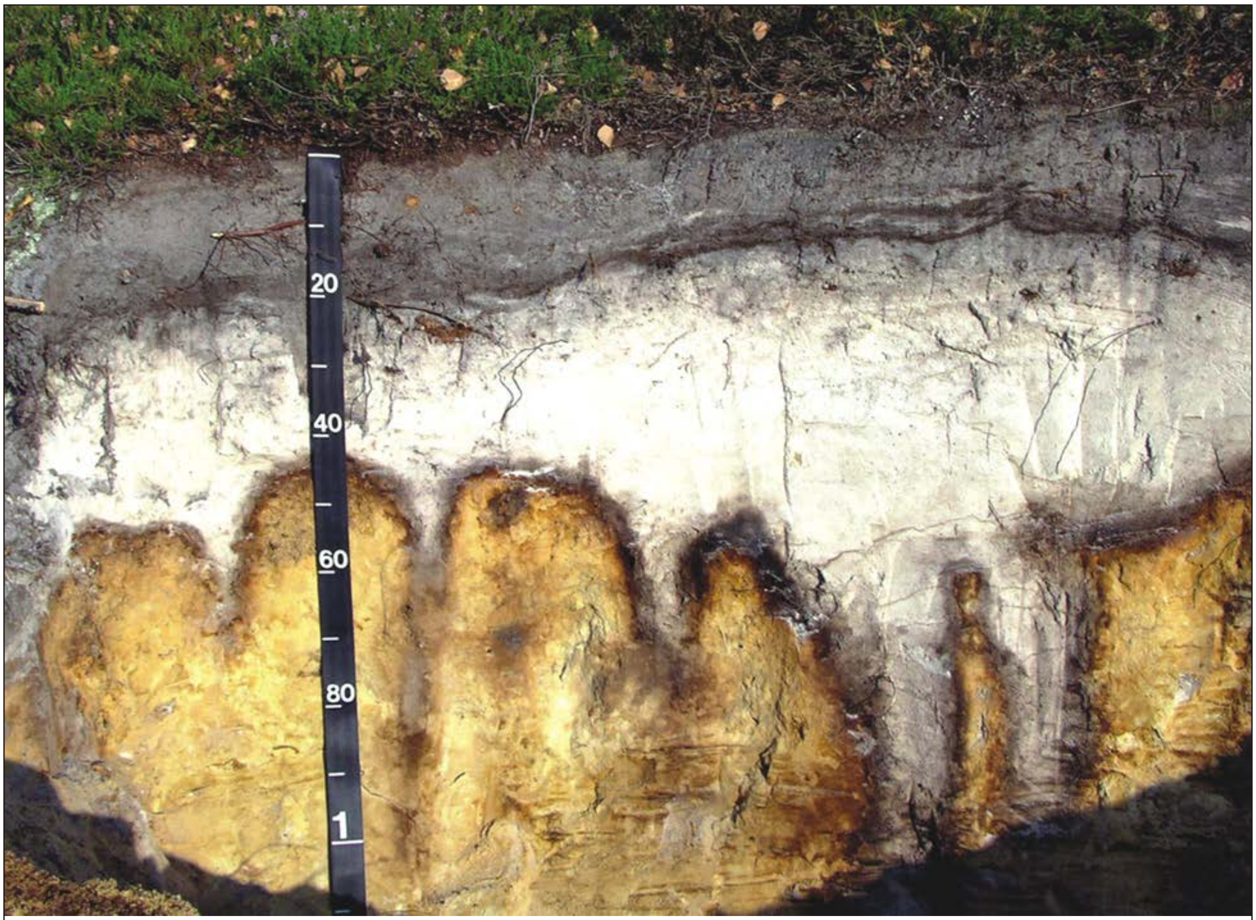

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Exploring Folk Knowledge of Soil

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Abstract: Understanding folk knowledge of soil offers broader insight to help design more appropriate participatory agricultural research programs and facilitate better communication with farmers. To address this issue, semi-structured interviews were conducted with 90 farmers (age > 20 years) from three villages in Bengkulu Province, Sumatra, Indonesia. The objective of this study was to explore the folk knowledge toward soil classification, soil fertility, soil degradation and soil management. Farmers used 11 criteria to classify the soils. They described nine soil classes based on color and texture. Common colors for fertile soils are black, brown and mixed brown-black, but infertile soils are red and red-yellow. To better manage the soils, farmers recognized the importance of manures, crop residues and compost as soil amendments and legumes in cropping systems. Two-year fallow was commonly applied by farmers to restore soil fertility after five years of cultivation. This study suggests that there is a need to maximize the benefits of local knowledge of soil by combining it with scientific knowledge to enhance rural development projects, help precision farming and better manage natural resources.

