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Comparison of Indigenous and Scientific Knowledge on Soil Classification Among Farmers in Imugan, Nueva Vizcaya, Philippines

ABSTRACT

This study was conducted to verify the application of indigenous knowledge of Imugan farmers in soil classification in the Imugan watershed of Sta Fe, Nueva Vizcaya. The results were further compared with the scientific knowledge on soil classification. Drawing out the indigenous knowledge was made through the use of participatory rural appraisal techniques such as focus group discussions, key informant interview, and transect walk. Field observation was also done. On the other hand, scientific knowledge included soil profiling, characterization and soil laboratory analysis. Criteria used by Imugan Farmers in soil classification are their experiences supported by their ability to observe attributes of soil resource. This is their way to identify the best use, and appropriate management practices of the soil resource. Scientific soil classification system is a thorough process of soil characterizations that investigates not only the surface soil's properties, its genesis and chemical properties but also subsoil's characteristics. This expensive and rigorous procedure is intended to aid decision making on the land's best use and crop choice. The two systems of soil classification- knowledge that is tested through time combined with knowledge formed from scientific analysis- may have differences, but combining them together in the framework of soil classification will benefit Imugan farmers. The combined system of soil classification provide detail information about nutrient deficiency and attributes of each soil type, the variety of crops suitable for each soil based on farmers' preference and appropriate inputs in raising crops that are less or not suitable in a given soil.

Key words: *agroforestry, tree-based farming, analytical hierarchical process, crop selection*

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INTRODUCTION

Poverty in the Philippines is greatest in watersheds where agriculture provides the economic base of their settlers. Agricultural development on sloping lands is intensifying in response to increasing population and the need to diversify food and income streams. However, sloping lands are vulnerable to erosion and this reduces the capacity of a watershed to provide vital economic benefits and ecological services. To reduce poverty there is a clear need to increase total agricultural productivity from sloping lands as well as to protect the watersheds. Unsuitable forms of land use and the use of inappropriate land management practices in the uplands or watersheds have to be addressed.

Detailed knowledge of soils and soil properties is critical in achieving sustainable land use. Thirty years ago, the FAO of the UN developed a framework and guidelines for land classification methodology for land use selection. Unfortunately, land classification as a basis for land use selection process has been done mainly through soilsurveys which farmers may not fully understand and which exclude the social and cultural aspects (*Buthelezi 2010*).

Weib (*2006*) claimed that farmers have profound knowledge on soils and their resources. Understanding the local knowledge of soils has come to be seen as essential in understanding the local realities of people especially farmers. Understanding farmers' knowledge on soil and land management strategies appeared to be of utmost interest for developing improved technologies for sustainable soil fertility management at local level. Local soil names and the knowledge that farmers possess for each soil are extremely useful though they have their limitations, especially if one tries to regionalize local names (*Tabor et al. 1990*). The use of indigenous knowledge (IK) on soil classification as basis for land use selection and land use planning would be ideal means of facilitating dialouge between farmers and scientists in any development projects. Scientists evaluate the land based on land quality that can influence a particular land use, while a local farmer assesses land by empirical testing over centuries of trial and error (*McRae and Burnham, 1981*).

Gowing et al. (*2004*), who did a study on integrating indigenous and scientific knowledge in classifying soil in

Uganda and Tanzania claimed that there is much to gain by combining elements of broad scale scientific survey with a localized assessment of indigenous knowledge. *Cools et al*. (*2003*) also concluded that to work more efficiently, it is very important to listen first to the farmers' needs and experiments before conducting detailed soil surveys in vast areas. In this way, both parties - farmers and scientists- will profit. Researchers learn from farmers and farmers receive answers on their questions.

The inhabitants of Imugan, Sta. Fe, Nueva Vizcaya are considered the largest community of the Ikalahan Reserve, thus, representing an indigenous people that have unique knowledge of their local environment and their utilization. The study site is one of the major sources of root crops like ginger (*Zingiber officinale*), camote (*Ipomea batatas*), taro (*Colocasia esculenta*) as well as sayote (*Sechium edule*) and soft broom handicraft in the province of Nueva Vizcaya. Areas for production are located within the Imugan watershed. Thus, farmers must protect the soils from erosion and maintain a maximum vegetative cover, since this is a major source of domestic water supply. The objectives of this study were to describe, determine, and classify soil using local/ farmers' knowledge and compare such with the scientific methods and standard of investigation of soil classification.

MATERIALS AND METHODS

The Ikalahan Ancestral Domain extends to two municipalities in the province of Nueva Vizcaya, the municipalities of Sta. Fe and Aritao. It includes nearly 15,000 ha of steep mountain lands between 600-1,700 masl. It is located at 16 degrees north latitude and 120 degrees east longitude in Northern Luzon, Philippines. Part of the ancestral land covers Mount Aklob, sometimes called Mount Imugan, which is 1,658 masl. The center of the study site is Barangay Imugan, Sta Fe, Nueva Vizcaya (**Figure 1**).

Research Methods

Methods used in this study are both descriptive and quantitative approches. Primary data for analysis of indigenous knowledge on soil classification was gathered using participatory rural appraisal techniques such as the focus group discussions and augmented through open-ended survey questions and key informant interview. The descriptive method is a purposive process of gathering, analyzing, and tabulating data about prevailing conditions practices, beliefs, processes, trends and then making adequate and accurate interpretation with or without the aid of statistical tools (*Tanguiling 2004*). The method is particularly useful for exploring people's knowledge and experiences and can be used to examine not only what people think but how they think and why they think that way (*Kitzinger 1995*). In addition, quantitative research was being used on the presentation of the results of the questionnaires answered by the respondents as well as the outcome of the laboratory analysis of soil samples using frequency and percentages.

