tropical countries are very thorough in their understanding to local ecosystems (Gosai *et al.*, 2011). Astapati and Das (2010) in their findings proposed that *Imperata* grasslands of Barak Valley, Assam, originated on the abandoned cultivated land and are managed by the smallholder farmers. The local residents of the village use the thatch grass (*Imperata cylindrica*) for roofing their kaccha houses. Rice cultivation was known to be the basic farming systems of the local people in addition to the maintenance of their grasslands. Farmers' field experiences about the heterogeneous environment including the soil characteristics lead to the development of systematic knowledge effective in addressing land degradation and reclamation (Fiarhead and Scoones, 2005). Huynh *et al*. (2022) affirmed about the combination of local soil knowledge and scientific knowledge for confidence building amongst local communities and implementing the same in their farming practices. Hence, the present study aimed in understanding of the local soil wisdom to categorize the soil classes and comparing thereafter with the physicochemical properties of soils identified on the basis of experimental analysis in *Imperata* grasslands of Barak Valley, Assam, northeast India.

Material and Methods:

Study area

The study area was located at Dargakona village (24°40' N latitude and 92°46' E longitude) of Cachar district, Barak Valley, Assam. The Valley lies between the North Cachar hills on the north and the Mizo hills on the south. The regional landscape marked the presence of hills, hillocks, low-lying stagnant water bodies and the plains. The climate is hot and humid type with total annual rainfall of 2365 mm during the study period. The year is divisible into three distinct seasons viz. short summer (March – April), rainy (May – October) and winter (November – February). The local inhabitants of the studied area are brought from Bengal and Bihar by the Britishers with the onset of tea plantations in the region (Gopalakrishnan, 2000). *Imperata* grasslands of the Dargakona village are managed by sustenance farmers whose prime occupation is paddy cultivation and form peasant society.

Methods:

Thorough interview was carried out by adopting standard questionnaire (Chambers *et al.*, 1989) with all 48 grassland owners (also known as smallholder farmers) of Dargakona village. The survey work was carried out to collect information on the insight of farmers' own

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soils followed by comparing primary data with scientific analysis of soil samples. Folk soil classification systems were the result of day to day observations primarily of the surface soil by rural communities. Hence, at the time of grassland soil collection, farmers' knowledge on the soil type and their characteristics were taken into account. Consequently, textural classes were assigned based on morphological explanation of grassland soils by the local community. Important variables considered by the farmers were sand, clay proportions, loose or compact soils, earthworm casts and soil appearance for determining local soil terminology. Grassland management involved cutting of the mature grass leaves and subsequent burning of the fallow land on an annual cycle. Such practice results from a belief that burning is the most suitable form of management tool in the grasslands, as it successfully maintained arrested succession and subsequent regeneration of the species.

Soil samples were collected by selecting 17 grassland sites based on farmers' choice. Sampling was done with a soil corer of 5.6 cm inner diameter to a depth of 0-10 cm, 10-20 cm and 20-30 cm. The samples were then transferred to laboratory and air dried ground and passed through a 2 mm sieve for physicochemical analysis. Bulk density was determined by soil corer method (Brady, 1990), soil texture by Bouyoucos soil hydrometer method (Anderson and Ingram, 1993). Soil collected was assigned to different textural classes on the basis of soil texture triangle (Brady, 1990). Water holding capacity was calculated using perforated circular Keen's boxes (Piper, 1944). Soil pH was determined in 1:2.5 soil: water suspension (Jackson, 1973) and organic carbon content by Walkley and Black's wet oxidation method (Jackson, 1973).

Results:

The list and assessment of farmers' soil quality indicators are presented in Table 1.

