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Indigenous knowledge of soil fertility management in the humid tropics of Arunachal Pradesh

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Traditional ecological knowledge has been established to have a bearing on natural resource management by the indigenous communities living in biodiversity rich North eastern hill region. The present study correlates the indigenous knowledge and scientific knowledge in assessing the nutrient availability status of the agricultural soil as practiced by the '*Nyishi*' tribes who use visual properties such as colour, texture and topographic positioning of land/terrain. The physico-chemical analysis of the soil samples for soil characterization and appropriate land use thereof is in concordance with the working model of the indigenous soil knowledge of the '*Nyishis*'. Thus, there arises a need to document the traditional knowledge base and include the same for validation and scientific application for better management of soil and other resources.

Keywords: Arunachal Pradesh, Fertility; Indigenous soil knowledge, Land suitability, Northeast India, *Nyshis*, Texture

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The increasing attention paid to local soil knowledge in recent years is the result of greater recognition that the knowledge of people who have been interacting with their soils for a long time can offer many insights into the sustainable management of tropical soils[1]. Traditional subsistence farmers' throughout the tropics exhibit a deep understanding of their local ecosystems[2]. Small farmers in such farming systems are often confronted with complex and heterogeneous environments, including different soil qualities of which they develop a systematic knowledge. To improve the success of soil fertility initiatives, other development programs and research in the area of soil productivity losses' there is a need to include the perceptions of local people and their tacit soil knowledge[3] for it is believed that more rich and tacit the knowledge is, the more technology should be used to enable to share that knowledge directly[3,4]. They retain indigenous soil classification or 'folk soil taxonomy' and have adapted to their indigenous soil/land management practices[5]. Recently, indigenous knowledge systems in soil characterization, fertility assessment, and land use decision making and management practices have been widely recognized[6,7,8]. In general, the farmers consider soil fertility, land use suitability and other related environmental conditions based on easily observable criteria such as colour, texture and topographic positions of the respective soils[8,9,10]. Although the existence of indigenous knowledge has been receiving greater attention for the past few decades, farmers' knowledge on soil and land degradation has not yet been synthesized as a component in addressing sustainable land management and environmental initiatives[10,11,12].

Thus the present study reports on the role of indigenous knowledge in soil characterization, land use suitability, and land management in the highland agro-ecozone of the Papum Pare district of Arunachal Pradesh in Northeast India and has attempted to correlate the indigenous knowledge with conventional land evaluation procedures and management recommendations made by the soil scientists. The following hypotheses were however framed for testing under field conditions.

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Local communities manage their soil resources through better decision making and local monitoring of their environment.

Such management decisions are often designed to boost up the soil management practices and find practical solutions to indentified soil constraints.

Methodology

Arunachal Pradesh, the land of rising sun comprises of mountainous and sub-mountainous portions of the Himalayan system in its extremity, covering an area of 83,743 sq km. This state is skirted by Bhutan in West, Tibet and China in North and Northeast, Burma in East and Assam in South. It is the largest state area wise in Northeast region of India. Barring only 12 towns, entire area is rural where an overwhelming 94 % of its population lives scattered in 3257 villages grouped under 48 integrated development blocks. The study was conducted in three villages, viz. Model, Lekhi and Nirjuli of the Papum Pare district (26°55´ and 28°40´ N latitude and 92°40´ and 94°21´ E longitude) of Arunachal Pradesh in the Northeastern region of India. All these villages are good representatives of rainfed agricultural systems within the same agro-ecological zone[13] and is being inhabited by the '*Nyishi*' tribes. The area experiences a warm humid climate with a mean annual rainfall of 2800 mm and average mean annual ambient temperature is about 28° C.

Rigorous field survey, personal interviews' using some standardized questionnaires followed by group discussions were conducted in three different villages inhabited by the '*Nyishi*' people in the Papum Pare district of Arunachal Pradesh. The objective was to document the traditional ecological knowledge on soil type and to investigate and analyze the contribution of both indigenous as well as scientific knowledge systems in land suitability evaluation and in land management decision-making opportunities (Fig. 1). Prior Informed Consent (PIC) of the villagers and the community leader were taken to maintain the ethics of preserving the knowledge systems of its property holders.

