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Ethnopedological knowledge of farmers for a decision support system in Manipur state, northeast India

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Ethnopedology has gained importance in the recent years providing a better understanding of the local community practices in relation to preserving local soil knowledge of indigenous and rural communities. Despite the use of soil among present day and ancient societies with respect to technology, key soil procedures and changes included are comparable. The present exploratory study is conducted in three tribal villages in Manipur state to study the ethnopedalogical classification on the basis of several indicators used by the farmers. Data was collected from the farmers through key informants focused group discussions, transect walk and brainstorming technique. The validation of the ethnopedological knowledge based on the physico – chemical properties of the soil determined from the laboratory testing ascertain that the classification of soil by the farmers. The findings of the study have important policy implications for sustainable agricultural practices in the region.

Keywords: Ethnopedology, Indicators, Manipur, Physico – chemical properties, Validity

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Ethnopedology or indigenous soil knowledge consists of two dimensions namely the physical dimension concerning the knowledge derived from the observable characteristics of the soil like colour and texture and the perpetual dimension concerning of factors effecting soil workability, crop suitability, land use, etc. The term ethnopedology was coined very recently by Williams and Ortiz-Solorio[1] in 1981. Ethnopedology is increasingly expanding significance providing a better comprehension of local community practices for sustainable practices. Additionally, there is an increased awareness for preserving the soil before it is harmed due to the ever-changing social, cultural and agricultural factors. Indigenous soil characterization, which is synonymous with ethnopedology, is the investigation of the neighborhood or indigenous information of soil and land management from an ecological viewpoint. It is a rapidly developing approach combining land – use knowledge and soil conditions[2]. Records suggest that the Chinese pioneered in ordering soils and were making use of soil classification 4000 years back for duty evaluation and tax assessment. Dokuchaev and others utilized vernacular soils like *chernozem, solonetz* and *gley* as focal ideas for their logical soil order[3]. Logical frameworks and scientific soil mapping are supplanting folk classifications, particularly in developed nations since local classifications, regardless of whether they exist, are just locally substantial and have generally constrained applicability. Regardless of every one of these confinements, indigenous categorizations can present information that is helpful to understanding the land scape structure, capacity and change, particularly in developing nations with restricted assets for research for a wider and diversified canvas. The potential offered by the indigenous classification is often underutilized to solve critical problems in relation to quality soil classification[4].

Farming communities have been classifying soils based on the suitability of the soils to the crops or based on the land management found suitable in the area. Farming communities have been continuously transforming this taxonomic knowledge into farming strategies and practices which could be used for their development. Local farmers have a profound knowledge of their soils[5]. It is quite crucial in the successful deployment of management practices like the proper calibration of cropping systems to the agricultural possibilities available on the field and greater adjustment to the conservation measures of

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soil[6–8]. They develop a local taxonomic system of soil classification that is usually use-oriented[9–11]. They commonly adopt parameters such as colour, texture, depth, changes in soil behavior under different conditions, drainage and parent materials/geomorphic features in classifying the soils for their own assessment and use[12–14]. Indigenous soil information offers essential long-term understanding about human reactions to environmental change, such as climate change and desertification. If soil surveys start from indigenous soil classification, research and development efforts would have an advantage over time and would gain insight, and communication between farmers, scientists and extension workers would be greatly improved if local soil nomenclature is used[15,16]. Ethnopedology can serve to document local knowledge and help the indigenous people maintain and protect their local cultural knowledge base, even as modernization proceeds. The current research is an attempt to identify the ethnopedological classification of the three tribal farmers' communities in Manipur state, Northeast India. The comparative analysis of ethnopedological knowledge of the three tribes is studied and validated on the basis of physico-chemical properties of the soil determined from laboratory soil testing.

Study area

The study was conducted in Molnom, Khawmawi and Saipum village located at the slope of a continuing chain of hillocks under Tuibuong tehsil in Churachandpur district of Manipur state situated between Latitude $24^0 3'$ and $25^0 3'$ North and Longitude $92^0 8'$and$93^0 8'$ East. The villages possess rich cultural as well as social heritage. Molnom village is located on the slope of the Thangting hill range up to the banks of the Tuithapiriver in the tehsil situated at 55 km from the state capital, Imphal. The village constitutes of about 400 households covering an area of approximately 50 hectares. It is one of the oldest inhabited village in Churachandpur district and has celebrated its 60th anniversary in the year 2011. The village is predominated by the Thadou – Kuki tribe intermingled with other tribes such as Vaiphei and Hmar.