Respondents of the Study

The respondents of this study are members of the Ikalahan tribe of Imugan, Sta. Fe who occupy the Ikalahan Ancestral domain and known to have practiced sustainable forest management and agriculture. The total number of population and households in the study area was based on the NCIP Census of population last December 2003 was 588 and 124 households.

Sample Size

The sample size was chosen from the representatives of 124 households whose main occupation is farming. The total number of farmer-respondents determined was 61 using the Slovins' Formula (*Paguso and Montana 1985*) as follows:

$$n = \frac{N}{1+Ne2}$$

Where: e = Margin of error (5%-10%, 9% was used)
n = Sample Size : 61 respondents
N = Population Size: 124

Profile of Respondents

The Ikalahans is one of the several tribes generally known as Igorots who settle in the upper, forested region of the Cordillera and Caraballo Mountains of Northern Philippines. They originated from the Proto-Benguet Tribe that lived in ancient times at the southern end of the Cordillera Mountains.

Women were the majority respondents in this study accounting to 77% (47) of the total while male accounts only to 23%. Majority of the respondents (61%) belonged to age bracket 51-60 years old and above. The youngest respondent is 35 years old and the oldest one is 90 years old. Forty-four percent (44%) of the respondents is high school level while 8% of the respondents had no formal education. Only a small percentage (11%) entered college.

The primary source of income in Imugan is farming. Almost all of the households have one or more members engaged in farming. The Ikalahan women claimed that they

Figure 1. Map of the Imuga, Sta. Fe, Nueva Vizcaya. Philippines.

were the one who are more engaged in farming than men. Men were only involved in the preparation of the land for planting and during harvesting.

RESULTS AND DISCUSSION

Farming System

Swidden farming remains the primary source of livelihood for the Ikalahan to date. The cropping pattern of the farmers is based on the prevalent weather of the study site, heavy and low rainfall seasons. Out of 61 respondents, 59% of farmers practiced crop rotation. According to Ikalahan farmers of Imugan, the schedule of rotation of their crops depends on the crops that condition easily with the soil types they identified, the season or planting schedule of crops, and the prevailing price of these crops in the market. Usually, the crops that the farmers plant during the rainy seasons were several varieties of camote or sweet potato. After the harvest of camote, comes the dry season, the time to plant of vegetables and legumes such as beans, corn, squash and peanuts.

Another farming system that the farmers adapted in the Domain is the multiple cropping or intercropping of which 65% of the 61 respondents claimed was applied in their farms. Farmers aimed to increase productivity while providing protection to the soil from erosion. This practice involves sequential cropping, the growing of two or more crops a year in sequence; or intercropping, the growing of two or more crops in the same piece of land. For farmers of Imugan, they practice intercropping of root crops, vegetables and legumes to address their household needs. In addition, this is also to maximize the use of their land and a strategy to reduce the attack of crops by pest and diseases. Intercropping system could be found either in their uma or home gardens. In flat areas or home gardens, or along gorges of riverbanks, the usual crops used for intercropping/multiple cropping were rice (*Oryza sativa*), corn (*Zea mais*), and vegetables like squash (Cucurbita maxima), okra (*Abelmoschus esculentus*), beans (*Phaseolus vulgaris*), peanut (*Arachis hypogaea*), cucumber (*Cucumis sativus*), tomato (*Solanum lycopersicum*), eggplant (*Solanum melongena*), and cow pea (*Vigna unguiculata*). In high hilly lands, crops used for the said pattern are mostly root crops such as camote (*Ipomea batatas*), ginger (*Zingiber officinale*), and taro (*Colocasia esculenta*). An additional cropping is single cropping for sayote (*Sechium edulea*), rice (*Oryza sativa*) and tiger grass (*Thysanolaena maxima*). Sayote (*Sechium edulea*) is usually found along the walls of hills, gullies, and some marginal lands of the area. This crop was raised throughout the year making it a dependable source of cash year round. Majority of the fields for rice (*Oryza sativa*) are solely for rice production only and planted thrice in a year. Lastly, tiger grass (*Thysanolaena maxima*) which was used as raw material for soft brooms and at the same time to control soil erosion was planted throughout the year along the exposed hillsides, forest margins, and side slopes. Panicles usually develop from October to March. The best time therefore to harvest the panicles is during the months of February and March.

Indigenous Knowledge and Scientific Knowledge on Soil Classification

Indigenous knowledge of Ikalahan farmers on soil characteristics/properties. Only the physical characteristics of the soil were evaluated and based mainly on the sense of vision, and touch. Based on the group discussion and interview with individual farmers of Imugan, for vision, the criteria were colors, depth of the soil, water retention or drainage, and porosity of the soil. In terms of touch, the main indicator was texture as indicated by the soil's loaminess, stickiness and sandiness. Soil acidity was another criterion but since they cannot use taste to test acidity, they merely used its plant indicator which is the presence of cogon (*Imperata cylindica*). Among the eight soil characteristics (acidity, color, texture, structure, consistency, drainage, depth, and porosity), six characteristics were assessed by farmers in the same manner as that of the scientists (**Table 1**). The difference lies in that soil scientists evaluate not only the physical characteristics of the soil, but also its physical and chemical characteristics. Physical characterization was just the first stage that a soil scientist evaluates but further assessment was made using laboratory facilities for more conclusive results.