Table 1. Assessment of farmers' soil health indicators in the *Imperata* grasslands of Barak Valley, Assam, northeast India

Indicator	% of Farmers who agree with the Indicator	Farmers' Declaration
Essential soil character Soil colour, texture	95	Dark colour with finer particles indicated good quality soil whereas light colour with pebbles and gravels means poor soil.
Earthworm casts	21	High potential soil showed the presence of earthworm populations
Soil Aggregation	78	Soft soil enhances growth of grass shoots while hard and cracked soil limits longitudinal development
Thatch grass Performance Yield	84	High foliage production mean better soil health
Pure/Mixed vegetation	59	Pure stand is far better in terms of productivity than mixed plots as weeds compete with the dominant grass for resources stored in soil
Plant (thatch grass) colour	89	Lush green appearance of grassland indicated that the soil is strong
Land management	92	Annual burning of the dried and dead plant parts after cutting shootsat ground level adds nutrients to the soil thereby improving soil condition

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The soil health indicators were the outcome of interview with 48 respondents during the study period. Physical assessments of soil by the grassland managers whose occupation is agriculture were generally qualitative revealed by their emphasis on soil colour and textural factor in defining the soils of Dargakona village. The survey report indicated that farmers focused and addressed the surface soil properties frequently rather than subsoil in determining the soil quality. Farmers feel the soil with touch (rubbing soil between fingers) and perceiving colour. General perceptions of the rural community showed dark coloured (black or grey) soil with smooth surface to be strong soil. In contrast, light coloured soil contained high sand particles, larger granules and rough surface identified as poor soil. The degree of soil aggregation was mentioned in the farmers' interview as they laid emphasis upon soft soil to be better for grass growth. Presence of earthworm casts was taken as another key indicator to determine soil health. Several indicators related to thatch grass performance (grass yield, pure or mixed vegetation and thatch leaf colour) were included to study the soil health. Many of the grassland managers discussed about the grasslands management procedure since their inception and thus also integrated as an important criterion of soil health indicator. Farmers' classification and characterization of local soils in the *Imperata* grasslands are depicted in Table 2.

Table 2. Farmers' classification and characterization of local soils in the *Imperata* grasslands of Barak Valley, Assam, northeast India

Local soil terminology	% of Respondents who name the soil	Farmers' understanding on soil type	Grassland topography	Distribution	Dominant grasses
Lal	33.3	High sand, loose soil, low in fertility, poor water retention	Undulating land locally called "*tilla*"	Frequently distributed	*Imperata cylindrica*, bamboo groves, *Vetiveria zizanoides*
Balu	37.5	High sand, loose soil, prone to surface run off	Undulating land locally called "*tilla*"	Frequently distributed	*Imperata cylindrica*, bamboos, *Vetiveria zizanoides*
Athail	20.8	Clay high, smooth surface, deep cracks in dry season, good to puddle, soil support plant growth	Flat low-lying land and flood prone	Moderately distributed	*Imperata cylindrica* and bamboos forming hedges
Citta	8.3	Clay high, blackish, can retain water and nutrients in top soil, compact in nature	Undulating land locally called "*tilla*"	Sparsely distributed	*Imperata cylindrica* as dominant grass, local bamboo species forming hedges

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The interview with farmers recognized four soil types in the *Imperata* grasslands viz. '*lal*', '*balu*', '*athail*' and '*citta*' soils. Majority of the respondents (37.5%) stated *balu* soils to be dominant as grassland soils followed by *lal* (33.3%), *athail* (20.8%) and *citta* (8.3%). *Balu* and *lal* soils were recognized to be high in sand, loose, erosion prone and poor in fertility. *Athail* and *citta* with high clay, dark, compact, adequate moisture, organic matter, more soil organisms was best soil and hence fertile with larger produce. *Imperata* grasslands topography was named as '*tilla*' by the local people who mean those as undulating plains or hillock. However, few respondents were of the opinion about the existence of flat low-lying areas as grassland sites. The questionnaire study also recorded the grass species like *Imperata cylindrica* as dominant intermingled with *Vetiveria zizanoides* in impure stands. The local varieties of bamboo stocks surround and formed edges in typical grassland locations. Empirical analysis of local soil samples for characteristics viz. texture, bulk density, water holding capacity, soil pH and organic carbon content are illustrated in Table 3.