From each of the study sites, soil samples (10 replicates) were collected from the paddy fields with the help of soil corer (5.5 cm inner diameter) to a depth of 0-30 cm. During collection the local name of each of the soil type and characteristics were noted based on the traditional ecological knowledge of the '*Nyishis*'. The soil samples were brought to the laboratory, sieved through 2 mm mesh screen, and

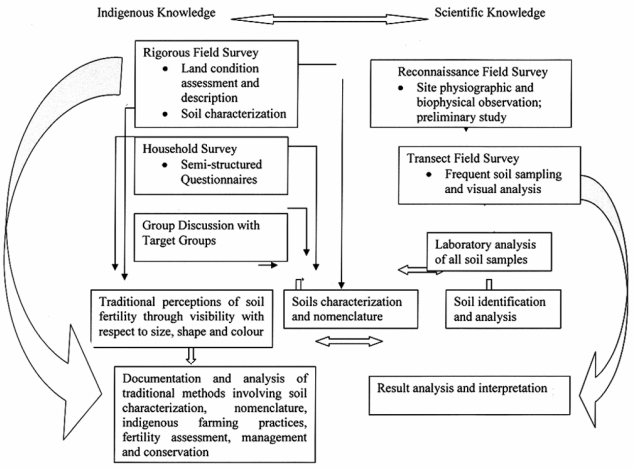

Fig. 1—Schematic flow chart showing an overview of methodology followed to interlink Indigenous Knowledge with Scientific Knowledge

used for the analysis of soil physicochemical properties. Soil texture was analyzed by Bouyoucos soil hydrometer method, water holding capacity by Keen's box method and organic carbon content by rapid titration method[14]. Soil *p*H (1:2.5 w/v H_2O) was measured using a digital *p*H meter (Systronics, India). Soil moisture was determined gravimetrically and total N by semi-micro Kjeldhal method[15].

Results

Farmers of the study villages use physical as well as perceptual characteristics of the soil and the land to name and classify their soils. The physical dimension deals with the most observable criteria that farmers use to distinguish their soils. For instance, the '*Nyishis*' characterize the soil by texture, topographic position, visual appearance (colour) and yield. Their method of soil characterization are conforming to similar studies elsewhere in India[5] and abroad[3,6,8-10].

Based on the traditional ecological knowledge, *Nyishis* have classified their soils into 5 major types, viz. *Uttola, Kanla, Kannam, Lengching* and *Ponglung*. Of these, '*Kannam*' the dark soils according to the farmers, are the more fertile. However, the '*Uttola ked*' (sandy soil) is abundant in the study area. For example, the '*Uttola ked*' type occupies almost 45 % of the land area, followed by '*Kanla*' (21 %), '*Kannam*' (19 %), '*Ponglung* (8.5 %) and '*Lengching*' (6 %). It is also perceived that the '*Kannam'* soils are considered to be good to puddle and contain more silt and clay as well as rich in organic matter, and are more suitable to grow *tapio* (maize), *yangkya* (leafy vegetables) and *tia* (millets).

'*Kanla'* or the dark greyish brown soils are soils found on the hill slopes where shifting cultivation (locally known as '*jhum*') is practiced and are believed to bear low to moderate level of nutrients and henceforth, high nutrient efficient crops such as chillies (*yamdak*), ginger (*take*), cucumber (*mekung*), cucurbits (*tarok*) and white sesame (*tanam*) are suitably grown. '*Lengching'* or the red soils has low water retention capacity and possess low productivity and fertility. And the pale brown soils named '*Uttola*' consist of gravels and stones beneath the top soil and were abundant on the rocky hill sides and steep slopes where a few crops such as *tapio* (maize), *piyok* (millets) and *nincho* and *rakteh* (paddy) are cultivated seasonally.

Traditionally, soil colour can be considered to be the dominant visual criteria in differentiating most of the soils along with the textural properties being a vital component in distinguishing any two soils bearing similar colour. Soil texture determines soil organic matter content that endorse wide diversity of macro and microorganisms in the soil environment[16]. Nonetheless, in the present study all soils could be described both by colour and texture with the latter considered being one of the dominant properties for soil identification[17].