Indigenous soil fertility classification of Ikalahan farmers. Imugan farmers' classification of soil can be understood in how they regarded land units which represent soil types. Classification was reflected in the term used. Soil was known locally as "pitak". Soil was generally classified into three groups using fertility as the basis: soils that are fertile (Magabay), moderately fertile or not so fertile (Uplit) and not fertile at all (Pitak ni Nabatuan). Fertility of soil determines the suitability of the crop of the land.

The basis for fertility classification was color. The very fertile soil is black (*natuling*). For moderately fertile soil type, the colors could be categorized as pure red (*ambalanga uplit*), yellow (*ngemmila*) and white (*amputi*). For those with low fertility, Ikalahan farmers use texture as distinguishing criterion. Soil with low fertility can have sandy content, stony or fine sand (*buad*).

Farmer's Key Criteria on Soil Classification

Soil Color. Most farmers used soil color to differentiate soil fertility through vision. Farmers in the study area concluded that the darker the soil, the more fertile it is. At least 95% (58) of the farmer-respondents claimed this was their main distinguishing factor in soil classification.

Soil Texture. Farmers evaluate soil texture through touch and sight. Soil can be fine or coarse or with presence of stones or pebbles. Farmers also associate soil texture with the capacity of the soil to hold water that was available for plants for some time and the easy penetration of roots through the soil. Based on the result of the survey, 92% (56) of the farmer-respondents stated that texture was the next main distinguishing factor in local soil classification.

Soil Consistency. At least 74% (45) of farmers in the study site claimed that soil consistency had much more influence on the soil's workability. Workability depends mostly on the hardness and dryness of the soils. It was acknowledged by farmers as a limiting attribute.

Soil Drainage. Based on the survey conducted 82% (50) of the farmers in the study site considered soil drainage as a good attribute of all the soil types identified since the study

Table 1. Indigenous knowledge of evaluating soil characteristics/properties by Imugan farmers.

Means of Measurements			
Soil Characteristics	Farmers/Number of farmers in percent n=61	Soil Scientist	Remarks
Acidity (Ph)	taste and plant Indicator (95%)	chemical reagent, pH meter, pH paper	Distinct/different
	by sight (100%)		
Color	by sight and touch	Munsell Color Chart Book	Distinct/different
Texture	(85%)	touch	no distinction/difference
Structure	by sight (93%) and touch (100%)	by sight and touch	no distinction/difference
Consistency	Touch (91%)	touch	no distinction/difference
Drainage	by sight (100%)	by sight	no distinction/difference
Depth and Effective Depth	by sight (100%)	by sight	no distinction/difference
Porosity	by sight (88%)	by sight	no distinction/difference

site has a high relief. Thus, well drained soil is desirable.

Available Water Holding Capacity. At least 90 % (55) of the farmers in the study area considered water retention as a limiting attribute for soil that was dominated with large pores. Slope. The result of the survey revealed that 90% (55) of farmer-respondents in the study site, slope was considered as one of the limiting criteria due to the fact that the topography of the domain is mountainous and with a rugged terrain. To prevent the erosion of soil in the steep areas, farmers planted tiger grass (*Thysanolaena maxima*) and employed other soil conservation strategies such as fallow period, crop rotation and intercropping (**Table 2**).

Description of Indigenous Soil Classification

Very fertile soil (*Magabay*):

Black soil (*Natuling*). The black soil (*natuling*) was found inside the forested areas with some spots on the lower or plain of the Imugan domain. It was identified as moderately fine in terms of texture. It was classified by farmers as the most fertile (*magabay*). Fertility was based on the experience of farmers where they found that crop survival was insured with this soil. This means that all types of temporary crops such as sweet potato ginger, taro, sayote, beans, tiger grass and permanent crops like guava, dagwey, lime and lemon can grow on it and the land produces higher yields compared with the other identified soils. Indicators of fertility of the soil were the robust appearance of crops and the immediate occurrence of weeds and grasses after tilling the land. Farmers believed that the darker the soil the more productive it is.

According to 81% to the respondents, this black soil has slight stickiness when wet when compared to red ones; thus, black soil imposed no constraint in plowing. Stickiness is the capacity of the soil to adhere to other objects. Black soil has good water holding capacity; that means crops survive even without frequent watering and no sign of wilting even without heavy rains. It is well drained since farmers have not experienced any flooding condition in their fields. Farmers also observed that this soil has no restriction on root growth. The degree of erosion was slight or moderate when compared to sandy soil. Hence, farmers considered this type of soil to pose no limitations in terms of farming operation. Based on the survey, 69% (42) of the farmers observed black soil in their farm.

Table 2. Criteria used by farmers in classifying soils.

Variable	Number of Farmers n= 61	Percent of Total
Color	58	95
Texture	56	92
Consistency	45	75
Drainage	50	82
Water Holding Capacity	55	90
Slope	55	90

Moderately Fertile Soil (*Uplit*):

Red Soil (*Ambalanga*). About 83% (53) of the farmers observed red soil in their farm. The red soil or locally known as *ambalanga* was categorized by the Ikalahan farmers as "less or not so fertile" (*Uplit*). Red soil can be found in the hill sides and scattered on the steep slopes of the Domain. It was observed to have fine texture. This soil is sticky and slippery when wet. In terms of its workability, farmers could only plough their red-soil fields easily after a light rain. This is one of the limiting attributes in non-mechanized or human labor-dependent farming operations. Farmers also observed that roots of the plants could hardly penetrate the soil due to its hardness when dry. However, farmers claimed that this kind of soil has good water retention capacity but cannot produce high yields for root crops, vegetables and legumes unless supplemented by fertilizers. It is not that well drained and its degree of erosion is slight.