Table 3. Physico-chemical properties of farmers' soil types in the *Imperata* grasslands of Barak Valley, Assam, northeast India

Local Soil type	Soil depth (cm)	Bulk density ((g cm^{-3})	Sand (%)	Silt (%)	Clay (%)	Textural class	Water holding capacity (%)	pH	Organic carbon (%)
Lal	0-10	1.20±0.01	55.37± 13.14	27.25± 8.85	14.87± 4.58	Sandy loam	38.44± 3.05	5.08 ± 0.36	0.77 ± 0.16
	10-20	1.38±0.10	42.67± 8.04	29.0± 8.76	28.33± 9.31	Loam	38.99± 2.92	5.05 ± 0.22	0.55 ± 0.14
	20-30	1.40±0.02	44.17± 9.16	27.0± 4.93	28.83± 4.96	Sandy clay loam	37.94± 2.09	5.02 ± 0.23	0.39 ± 0.21
Balu	0-10	1.21± 0.002	58.90± 9.48	26.10± 5.55	13.80± 5.72	Sandy loam	36.99± 1.04	4.94 ± 0.10	0.66 ± 0.09
	10-20	1.40±0.01	53.57± 10.8	24.70± 8.41	21.80± 5.99	Sandy clay loam	37.12± 1.78	5.05 ± 0.17	0.53 ± 0.12
	20-30	1.41±0.02	48.0± 12.02	24.70± 6.50	27.40± 7.43	Sandy clay loam	40.16± 4.02	5.10 ± 0.13	0.38 ± 0.09
Athail	0-10	1.18±0.02	48.90± 3.89	33.20± 7.16	19.90± 3.24	Loam	47.35± 13.31	5.16 ± 0.24	0.93 ± 0.09
	10-20	1.38±0.04	38.0± 14.21	33.92± 10.95	28.08± 7.19	Clay loam	45.07± 9.60	5.22 ± 0.23	0.59 ± 0.12
	20-30	1.38±0.04	29.75± 13.44	38.83± 15.06	32.83± 4.19	Clay loam	47.15± 9.68	5.47 ± 0.24	0.40 ± 0.07
Citta	0-10	1.19±0.02	50.50± 26.37	27.50± 9.67	22.0± 16.68	Sandy clay loam	43.08± 0.58	5.10 ± 0.56	0.78 ± 0.02
	10-20	1.39±0.03	45.0± 29.01	25.0± 5.27	30.0± 23.73	Clay loam	44.10± 0.65	5.34 ± 0.23	0.52 ± 0.03
	20-30	1.39±0.04	39.5± 28.13	27.5± 8.79	33.0± 19.34	Clay loam	45.62± 1.21	5.50 ± 0.38	0.34 ± 0.03

The analytical findings supported the local classification of soils by the farmers. Bulk density of the soils studied, increased with the incremental depth of soil column across the study sites. However, the bulk density of the farmers' soil types is without any distinct variation in the values. In top soil layer, sand content was highest in *balu* (58.90%), followed by *lal* (55.37%), *citta* (50.50%) and *athail* (48.90%). Contrary to sand, proportions of clay were found as 22%, 19.90%, 14.87 and 13.80% in *citta*, *athail*, *lal* and *balu* soils respectively. The percentage share of silt ranged from 33.20% to 26.10% in different soil types with maximum values in *athail* and minimum in *balu*. *Lal* and *balu* soils of the surface layer togetherly were designated as sandy loam in texture. The textural class of *athail* soils identified as loamy in surface, clay loam in subsurface layers. *Citta* soils ranged from sandy clay loam to clay loam across the soil gradient. Water holding capacity in surface soil varied from 36.99% to 47.35% in different soil types, most in *athail* soils and least in *balu* soils. The pH of top soil varied from 4.94 to 5.16 amongst the soil types and was therefore acidic. The tendency of soil acidity also continued in subsurface layers. Organic carbon ranged from 0.77% to 0.39% in *lal*, 0.66% to 0.38% in *balu*, 0.93% to 0.40% in *athail* and 0.78% to 0.34% in *citta* soils. Hence, minimum values recorded in *balu* and maximum in *athail* soils across the study sites.