Khawmawi village is located at the banks of the Tuithapiriver, meeting Molnom village at the end of the hill slope. It constitutes about 200 households with Hmar tribe covering an approximate area of 20 hectares. Saipum village is also located on the banks of the Tuithapiriver just 3 km away from the Khuga dam multipurpose project. It constitutes about 300 households covering an area of around 35 hectares. The village is considered an ideal site for ethnopedological studies as the Vaiphei tribe has been residing in the area for a long period possessing rich farming culture. The study area experiences a warm humid climate with a maximum temperature of 37^0C and a minimum of 0.5^0C. The mean annual rainfall in the region is 2350 mm. Paddy is the primary cereal grown in both hills and plains. Other crops of interest grown in the region are maize, pulses, oilseed, sugarcane cultivated through shifting cultivation.

Methodology

Information on the predominant ethnic community from each tribe was collected with direct information from the farmers and district revenue office. A list of 50 villages were closely examined from Tuibuong tehsil and three villages were randomly selected, one for each dominant tribe. The villages selected were Molnom, Khawmawi and Saipum. The three tribes namely the Thadou – Kuki, Hmar and Vaiphei respectively were selected purposively since they are major tribes residing in the tehsil. Data was collected from the tribal farmers as respondents through focused group discussion, transect walk, and brainstorming technique. Around 25 farmers from each tribe were involved in focused group discussion and transect walk belonging to different age groups with a representation of both women and men. The selection of the participants was done considering their experience in farming for a considerable length of time.

For the analysis of soil, composite soil sampling was followed for the collection of soil sample in which soil samples are collected from a number of furrow slices (depth 0 – 15 cm) from the area using a spade as per standardized protocol and the collected samples are thoroughly mixed. The furrow slices collected from each site are of uniform volume, and all the furrow slices were randomly selected. Six random sites were selected from each area as heterogeneity of the soil decreases with increasing number of furrow slices. The soil sample was tested in the laboratory for pH and electrical conductivity (1:2.5 soil-to-water ratio), organic carbon[16], available phosphorus with $NAHCO_3$ (pH 8.5)[17] and available potassium using 1 mol L^{-1} NH_4OAc (pH 7.0)[18]. With the help of the respondents, soil properties that are important in the local classification method were identified. For this purpose, soil texture and depth of different horizons were determined and recorded during the field survey.

Results and Discussion

Indigenous soil classification of the Thadou – Kuki tribe

Preliminary information regarding the soil types in the region was carried out by conducting Transect walk in the research area in which seven soil types were found to be prominent among the Thadou – Kuki tribe (Table 1**).** The soils were identified, classified and elaborated on the basis of farmers' knowledge. The soils are Lei Eng, Lei San, Changpal Lei/ Zou Lei, Lei Si, Neldi Lei, Phai Lei and Vadung Lei. The soil classification is mainly attributed on factors like colour, texture and land – use which is quite similar to the classification observed on different pieces of the tropics[19–21]. The Thadou – Kuki tribe base their classification on these significant criteria or a mix of any two. These criteria are imperative to the farmers as they are noticeable and reasonable as far as the administration of the soil based on top – soil characteristics are concerned, as observed in North Ghana[22].

As far as the colour of the soil is concerned, the farmers order the soil as indicated by red, dark, brown, and grey soils with grades of each shading for comparison, for example very red or light red. Nonetheless, the farmers do not have a different name for these evaluations. The soil groups ordinarily incorporate various soils with various logical characterization. This clear consistency is on the grounds that the logical arrangement framework recognizes the soil complex while farmer's grouping does not.

The farmers characterize the soil based on the sand and clay content. A mix of the two provides the premise of naming the soil. The position of the soil on the catena is also another important criterion used extensively by the farmers of the Kuki tribe to classify the soils of the area. The land-use and geophysical location of the soil is also taken into consideration. The soils found in the hills are called Zou Lei, which may be at the apex of the slope. The soil found in the plains is called Phai Lei. Zou Lei consists of the red soil predominantly found in the hills like Lei San and Lei Eng. Phai Lei consists of the soils found in the plains of the hill which are sandier in texture than compared to the soils found on the hills.

The Kuki farmers did not use indicator plants extensively for classification. They use the weeds like Indian Pennywort (*Centellaasiatica*) and other weeds to identify the fertility of the soil. In general, the high abundance of weeds in the area is used as an indicator for the fertility of the soil. The dark coloured vegetation also denotes high fertility.