Yellow soil (*Ngemilla*). Yellow soil was considered a less fertile soil (Uplit). It is locally known as *ngemilla*. This could be found at the lower slopes and in some spots at the hilly sides. It was identified as medium in texture. Compared to red soil, it has slighter stickiness and was moderate hardness when dry. It has good water retention and good drainage. The degree of erosion was considered slight. However, just like the red soil, it has to be supplemented with fertilizer/manure application before for planting. Furthermore, farmers mentioned in the key interview that the usual inorganic fertilizer they applied in yellow soil is the complete fertilizer which is the triple 14, consisting of commercially manufactured mineral nutrients.

Farmers had indications in determining the elements needed by the plants. Example of this is the nitrogen. They observed that plants need nitrogen when its leaves are light green or pale green. Another one is the lack of phosphorous. They observed the discoloration of leaves into reddish and then yellow. They used phosphorous element for the plants to become robust and potassium to bear more fruits. Aside from perennial/permanent crops, at least 34% (21) of the farmer-respondents indicated that they were tilling yellow soils.

White Soil (*Amputi*). Out of 61 farmers, 25% (15) cultivated white soil. White soil is locally known as amputi, another kind of less fertile soil. This soil maybe found more in the steep slopes of the Domain (from the top of hills to low lying areas). It has medium texture and with the same stickiness and hardness as yellow soil. However, this is less erodible than sandy soil. It is well drained also but easily waterlogged after a series of heavy rains. It requires higher management inputs similar to yellow soil to overcome constraint in planting. Some root crops were being planted in this soil and all permanent crops such as citrus species and degwey (*Phyllanthus acidus*) as means to control soil erosion.

Soil of low fertility (sandy, soil with stones and rocky)

Sandy soil (*Buad*). Sandy soil is generally regarded by the *Ikalahan* farmers as soil with lowest fertility. Under sandy soil, there were three categories: the *buad* (sandy), *behil* (soil with stones), and *gallubah* (rocky). *Buad* soil is found near rivers and streams and other spots of the domain. It was known as not fertile. For behil and gallubah these were found mostly near the streams and rivers. These soils were considered as coarse in texture, thus, not sticky, with poor water retention capacity and fertility status. It was generally erodible. Bench terracing using stones (tuping) and hardened soil (balibal) for riprap was usually employed as a strategy to prevent erosion. Vegetable can be grown in buad soil but with the application of manure. These crops were usually the shallow rooted ones, such as camote, squash, peanuts and corn. Based on the focus group discussion, farmers were aware of the characteristics of these kinds of soils. A total of 61 farmer-respondent, 18% (11) have this type of soil for crop production.

The Ikalahan farmers system of soil classification and corresponding management practices serves as a guide to Ikalahan farmers in terms of soil classification and management (**Table 3**).

Scientific knowledge of soil classification

Scientific soil classification through soil profiling was conducted in order to classify soil systematically. Soil samples were collected from surface and subsurface horizons of each soil profile. There were 23 soil samples all in all and these were brought to the Bureau of Soil and Water Management (BSWM) for complete soil analysis. The result of the analysis was the basis in classifying soil types.

Soil profiles and description

Black Soil. The representative pedon of black soil NV-2013-01P was taken from the slope that falls under the category of 30-50 percent considered as steep areas. Soil in this area was well drained and with no flood hazard. No water table was encountered.

The upper part of the soil exhibited black color, with weak granular structure and mollic epipedon type, meaning that kind of surface horizon of mineral soil that was dark colored. The sub horizons met the characteristics of cambic epipedon, therefore it belongs to the soil order Mollisols (**Figure 1**). In terms soil fertility, it was considered of adequate fertility status (**Tables 4** and **5**).

White Soil. This was represented by pedon NV-2013-02P taken from the slope that falls under is 30-50 % which was considered as steep slope. Run off occur in the site and soil erosion was common. Water table was not encountered. The upper part of the soil exhibited grayish color, dominated by iron oxide, and blocky in structure. It was an ochric epipedon. The sub horizons belong to cambic horizon of the soil order Inceptisol (**Figure 2**). Fertility status of this soil was low (**Table 6** and **7**).

Yellow Soil. This is represented by pedon NV-2013-03P taken from the slope that falls under is 30-50 % which is considered as steep slope. It was well drained and water table was not encountered. The upper component of the soil exhibited chocolate brown color and spheroidal structure. This structure is usually seen in the upper horizon of fine-medium textured soils and it resembles a granular structure. It is an ochric epipedon. The succeeding horizons belong to cambic horizon of the soil order Inceptisol (**Figure 3**). The soil has low nutrient reserved (**Tables 8** and **9**).

Red Soil. This was characterized by pedon NV-2013-04P, taken from the slope that falls under 30-50 % which is considered as steep slope. Soil drainage is good. The upper surface of the soil displayed brown red color, with blocky sub-angular structure. It is an ochric epipedon. It is an argillic sub surface horizons, thus, follow the soil order Ultisol (**Figure 4**). The soil fertility status is low (**Tables 10** and **11**).

Sandy Soil. This was represented by pedon NV-2013-05P taken from the slope that falls under is 30-50 % which is considered as steep slope. The upper surface of this soil exhibited brown color, with granular structure and it is a ochric epipedon. The whole sub horizons are classified as ochric, belonging to the soil order Inceptisol (**Figure 5**). The soil has very low nutrient reserved (**Tables 12** and **13**).