Discussion:

The interview with the grassland managers revealed that they have a broad understanding of the farmers' soils. The farmers defined their soil type as an assimilation of physical, chemical and biological characteristics. The occupants of Dargakona village measured their soils with visual observation i.e. colour and touch (Saito *et al*., 2006; Lima *et al*., 2011). Darker the soil colour, more is the clay and organic matter and therefore produce more yield. Conversely, lighter colour soils are poor and least fertile. *Imperata cylindrica* (dominant thatch grass) with associated grasses in study sites are integral part of the village ecosystem as it served subsistence benefit to the indigenous people. Grassland managers opined of management procedure, considered to be key in maintenance of grasslands and thus a descriptor of soil quality. The diversity of indigenous soil types in the present study corroborated with an earlier study of Barak Valley, Assam (Das and Das, 2005) where farmers classified five major soil types: athail (sandy clay loam), poli (sandy clay loam), ujar (sandy clay loam), lal (sandy loam) and balu (sandy). Kshirsagar and Pandey (1996) reported three major farmers' soil types: balia (sandy), kelua (clayey) and dorosa (silty or loamy) in a rainfed village in Orissa. Soil colour and texture altogether constituted a crucial factor for soil classification as suggested by (Brinkmann *et al*., 2018; Popy, 2020). *Athail* and *citta* soils of *Imperata* grasslands with rich clay, organic matter and soil organisms provide adequate environment for plant growth (Lima *et al*., 2011; Popy, 2020). In a recent study in Manipur, northeast India, Sinha *et al*. (2020) addressed about the farmers characterization succeeded by nomenclature of soil on the basis of proportionate mixture of sand and clay content. The presence of earthworm casts in a few *Imperata* grasslands was believed to be an indicator of productive and good soils by the farmers (Desbiez *et al*., 2004). Though the present study showed farmers' valuation of soils on qualitative terms, the scientific analyses of soils were found positively correlated with the traditional knowledge base of the local populations (Dvorak, 1988; Bellon and Taylor, 1993; Niemeijer, 1995; Das and Das, 2005; Nath *et al*., 2015). It was therefore, advocated to

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exploit the complementary nature of local as well as scientific knowledge (Dawoe et al., 2012). Increase in bulk density values along the sub surface and deeper layers of soil column may be ascribed to the loose nature of the surface soil with low bulk density and compact structure of the sub soil with high bulk density (Brady, 1990). This trend of bulk density in the grasslands substantiated the findings of Padhan (2017). Opposing to *Lal* and *balu* soils, *citta* soils were blackish grey, clayey and thereby supporting plant growth. Similarly, higher clay proportions of *athail* soils corresponded directly with water holding capacity, essential for nutrient retention (Percival *et al*., 2000; Ramya *et al*., 2021). Moreover, soils enriched with clay (*athail* soils) presumed to escalate the organic carbon content thus, accepting the local knowledge of soils in a rural community (Das and Das, 2005).

Conclusion:

Traditional knowledge systems of farmers are pertinent in view of *Imperata* grassland foliage production and their management in Barak Valley, Assam northeast India. The identification and categorization of surface soil by the local people (smallholder farmers) determine the grassland potential at present and future. In the national planning and policy formulation process of sustainable land-use, inclusion of farmers' perspective is vital particularly the established rich knowledge base of soils. Farmers' understanding of soil would therefore act as a guide in sustainable land-use management and environmental program.

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