Table 1 — Ethnopedological classification of soil based on different parameters of Thadou – Kuki tribe

Parameters used	Lei Eng	Lei San	ChangpalLei	Lei Si	NeldiLei	PhaiLei	VadungLei
Colour	Pale – red	Bright – red	Pale – brown	Pale reddish – brown	Greyish – brown	Dark greyish – brown	Reddish – brown
Abundance in the area	Low	High	High	Low	Medium	High	Medium
Drainage quality	High	High	Good	Good	Good (more than Lei si)	Low	Medium
Indicator plants	*Saccharumspontaneum, Phyllanthusemblica*	*Saccharumspontaneum, Mikaniascandens*	*Ageratum conyzoides, Amaranthuscaudatus*	*Setariaitalica, Lantana camara*	*Centellaasiatica, Cynodondactylon*	*Centellaasiatica, Plantago major*	*Ageratum conyzoides, Cynodondactylon, Eleusineindica*
Fertility	Poor	More fertile than Lei Eng	Good	Poor	Less fertile than Changpal Lei	Good	Highly fertile
Position on the catena	Mainly on the top but also found on mid – slope	Upper slope or mid – slope	Mid – slope	Mid – slope	Lowe slopes or foothills	Plains or near a river	Near a river or stream
Erodibility	Poor	Easily eroded only at the slopes	Easily eroded	Easily eroded	Easily eroded	Less erodible than Neldi Lei	Highly erodible
Cracking	Cracks	None	None	None	None	Cracks	None
Texture	Sandy	Sandy clay	Sandy clay	Sandy clay	Sandy	Clay	Silty clay
Coarseness	Coarse elements	Coarse elements	Coarse elements	None	None	None	Coarse elements
Hardness	Very – hard	Hard	Medium	Soft	Very – soft	Hard	Soft
Water retention capacity	Poor	Poor	Good	Poor	Very – poor	Good	Good
Characteristic stickiness	Non – sticky	Mildly sticky when wet	Sticky	Non – sticky	None – sticky and loose when dry	Very – sticky and slippery when wet	Very – sticky
Crops	Soybean, Pineapple, Turmeric, Ginger	Maize, Banana, potato	Banana, rice, local sticky rice, maize, cowpea, pumpkin, cucumber	Fruit tress like lemon, lime, orange	Onion, potato, maize, bottle gourd	Rice, potato, cowpea, chilli, onion, cabbage	Maize, pumpkin, cucumber, taro, water melon
Suitability	Good for pineapple and soybean	Good for pineapple, ginger and turmeric	Growing all types of crops including rice	Used for growing fruit trees. The soil is preferred for building farm huts	Good for rice, potato and maize	Good for growing rice	Good for growing all type of crops
Unsuitability	Maize when grown is too dry and hardy. Other crops are stunted	Not good for growing vegetable crops	Not good for growing winter crops	Not good for growing any type of vegetable crops	Not good for growing fruit trees and banana	Not good for growing solanaceous crops	None

(*Contd.*)

Table 1 — Ethnopedological classification of soil based on different parameters of Thadou – Kuki tribe (*Contd.*)

Parameters used	Lei Eng	Lei San	ChangpalLei	Lei Si	NeldiLei	PhaiLei	VadungLei
Unique management practices	None	Harvesting of thatch grasses during winter. Burning of thatch residues followed by plantation of crops	Shifting cultivation	Integration with fruit crops due to poor fertility of land	Soil mulching with crop residue	Burning of straw and crop residues	Mixed cropping using maize stalk for bunding and fencing
Management constraints	Difficult to plough, low fertility	Difficult to plough when too wet to too dry. Low fertility. Coarse soil with stones	Difficult to plough when dry. Excessive weed infestation	Low fertility, prone to water erosion	Prone to wind and water erosion. Difficult to plough when wet	Difficult to plough during rainy season, very sticky	Prone to water erosion, flooding during rainy season
Management practices to overcome the constraints	Ploughing after light rain, growing trees	Ploughing after light rain, manuring once a year	Burning of weeds and crop residue after harvest	Digging deep pits to plant fruit trees	Ploughing before rain. Grass – strips or stone lining to control erosion	Ploughing before rain. Nursery for growing seedlings	Rock lining of the fields near river bed
Soil conservation practice	Waterways for drainage	No	Bamboo and banana plants as wind breaks	Bunds less than 1 ft. height	Terrace bunds (1 ft. high)	Terrace bund	Green gram and black gram broadcasted on the field