Comparison of Indigenous Knowledge of Ikalahan Farmers and Scientific Knowledge on Soil Classification

Ikalahan farmers' indigenous knowledge on soil classification and attributes run parallel with scientific findings on soil analysis of various types of soil in Imugan. While these farmers used color and texture as the primary criteria in soil classification, their ability to recognize soil types and their attributes reflect the sophistication of their knowledge, borne out of experience and long interaction

Table 3. Indigenous soil classification system and management of farmers in Imugan, Sta Fe, Nueva Vizcaya.

Criteria	**Types of Soil (Pitak)**						
Fertility Status	**Fertile (*Magabay*)**	**Less Fertile (*Uplit*)**			**Not Fertile (*Pitak ni Nabatuan*)**		
Local Soil Type	*Natuling* (Black)	*Ambalanga* (Red)	*Ngemilla* (Yellow)	*Amputi* (White)	*Buad* (Sandy)	*Behil* (Soil with stones)	*Galluhba* (Rock)
Color	black	red	yellow	white	brown-gray	gray	gray
Texture	moderately fine	fine	moderately coarse	moderately coarse	coarse	coarse	coarse
Consistency	slightly sticky	very sticky	sticky	sticky	loose	loose	loose
Drainage	good	good	good	good	good	good	good
Water Holding Capacity	good	good	good	good but sometimes waterlogged	dries up quickly	dries up more quickly drained	dries up more quickly drained
Degree of Erosion	slight	slight	moderate	moderate-high	drained high	high	high
Land Use Management Practices	Fallow, day-og, crop rotation, intercropping	Fallow, day-og, crop rotation, intercropping	Fallow, day-og, crop rotation, intercropping	Fallow, day-og, crop rotation, intercropping	Intercropping, crop rotation	Tuping Hakdel balibal	Tuping balibal

Note: *Gen-gen* is a hedgerow using the vines of sweet potato after their last harvest. It is used for erosion control and decompost for organic fertilizer.
Hakdel is term for hedgerow using kakawate branches, tiger grass and other local shrubs.

Table 4. Particle size classes, pH, CEC and base saturation of black soil.

Horizon	**Depth**	**Particle Size Classes**			**pH**	**CEC Sum**	**Base Saturation % Sum**
		Sand	**Silt**	**Clay**			
A	0-28	39.6	32.8	27.6	6.7	61.2	86.95
B1	28-61	39.8	28.6	31.6	7.1	65.03	90.61
B2	61-100	33.8	38.6	27.6	6.9	59.15	88.74
$B_{sesqui\text{-}oxide}$	100	31.8	40.6	27.6	7.0	55.13	88.14

Black Soil

Horizon	**Depth (cm)**	**Description**
A_{hp} A_{humus} Aplowing	0-28	Brown, clay loam, weak granular structure, sticky, plastic and friable, horizon boundary abrupt, presence of pores, fine to medium roots.
B_1	28-61	Yellowish brown, weak granular structure, sticky, plastic and friable, clay loam, presence of pores, diffuse horizon boundary, fine to medium roots
B_2	61-100	Brown, sub-granular blocky structure, sticky, plastic, and friable, clay loam, presence of pores, diffuse horizon boundary, few fine roots
$B_{sesqui\text{-}oxide}$	100	Reddish brown, sub-angular blocky structure, sticky, plastic, and friable, clay loam, presence of pores, few fine roots

Figure 1. Profile Description of Black Soil.

White Soil

Horizon	**Depth (cm)**	**Description**
A	0-40	Grayish, dominated of ion oxide, blocky structure, slightly sticky, slightly plastic, and friable, silty clay, diffuse horizon boundary, fine to medium roots.
B_1	40-86	White soil is mixed with real soil component, blocky structure, slightly sticky, slightly plastic, silty clay loam, diffuse horizon boundary, fine to medium roots
B_t	86	White-gray in color, Argillic or illuvial horizon of accumulation of clay, blocky structure, sticky, plastic, clay loam , diffuse horizon boundary, a presence of fine roots

Figure 2. Profile Description of White Soil. Soil Order Inceptisol.

Table 5. Organic carbon, organic matter and exchangeable bases data of black soil.

Horizon	Depth (cm)	Organic Carbon	Organic Matter	Exchangeable Bases (Milliequivalents/100gSoil)			
				Ca	Mg	Na	K
A	0-28	1.57	2.70	44.9	6.7	1.2	0.4
B1	28-61	0.55	0.95	50.0	6.96	1.71	0.26
B2	61-100	1.26	2.17	44.5	6.17	1.61	0.21
$B_{sesqui-oxide}$	100	1.14	1.96	42.8	5.61	1.60	0.18

Table 6. Particle size classes, pH, CEC and base saturation of white soil.

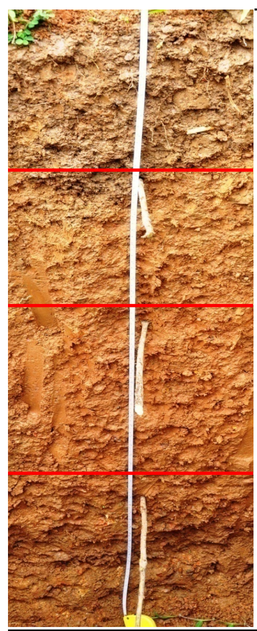
Horizon	Depth	Particle Size Classes			pH	CEC Sum	Base Saturation % Sum
		Sand	Silt	Clay			
A	0-40	13.6	40.8	45.6	5.5	40.8	65.68
B_1	40-86	19.8	42.6	37.7	5.2	59.13	72.60
B_t	86	29.8	38.6	31.6	5.7	54.28	75.87

Table 7. Organic carbon, organic matter and exchangeable bases data of white soil.