Over all, the knowledge of the '*Nyishis*' on the relationship between soil characteristic and topography has been observed to have a major implication on land suitability and further management practices. Soils located on higher altitude had choices for a different variety of crop than those at the lower elevation owing to agro climatic regime. For instance, crops such as chillies, ginger, cucumber, cucurbits and white sesame, etc. were grown abundantly at higher altitudinal agricultural system whereas in the lower altitudes crops such as paddy, maize and millets were cultivated. Also the variety of the same crop differed with respect to the topographic position of the soil and hence has been ranked by the '*Nyishis*' as good to worse depending on the soils' physical properties. Further, the '*Nyishis'* have good knowledge base of the variation within a plot and could distinguish soil in terms of cropping potential as well. Although the knowledge of nutrient content and the textural composition of the soils are not known to the local farmers, but their soil categorization and classification methods (Table 1) concords to the laboratory findings as well (Table 2). The soil properties as obtained through the laboratory analysis (Table 1) correlate to that of the traditional knowledge base of the '*Nyishis*' on soil characterization (Table 2). Moreover, the '*Kannam*' soils had greater organic carbon and nitrogen contents, whereas '*Lengching*' or the red soils registered low organic carbon and a very poor water holding capacity (Table 2), thus contributing to poor crop yield. Such a positive correlation between analytical estimates and folk soil taxonomy has also been reported earlier[5,18].

The result of this two-way exchange process is that it has a positive impact on the technical knowledge by nurturing it with local perceptions and demands. Positive impacts are also envisioned on the local knowledge base as it provides with a way for this tacit knowledge to be widely understood, assessed and utilized[1]. Thus it invites scientific researchers to be more holistic in their approach to agricultural research activities involving traditional ecological knowledge systems, particularly on soil and nutrient management

Table 1- Nomenclature and characterization of few major soils by the 'Nyishi' farmers in the humid tropics of Arunachal Pradesh

Local nomenclature	Soil characterization	Distribution and areal extent	Preferred crops
Kannam (Dark brown, clayey soil)	Good to puddle; contain more silt and clay; enrich in organic matter and high rate of fertility	Cover small areas in all the study sites and are scattered	Millets, maize and leafy vegetables
Uttola (Pale brown, sandy soil)	Consist of gravels and stones; low organic matter content and low rate of fertility.	Covers extensive area throughout the study sites	Maize, millets and paddy
Lengching (Red, loamy soil)	Low level of fertility, prone to erosion; poor water retention capacity; low in organic matter.	Sparsely distributed across the study sites	Cotton, Potato and beans
Kanla (Greyish brown, sandy loam)	Moderate in fertility, found on hill slopes, difficult to work on	Widely distributed throughout the study sites	Chilies, ginger, cucumber, cucurbits and white sesame
Ponglung (yellowish brown, loamy soil)	Good fertility, ease of workability	Cover smaller areas throughout the study sites	Paddy, maize, millets and vegetables

Table 2- Physico-chemical properties of the five major soils identified by '*Nyishi*' farmers

Soil Type	Soil Colour	Sand (%)	Silt (%)	Clay (%)	Textural Class	pH	SOC (%)	N (%)	C/N
Kannam	Dark brown	8.01 ± 0.09	43.74 ± 0.51	48.25 ± 0.26	Silty clay	39.56 ± 0.34	5.2 ± 0.01	1.71 ± 0.29	0.29 ± 0.08	5.89
Kanla	Dark greyish brown	73.43 ± 0.07	18.35 ± 0.21	8.22 ± 0.05	Sandy loam	31.37 ± 0.17	5.6 ± 0.09	0.61 ± 0.07	0.20 ± 0.02	3.05
Uttola	Pale brown	86.81 ± 0.64	6.93 ± 0.91	6.26 ± 0.14	Sandy	27.56 ± 0.27	5.9 ± 0.16	0.41 ± 0.27	0.24 ± 0.05	1.71
Ponglung	Yellowish brown	50.34 ± 0.57	35.3 ± 0.04	14.35 ± 0.28	Loam	28.81 ± 0.45	5.7 ± 0.24	0.73 ± 0.41	0.27 ± 0.04	2.70
Lengching	Yellowish red	50.30 ± 0.31	39.4 ± 0.11	11.30 ± 0.61	Loam	18.55 ± 0.11	5.9 ± 0.32	0.25 ± 0.37	0.23 ± 0.08	1.09

± SE (n=5)

for sustainable yield. Consensus building thus could serve as an important step prior to collective action by farming communities resulting in the adoption of improved soil management strategies at the landscape level.

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