Indigenous soil classification of the Hmar tribe

The transect walk conducted among the Hmar tribe brought out seven types of soil types namely, LungbuotPil, PilSen, ChungzangPil, TieusietPil, PhainphinPil, ThlakPil and TuithaPil (Table 2). Among these, two types of soil types, namely PhaiphinPil and TuithaPil is believed to be closely related. The parameters used for soil classification consist of origin in case of Lungbuot Pil, colour in case of PilSen, location in case of Chungzang Pil, Land use in Tiesiet Pil and Tieusiet Pil, texture in Thlak Pil and location in case of Tuitha Lei. The abundance of soil in the region ranges from high with respect to Pil Sen, Chunzang Pil, Thlak Pil, Tuitha Pil, and Phaiphin Pil and are found moderately distributed in the region. Tieusiet Pil ranks the lowest in terms of their abundance in the region.

The Hmar farmers also base the classification of the soil on the basis of origin, colour, texture, and land – use. In terms of colour, the farmers classify the soils into red, brown, or grey soils. The farmers also have different grades of each colour for comparison. Different scientific classification may be observed on the basis of sand and clay content. The dark coloured soils are generally considered as more fertile than the light coloured soils[23]. The combination of the two in the soil complex constitutes the basis for naming the soil. The farmers also classify the soil based on the ease of ploughing during land preparation. The degree of soil adhesion to the tillage implements can be a hindrance which is mostly dependent on the texture of the soil. The coarseness of the soil is used to differentiate the sandy soils into PhaiphinPil and TuithaPil. The cultivation on such soils usually require the removal of gravel from the soil using implements.

Hardiness, stickiness, water retention capacity, drainage, and erodibility are some of the characteristics used by the Hmar farmers to describe the soil further. Cracking, fertility, management constraints, are also used informally for classification. One simple and broad base criterion used is the location of the land where the soil is found. The soils located at the hill is called ChungzangPil where Shifting cultivation is practiced. Soil on the valley plains are called PhaiphinPil if it is sandy and ThlakPil if it is clayey in texture. Indicator plants like *Centellaasiatica* usually indicate good soil structure. The presence of *Ageratum conyzoides* indicates the presence of clay in the soil. The high presence of weeds on the soil is generally perceived as an indicator of high fertility status of the soil.

A notable soil conservation measure observed in the soil of Thlak Pil where farming is practiced on terrace with bunds. Rock lining was also observed in Pil Sen. In places where suitable rocks are not available, tree logs and timber are temporarily used for the prevention of soil erosion. In Chunzang Pil, closely fences bamboo sticks are also seen which serves the dual purpose of land demarcation as well as control measure for the prevention of soil erosion. Soil mulching with maize stalks is also observed in PhaiphinPil after the harvesting of corn from the plants.

Indigenous soil classification of the Vaiphei tribe

Six soil types were identified by the Vaiphei tribe during the transect walk. They are Lei Eng, Lei San, Kang Lei, Nel Lei, Thilou Lei, and Tuitha Lei (Table 3). Lei San and Kang Lei are abundantly found in the region, whereas Lei Eng, Lei San, and Nel Lei are low in their abundance. Tuilou Lei and Tuitha Lei were found to be moderately distributed in the region. The fertility of soil ranges from poor in case of Lei Eng and Lei San to medium fertile in case of Nel Lei. It was good in case of Kang Lei and Tuilou Lei while highly fertile in case of Tuitha Lei.

The visibility and practicality of the criteria in terms of the management of soils in crop production on the agricultural field are important attributes for

Table 2 — Ethnopedological classification of soil based on different parameters of Hmar tribe