Horizon	Depth (cm)	Organic Carbon	Organic Matter	Exchangeable Bases (Milliequivalents/100gSoil)			
				Ca	Mg	Na	K
A_{hp}	0-15	0.54	0.93	22.6	2.7	1.4	0.1
B_t	15-82	0.60	1.03	37.0	3.37	2.44	0.12
B_{ts2}							
B_2	82	0.34	0.58	35.9	2.50	2.66	0.12

Yellow Soil	Horizon	Depth (cm)	Description
	A_{hp}	0-15	Chocolate brown, spheroidal structure, slightly sticky, slightly plastic and friable, loam, diffuse horizon boundary, presence of pores, fine to medium roots
	B_w	15-82	Yellowish, argillic/illuvial horizon of clay accumulation,
	B_{w2}		Accumulation of oxides of Al and Fe (sesquioxide), spheroidal structure, non sticky, non plastic, and friable, sandy loam, diffuse horizon boundary, presence of pores, fine to medium roots
	B2	82	Brown, blocky in structure, slightly sticky, slightly plastic, and friable, sandy clay loam, diffuse horizon boundary, presence of pores, few fine roots

Figure 3. Profile Description of Yellow Soil.



Red Soil	Horizon	Depth (cm)	Description
	A	0-22	Brown red, blocky angular structure, sticky, plastic and firm, clay loam, diffuse horizon boundary, fine to medium roots
	B_{t1}	22-46	Yellowish red, argillic/illuvial clay, sub angular blocky structure, sticky, plastic, firm, clay, diffuse horizon boundary, fine roots
	B_{t2}	46-86	Reddish brown, sub angular blocky structure, sticky, plastic, firm, clay, diffuse horizon boundary, few very fine roots
	B_{cs}	86	Brown to reddish brown due to cementation of sesqui-oxide (spodic), sub-angular block structure, sticky, plastic, firm, clay, diffuse horizon boundary, few very fine roots

Figure 4. Profile Description of Red Soil. Soil Order Ultisol.

with their environment (*Machara and Ng'ang'a, 2005*). Soil color was associated with soil fertility or productivity capacity while texture relates with the soil's coarseness/fineness, water holding capacity and workability. This confirms the statement of *Silitoe* (*1998*) who claimed that these criteria are the most common all local soil classification systems.

Black soil was recognized by Ikalahan farmers as the most fertile soil. They claimed that it can grow practically all crops with good growth and yield performance. Thus, this was the type of soil where they grow their staple crops (camote, taro and rice) and commercial crops (ginger, sayote, beans, and other vegetables). Farmers' decision making in choosing crops to be planted was influenced by

Table 8. Particle size classes, pH, CEC and base saturation of yellow soil.

Horizon	Depth	Particle Size Classes			pH	CEC Sum	Base Saturation % Sum
		Sand	Silt	Clay			
A	0-15	45.6	28.8	25.6	5.6	37.5	62.66
B_1	15-82	67.8	12.6	19.6	4.3	32.14	38.40
$B_{t\,s2}$							
B_2	82	47.8	24.6	27.6	4.1	29.6	28.04

Table 9. Organic carbon, organic matter and exchangeable bases data of yellow soil.

Horizon	Depth (cm)	Organic Carbon	Organic Matter	Exchangeable Bases (Milliequivalents/100gSoil)			
				Ca	Mg	Na	K
A	0-15	2.28	3.92	16.3	4.0	0.4	2.8
B_1	15-82	0.40	0.69	10.0	1.84	0.18	0.32
$B_{t\,s2}$							
B_2	82	0.32	0.55	6.62	1.33	0.17	0.18

Table 10. Particle size classes, pH, CEC and base saturation of red Soil.

Horizon	Depth	Particle Size Classes			pH	CEC Sum	Base Saturation % Sum
		Sand	Silt	Clay			
A	0-22	9.6	34.8	55.6	5.3	9.8	97.95
B_{t1}	22-46	7.8	26.6	65.6	5.0	19.4	12.37
B_{t2}	46-86	11.8	22.6	65.6	4.8	21.5	11.16
B_{cs}	86	23.8	20.6	55.6	5.0	19.99	9.95

Table 11. Organic carbon, organic matter and exchangeable bases of red soil.

Horizon	Depth (cm)	Organic Carbon	Organic Matter	Exchangeable Bases (Milliequivalents/100gSoil)			
				Ca	Mg	Na	K
A	0-22	1.48	2.55	7.4	1.8	0.2	0.2
B_{t1}	22-46	0.75	1.29	1.86	0.37	0.12	0.05
B_{t2}	46-86	0.60	1.03	1.85	0.37	0.11	0.07
B_{cs}	86	0.49	0.84	1.37	0.46	0.16	0.06

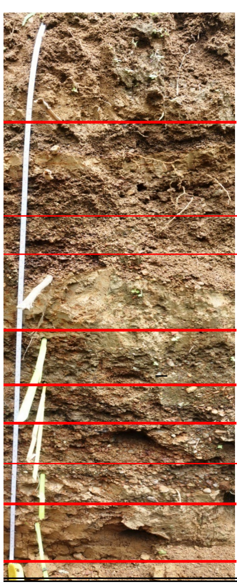
Sandy Soil	Horizon	Depth (cm)	Description
	A	0-19	Brown, granular structure, non sticky, non plastic, friable to loose, sandy clay loam, presence of pores, diffuse horizon boundary, fine to medium roots
	B1	19-23	Dark Brown, granular structure, non sticky, non plastic, sandy loam, gradual horizon boundary presence of pores, fine to medium roots
	B2	23-28	Same with horizon A, except that it has clear horizon boundary
	B3	28-43	Same with sub horizon B, except that it has diffuse horizon boundary
	B4	44-45	Same with horizon A, except that it has gradual horizon boundary
	B5	55-64	Same with horizon B1
	B6	64-67	Same with horizon A, except that it has clear horizon boundary
	B7	67-84	Same with horizon B1
	B8	87-97	Same with horizon A
	B9	97	Same with horizon A

Figure 5. Profile Description of Sandy Soil. Soil Order Inceptisol.

their objectives, focused on household demands like food supply, additional income for basic needs like clothing, and providing for the welfare of number of dependents in the household, like education for the young and maintenance for the elderly. They have a very clear idea of their needs and of their current and future situations (*Namriah 2001*).