Parameters used	LungbuotPil	PilSen	ChungzangPil	TieusietPil	PhaiphinPil	ThlakPil	TuithaPil
Colour	Pale – red	Bright – red	Pale – brown	Pale reddish – brown	Greyish – brown	Dark greyish – brown	Reddish – brown
Abundance in the area	Low	High	High	Low	Medium	High	Medium
Drainage quality	High	Very – high	Good	Medium	Good	Low	High
Indicator plants	*Saccharumspontaneum*	*Saccharumspontaneum*, *Cynodondactylon*	*Ageratum conyzoides*, *Amaranthuscaudatus*	*Setariaitalica*, *Mikaniascandens*	*Cynodondactylon*, *Amaranthuscaudatus*	*Centellaasiatica*, *Cyperusrotundus*	*Cynodondactylon*, *Eleusineindica*
Fertility	Poor	More fertile than Lei sen	Good	Poor	Medium	Good	Highly fertile
Position on the catena	Mainly on the top but also found on mid – slope	Upper slope or mid – slope	Mid – slope	Mid – slope or lower – slope	Lower slopes or foothills	At the foothills or plains	Near a river or stream
Erodibility	Poor	Easily eroded	Easily eroded	Easily eroded	Highly eroded	Less erodible	Highly erodible
Cracking	Cracks	None	None	None	None	Cracks	None
Texture	Sandy	Sandy clay	Sandy clay	Sandy clay	Sandy	Clay	Silty clay
Coarseness	Coarse elements	Coarse elements	Coarse elements	Coarse elements	None	None	None
Hardness	Very – hard	Hard	Soft	Soft	Soft	Hard	Soft
Water retention capacity	Poor	Medium	Good	Poor	Very – poor	High	Good
Characteristic stickiness	Non – sticky	Mildly sticky when wet	Sticky	Non – sticky	None – sticky	Very – sticky when wet	Very – sticky
Crops	Pineapple, Green gram, Black gram	Pineapple, soybean	Almost all types of crops. Prominent are Rice, maize and pumpkin	Pumpkin, bitter gourd and sweet gourd	Potato, cowpea, winged bean, mustard, rapeseed	Rice, cabbage, mustard, cowpea	Mustard, rapeseed, pumpkin, cowpea, maize
Suitability	Good for growing Oak tree and pine tree for firewood	Growing gooseberries, pineapple	Growing all types of crops	The soil is preferred for building farm huts, sheds.	With proper irrigation, good for growing potatoes, rice, maize and other cereal crops	Good for growing rice, maize, mustard	Good for growing mustard, rapeseed and rice
Unsuitability	Not suitable for vegetable crops	Not good for growing vegetable crops	Not good for growing winter crops	Low fertility for any crop to provide desirable production	Not good for growing trees as they get uprooted easily	Not good for growing chilli, potatoes as waterlogging occurs frequently	Fruit trees are avoided
Unique management practices	Crop residues are burnt and scattered on the field	Intercropping of pineapple and soybean. Minimum tillage	Shifting bunds are also constructed to serve dual purpose of land demarcation as well as soil erosion control	None	Zero tillage, soil mulching	Land preparation prior to monsoon	Zero tillage
Management constraints	Low fertility, difficult to plough when dry	Difficult to plough. Low fertility.	Excessive weed infestation.	Soil erosion problems. Low fertility	Soil erosion. No effect of ploughing. Fertility is poor	Water logging problems, soil erosion	Prone to water erosion, flooding during rainy season
Management practices to overcome the constraints	Ploughing after light rain	Minimum tillage, manuring once a year, dibbling of seeds	Burning of weeds before farming	Bunds and trenches. Manuring before farming	Soil mulching to control erosion. Light ploughing and manuring before farming	Well-developed drainage canals, bunds and terraces	Broadcasting of mustards and rapeseed at the corner of the field. Rock lining near the river bed
Soil conservation practice	None	Rock lining. Timber is also used temporarily	Bunds. Bamboo and banana for windbreaks.	Trenches and bunds	Soil mulching	Terrace bund	Rock lining. Weeds are not cleared until the next cropping season.

the classification of the soil. Using the textual differentiating criterion, sandy soils are called Nel Lei and clayey soils are called Tuilou Lei. Coarseness is also used to differentiate the soils into Nel Lei, Tuilou Lei, and Tuitha Lei. The degree of soil adhesion to the tillage implements can be hindrance for land preparation during cultivation. The Veiphei tribal farmers classify the soil into Lei Eng and Lei San as well as Nel Lei. The position of the soil on the catena is also a criterion to differentiate and classify the soils. Kang Lei is generally used for soils found at the hill slopes on which shifting cultivation is practiced. The soil is also referred to as Chang Lei where 'Chang' is the local term used for 'rice'. Land use is also an important consideration. Tuilou Lei refers to those soils found in the plain where the irrigation is practiced through water canals. Kang Lei or Lei San may be called Tuilou Lei if waterways are found in the farming areas. Tuilou Lei and Kang Lei is also differentiated through the water retention capacity. The soil is referred to as Kang Lei if the water seepage from the soil is quick else it is called as Phai Lei.