Soil analysis conducted by BSWM confirmed that black soil is the most fertile, with high organic matter content, exchangeable bases as well as good texture, good workability and soil depth effectivity. All these indicate that the crop choice or land use of Ikalahan farmers wassuitable on this soil type. The findings affirmed the earlier observations of *Ollier et al.* (*1971*) and *Sandor and Furbee* (*1996*) who found that indigenous farmers often single out one type of soil as being superior in productivity. The rest of the soil types (red, white, yellow and sandy) were considered substandard to black soil in terms of fertility.

Table 12. Particle size classes, pH, CEC and base saturation of the sandy soil.

Horizon	Depth	Particle Size Classes			pH	CEC Sum	Base Saturation % Sum
		Sand	Silt	Clay			
A	0-19	57.6	20.8	21.6	5.9	51.9	78.03-
B1	19-23	77.8	4.6	17.6	6.9	50.84	87.49
B2	23-28	53.8	30.6	15.6	6.0	59.73	80.24
B3	28-43	81.8	2.6	15.6	7.0	40.26	84.50
B4	44-45	41.8	40.6	17.6	6.7	54.97	86.00
B5	55-64	73.8	8.6	17.6	7.0	46.23	86.37
B6	64-67	81.8	2.6	15.6	7.0	45.43	86.00
B7	67-84	77.8	4.6	17.6	6.9	44.29	85.8
B8	87-97	31.8	42.6	25.6	6.0	57.71	79.83
B9	97	41.8	38.6	19.6	5.6	57.69	75.56

Table 13. Organic carbon, organic matter and exchangeable bases data of sandy soil.

Horizon	Depth (cm)	Organic Carbon	Organic Matter	Exchangeable Bases (Milliequivalents/100gSoil)			
				Ca	Mg	Na	K
A	0-19	0.87	1.50	35.0	4.4	0.6	0.5
B1	19-23	0.38	0.65	39.1	4.26	0.90	0.22
B2	23-28	0.36	0.62	41.7	4.89	1.17	0.17
B3	28-43	0.22	0.38	29.8	3.32	0.78	0.12
B4	44-45	0.47	0.81	41.2	4.87	1.04	0.16
B5	55-64	0.28	0.48	34.8	4.10	0.88	0.15
B6	64-67	0.17	0.29	33.8	4.14	0.94	0.19
B7	67-84	0.27	0.46	33.3	3.7	0.79	0.20
B8	87-97	0.72	1.24	39.10	5.38	1.21	0.12
B9	97	0.61	1.05	38.1	4.26	1.11	0.12

For red, yellow, and white soils, their fertility status were low and have acidic pH as indicated by the soil analysis conducted by BSWM. This analysis coincides with the observation of farmers that these soil types were not so fertile compared to the black one. Although these soil types were recognized by farmers as "less or not so fertile" and limit farming, they still utilized these soil type in growing root crops, vegetables and legumes aside from permanent crops. Household demands warranted the use of soil type. To improve chances of high yield, aside from indigenous management practices, Imugan farmers use complete inorganic fertilizer to overcome soil limitations.

Moreover fertility status of sandy soil was very low yet with moderately acidic to nearly neutral pH. This scientific analysis information for this soil type was the same with the perception of farmers. But again, farmers continuously make use of this soil for planting shallow rooted plants such as camote, squash, peanuts, and corn. *Mafalacusser* (*1995*) stated that each soil has a specific function, and the vegetation whether planted or natural, is modified in order to serve man's purposes.Flexibility is one of the strategies of farmers' survival. Farmers adjust applying inorganic fertilizer and adapting crops that offer the best short returns. Crop production is modified through diversification such as mixed intercropping and rotation cropping (*Malafacusser 1995*).

Apart from the two major criteria used by farmers, they also recognized the good and limiting attributes of soil which are water holding capacity, drainage, workability, proneness to erosion, and slope which are related to the location of soil. Their classification was dominated by topsoil properties and the diagnostic criteria/parameters were based mainly on the physical attributes of the soil. The scientific findings on the soil profile and order affirm the farmers' indigenous knowledge, all of which have clear importance in farming operations. Such classifications are a reflection of an integrated knowledge of the potentialities and limitations that the environment imposes on production Cervantes-Gutierrez, Gama-Castro and Hernandez-*Cardenas* (*2005*). Furthermore, these visible and practical criteria, are important elements on the management of the soil in the course of crop production (*Machara and Ng'ang'a, 2005*). Specifically, these will guide farmers as to what types of crops to plant and forecast the expected yield of crops being planted to avoid risks and attain success.

While it is true that the system of soil classification for Ikalahan farmers is well accepted within their Domain, the exchange of information among themselves can still be improved. Soil classification was based on the tangible changes in soil, which can be grasped only when substantial reductions on yield and growth performance are observed.