The Vaiphei farmers do not use indicator plants as extensively as other tribes in the area. It is generally used to assess the fertility of the soil. The presence of abundant weeds in the land denotes high fertility status, while dark coloured vegetation denotes the presence of high organic matter in the soil. Based on the management constraints, two broad-based classification is observed called 'Lei Tak' for soils which are difficult to plough and 'Lei Gam' for soils which are easy to plough and friable in nature. With respect to the soil conservation practice, maize plants were used for soil mulching and as wind barrier in case of Lei Eng soil. In Lei San, weed residues were left on top of the soil to control soil erosion as well as to prevent soil moisture. In Kang Lei soil, field bunds

Table 3 — Ethnopedological classification of soil based on different parameters of Vaiphei tribe

Parameters used	Lei Eng	Lei San	Kang Lei	Nel Lei	TuilouLei	TuithaLei
Colour	Pale – red	Bright – red	Pale – brown	Greyish – brown	Light – brown	Reddish – brown
Abundance in the area	Low	High	Very high	Low	Medium	Medium
Drainage quality	High	High	Good	Very high	Low	High
Indicator plants	*Saccharumspontaneum, Mikaniascandens*	*Saccharumspontaneum, Mikaniascandens*	*Amaranthuscaudatus, Centaureacyanus*	*Cynodondactylon, Eleusineindica*	*Centellaasiatica, Setariaitalica*	*Cynodondactylon, Cyperusrotundus*
Fertility	Poor	Poor	Good	Medium	Good	High
Position on the catena	Mainly on the top but also found on mid – slope	Upper slope or mid – slope	Mid – slope or lower – slope	Mainly on the foothills	On the slope if the stream is present around	Near a river
Erodibility	Poor	Poor	Good	Medium	Good	High
Cracking	Cracks	Less cracks	None	None	Cracks	None
Texture	Sandy	Sandy clay	Sandy clay	Sandy	Clay	Silty clay
Coarseness	Coarse	Less coarse than Lei Eng	Less coarse than Lei San	None	None	None
Hardness	Very – hard	Hard	Medium	Soft	Hard	Soft
Water retention capacity	Poor	Poor	Medium	Soft	Hard	Soft
Characteristic stickiness	Non – sticky	Mildly sticky	Sticky	Non – sticky	Highly sticky	Sticky
Crops	Pineapple, soybean, green gram, kidney bean	Banana, potato	Rice, banana, pumpkin, watermelon, cucumber	Onion, pea, potato, ginger, turmeric	Rice, mustard, cabbage, cowpea	Mustard, maize, rice, taro, yam
Suitability	Mainly used for growing Oak tree and pine tree for firewood and timber purpose	Good for growing pineapple and ginger.	Growing all types of crops in shifting cultivation	Potato, tomato, onion, ginger is cultivated with proper irrigation	Good for growing lowland rice. During winter, mustard is cultivated	Good for growing all type of crops
Unsuitability	Poor fertility and high altitude make it unfavorable for growing food crops	Not good for growing leafy vegetable crops as they tend to be stunted and unproductive	Not good for growing banana. Growing of winter crops is avoided	Not good for growing fruit trees as they tend to be uprooted easily	Not good for growing winter crops due to hardening/ cracking	Fruit trees are avoided due to lose soil and flooding
Unique management practices	Maize is broadcasted in fallow land for fodder purpose	Harvested thatch grasses are used for roofing purpose. Weed residues are burnt for weed and insect control	Shifting bunds are also constructed to serve dual purpose of land demarcation as well as soil erosion control	No land preparation for maize cultivation	Nursery for seedlings. Water from the top field flow to the low-lying terraces	Broadcasting of mustard at the corner of the field
Management constraints	Difficulty in ploughing. Soil infertility. High water seepage.	Low fertility, hard soil pan, perennial weed problem	Difficulty to plough when dry, rapid rate of weed infestation	Soil erosion. No effect of ploughing during rainy season	Very sticky. Weed problem during plantation. Difficult to plough during rainy season, prone to flooding of bunds	Prone to water erosion, flooding during rainy season
Management practices to overcome the constraints	Ploughing prior to crop plantation before rain. Use of maize stalk as soil mulch to loosen the soil during the ploughing of next crop	Ploughing after light rain. Weeds are uprooted and left on the field to rot.	Weeds and crop residues are burned on the field followed by ploughing before the rain	Bunds are developed surrounding the fields to control erosion, stone lining is also used	Ploughing before rain. Weeding is done after transplantation of rice	Closely spaced bamboo fences surrounding the field. Planning of crop harvest before heavy rain
Soil conservation practice	Maize crop is broadcasted to serve the dual purpose of fodder and serving as barrier	Weed residues left on the field to control soil erosion	Field bunds are commonly used	Bunding of the field	Terrace farming (bunds of 1 ft. height)	Closely spaced fences made of bamboo or maize stalks surrounding the field