In managing land use, farmers possess the important clues for the most limiting aspects to land management (*Machara and Ng'ang'a, 2005*), so they also equip themselves with certain strategy to adopt to the situation and find solution to those limitations based on the available resources within their Domain. According to (*Matechera 2008*), small scale farmers effectively utilize their indigenous knowledge and available resources for soil fertility management and sustained crop yield. Although IK soil classification run parallel with scientific findings on soil analysis, farmers' practical approaches tend to miss out detecting minor changes of soils that is not readily visible by them, i.e., are the exact pH status of the soils and amount of macro and micro nutrients present in soils. While sophisticated indigenous knowledge on soil and land use was found, there is still room for improvement in decision making.

This is where scientific knowledge becomes crucial. Scientific knowledge allows early detection of minor changes occurring in soil not readily observable to farmers. Soil chemical analyses have important implications for soil fertility and availability of nutrients (*Winowiecki 2014*). Soil analysis provides a better understanding of what and how much to allocate for fertilizer inputs to crops (*Lapoot et al. 2010*).

The cost of scientific analysis is however too high for subsistence based Ikalahan farmers. Scientific soil classification lies on classifying soils based on their genesis using soil properties as diagnostic features. It is both concerned with the morphological description of each soil sampling point and its complete physical and chemical analysis. Results of these descriptions form the basis of classifying surface and sub surface horizons and indetermining the taxonomy of the soils under survey. However, as (*Krasilnikov et al. 2010*) claims that the actual situation in soil classification is discouraging, mainly due to the diversity of national soil classifications, extreme complexity of developed soil taxonomies, costly and time-consuming diagnostics, and ambiguous, complex and confusing terminology. It should be noted that this information was often useless for practical users, because soil features are important for agriculture, such as nutrients availability and hydro physical characteristics, were usually variable and taxa-independent (*Krasilnikov et al. 2010*).

To sum up, scientific soil classification develops methods and standards by a systematic, clear and sectional approach, while indigenous/local knowledge approach was consequent of the daily experience sharpened through time. There is a way to harmonize the two knowledge systems if complementation is pursued instead of holding up uncompromising positions. Thus, cooperation between farmers and scientists is needed to ensure that success in farming is attained and sustained through many years.

Both scientists and farmers can learn from each other. Scientifically delineated units based on important diagnostic horizons could be compared to units perceived by farmers who are often more concerned with slight variations in surface soil that have a tangible impact on productivity (*Niemeijer 1995*). This is supported by the statement of *Hebarurema and Steneir* (*1996*) who believe that efforts to improve linkages between researchers, extension staff and farmers will only be successful if researchers and extensionists use a simple (local or regional) language that is understood both by farmers and extension field staff. A participatory approach, therefore, would facilitate the exchange of empirical farmer knowledge and theoretical surveyor knowledge that in the long run would enhances rural development projects (*Ryder 2003*). The indigenous knowledge and scientific knowledge in classifying soil types are compared in different criteria (**Table 14**).

Table 14. Criteria for scientific soil classification and local soil classification.

Criteria for scientific soil classification	Criteria for local soil classification
1. Conduct of soil profiling	Color
- Marking of surface horizon and depth	Texture
- Marking of sub-surface horizon and depth	Consistency
- Collection of soil samples per horizon	Drainage
2. Physical analysis per soil horizon	Water Holding Capacity
- Texture, structure, consistency and presence of pores	Slope
3. Chemical Analysis per soil horizon	
- % particle size classes (sand, silt and clay)	
- pH	
- Cation Exchange Capacity (CEC)	
- % Base Saturation	
- Organic Carbon Content	
- Organic Matter	
- Exchangeable Bases	

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Imugan farmers hold profound knowledge on soil evaluation and classification as revealed by their capability to categorize soil types based on visible and practical criteria. With these criteria, there is a lack of accuracy in identifying the exact amount of pH, nutrients and minerals needed by their crops. Nevertheless, they tend to overcome this by improving soil condition through their indigenous soil management practices that leads in sustaining their agricultural productivity and ensuring food sufficiency. On the other hand, scientific soil classification' plays a vital role in examining pH, determining nutrient content and mineral structural studies, all important in addressing changes in soil properties and attaining success in crop production.

The two systems on soil classification may have differences, but putting them together in the framework of soil classification – knowledge that tested through time combined with knowledge that came from scientific methods will benefit Imugan farmers in terms of providing them detailed information about nutrient deficiency and attributes of each soil type range of crops suitable for each soil based on farmers ' preference and appropriate inputs in raising crops that are less or not suitable to a given soil present in their farms.

In addition, understanding and incorporating indigenous knowledge on farming and management practices on soil classification will ensure proper land use and resource management in rural areas. Moreover, it could also enrich awareness on indigenous knowledge of the country as well as in designing policies, planning and strategies on land management in the Ikalahan Ancestral Domain, Imugan, Sta Fe, Nueva, Vizcaya in particular and in the region as the locale of indigenous people of Luzon.

To improve Ikalahan Ancestral Domain farm productivity, the following are recommendations based on the results of the study: information on growth requirements of different upland crops varieties, including tree species, should be readily available in all the municipal offices of the province and distributed to the farmers in popular form. The Office of the Municipal Agriculture should provide trainings on soil and its management to augment the capacity of farmers in distinguishing soil types, fertility and its management.

The following are recommended for further studies: an in depth study of the process of combining indigenous knowledge with scientific knowledge not only in the context of soil but also in the land use and management, and in depth study of local soil limitations such as moisture content, soil fertility, water holding capacity, oxygen availability, erosion hazard and soil salinity and additional study on the soil classification of the whole ancestral domain to come up indigenous soil classification framework.

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