Table 4 — Comparative analysis of category of soils identified by the tribal people with the help of soil testing results

Category	Soil category local name	Tribes	pH	Cation exchange capacity (meq/100 g)	%Organic content of the soil	Rating of Nitrogen in soil	Available phosphorus (kg/ha)	Available potassium (kg/ha)
1	Lei Eng	Thadou – Kuki,	6.8	14.76	0.89	Medium	25	120
	LungbuotPil	Hmar	6.7	15.37	0.83	Medium	22	124
	Lei Eng	Vaiphei	6.5	14.85	0.87	Medium	21	123
2	Lei San	Thadou – Kuki,	6.1	12.30	0.93	Medium	20	117
	Pil San	Hmar	6.4	12.59	0.96	Medium	24	120
	Lei San	Vaiphei	6.2	12.70	0.95	Medium	18	115
3	Changpal Lei	Thadou – Kuki,	4.3	14.97	3.50	High	27	245
	ChungzangPil	Hmar	4.7	15.10	2.60	High	31	242
	Kang Lei	Vaiphei	4.5	15.20	3.10	High	28	249
4	Lei Si	Thadou – Kuki,	5.1	19.12	0.62	Low	16	112
	TieusietPil	Hmar	5.1	19.32	0.68	Low	18	110
5	Neldi Lei	Thadou – Kuki,	5.6	20.13	0.51	Low	24	223
	PhaiphinPil	Hmar	5.8	20.43	0.45	Low	21	219
	Nel Lei	Vaiphei	5.7	20.31	0.48	Low	25	214
6	Phai Lei	Thadou – Kuki,	5.3	26.86	0.85	Medium	43	280
	ThlakPil	Hmar	5.4	26.78	0.92	Medium	39	275
	Tuilou Lei	Vaiphei	5.5	26.47	0.89	Medium	41	282
7	Vadung Lei	Thadou – Kuki,	4.2	27.34	0.78	Medium	27	248
	TuithaPil	Hmar	4.1	27.45	0.81	Medium	29	245
	Tuitha Lei	Vaiphei	4.4	25.67	0.75	Medium	24	247

served the dual purpose of land demarcation as well as control for soil erosion. In Nel Lei, bunding as a measure for soil conservation is commonly practiced while in Tuilou Lei, terrace farming with bunds as high as one foot is used for soil conservation. In Tuitha Lei, closely spaced fences made from bamboo or maize stalks are used as fencing for the control of soil erosion and providing boundary to the farm.

Validation of the ethnopedological classification of Thadou – Kuki, Hmar and Vaiphei tribe

Soil test results (Table 4) obtained from the laboratory for different soil samples collected during the transect walk points in favour of the indigenous soil classification of the three tribal communities. The soil test results with respect to the soil pH, cation exchange capacity, organic carbon content, available phosphorus, and available potassium showed markedly distant differences among the different types of soil identified in the study by different tribes. The soil test results conclude that the soil classification of the indigenous farmers of the Thadou – Kuki, Hmar, and Vaiphei tribe were valid. It further validates the claim that different names were given by different indigenous tribal community for the same type of soil.

Conclusion

The indigenous tribal farmers have developed a reservoir of local knowledge through years of experience and experimentation, which is useful in developing classification schemes that are simple, creative, socially acceptable, and useful for socially relevant and sustainable production technologies. The most important problem experienced by the farmers is the low fertility of the soil, which was improved with the application of animal waste, inorganic fertilizer, and crop rotation. The ethnopedological study has revealed that farmers have ample knowledge of the soil resources in their environment. The knowledge must be tapped by extension functionaries in an effort to improve and sustain the crop production potential of the rural communities. There is a need to establish a participatory appraisal aimed to link actors and researchers in a mutual relationship for continuous learning on farming needs suited to their prevailing context.

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