Key words: Farmer, folk knowledge, Indonesia, soil fertility, soil management

INTRODUCTION

Folk knowledge refers to local people's knowledge or indigenous knowledge (Bellon and Taylor, 1993). Folk knowledge related to soil is important for agriculture sustainability and environmental protection, especially in developing countries where most farmers have limited access to soil analysis (Smalling and Braun, 1996). Farmers usually derive their knowledge of soil from their long interaction with the environment (Altieri, 1990). It is the result of an intuitive integration of local agroecosystem responses to environmental change, such as climate, land-use and crop demand through time (Barrios *et al*., 1994). In this case, transfer of soil knowledge from generation to generation is critical to better understand soil which is a major part in agriculture ecosystems.

Failure to consider the local experience of farmers with soil has caused limited adoption of new technologies in agriculture in developing countries (Winklerprins, 1999). Increasing recognition of folk knowledge of soils can offer many insights about managing soils in a sustainable way (Hecht, 1990). The complementary role of folk knowledge for scientific knowledge in soil improvement has been previously acknowledged to nurture soil science (Handayani *et al*., 2006; Sandor and Furbee, 1996). Handayani *et al*. (2006) has provided recent information about the importance of combining local and scientific knowledge of soil to sustain agricultural production in the forest margins of Indonesia. In addition, there is increasing consensus about the need for enhanced understanding of local knowledge from farmers before planning and implementing development activities (Pawluk *et al*., 1992; Mundy and Compton, 1991).

Recently, there has been limited integration of farmers' soil knowledge into agricultural technology development and precision farming systems. Farmer knowledge of soil fertility has been largely ignored

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by soil researchers. However, the increasing interest in the participatory approach in research and rural development, folk knowledge of soil plays an important role in establishing programs in agriculture. This paper documents the findings from folk knowledge of soil with regard to classification, erosion, fertility and management.

MATERIALS AND METHODS

Study Site

The study was conducted during the year of 2000 in three villages of Bengkulu Province, Sumatra, Indonesia. These villages were located in the forest margins surrounding Kerinci Seblat National Park (KSNP). The altitude ranged from 500-1000 m. The most important distinguishing feature among the villages was the distance from protected forest in KSNP. *Tapos* village is the closest distance (about 20 km), *Donok* and *Pal* villages have distances of 50 and 80 km, respectively. All of the villages are predominantly inhabited by people of the *Rejang* ethnic groups and almost all of the households are engaged in agriculture. All the arable land is under level terraces hill slope cultivation. Average annual rainfall in the region is between 2800-3000 mm.

The agriculture system consists of: (a) lowland irrigated or partially irrigated land called *sawah*, (b) upland rainfed sloping terraces called *kebun*, (c) home gardens called *pekarangan* and (d) pasture land called *padang rumput*. Most land is either privately owned or rented. Some areas close to the forests are managed by the local community. The main crops in *sawah* and *kebun* are rice and coffee, respectively.

Interviews

Information about soil knowledge from farmers was collected through semi-structured interviews which took place in the interviewee's house. Thirty households were chosen at random from each village to be interviewed. At the end of the research, focus group discussion was performed to confirm and re-check information. Conversations, which were translated by an interpreter, were guided towards selected topics while remaining flexible enough to include any other topics of interest to the farmer. Topics covered included indicator of soil fertility (i.e., plant type), soil management practices and criteria to assess the level of soil quality and soil degradation. Information on soil characteristics and management of the field were obtained from discussions with farmers during interview with following questions.

Selected Questions for Interview

- What is the color of fertile soils?
- What is the color of infertile soils?
- What is/are important characteristics to detect good soils for farming?
- How do you detect if your land is not good for cropping?
- Do you utilize legumes in your farm? If yes, what kind?
- How often do you apply manures in your field?
- How do you maintain soil fertility in your land?
- Do you practice fallowing? If yes, please explain in detail.

RESULTS AND DISCUSSION

Respondent Characteristics

The main characteristics of the sample respondents, including the gender and number of years working experience in the fields, of the interviewees are shown in Table 1. In general, respondents

Table 1: Characteristics of the respondents

	Village		
Characteristics	Tapos	Donok	Pal
No. of respondents interviewed	30	30	30
Respondent ethnic group			
Rejang	25	22	20
Javanese	3	6	8
Other	2	2	2
No. of men interviewed	23	20	25
No. of women interviewed	7	10	5
Average experience of interviewee (years)	23	20	22
Average *sawah* size holding (ha)	3	2	3
Average *kebun* size holding (ha)	4	3	5
Mean number of buffalo owned	3	1	2
Mean number of goats owned	3	2	3

Table 2: Criteria applied by farmers to distinguish soil classification, explanation of the criteria and the number of farmers using them

Criterion	Description	Used by farmers (%)
Soil Organic Matter (SOM)	Content of humus (the thickness of humus)	95
Fallow vegetation	Indicator plants used to see if the soil is ready to cultivate for crops	96
Color	Determined by eye (darker, better)	100
Earthworms/Casting	Determined by eye or by touching	85
Texture	The contents of stones, gravel and sand determined by eye and fingers	100
Structure	Compactness, powdery, grain-like, determined ease of tillage	89
Depth of roots	Part of the soil that can be exploited by plant roots	62
Stickiness	Extent to which soil sticks to hoe and hand when moist, determined by eye and fingers	40
Subsoil	Soil layer that is an obstacle for root growth or tillage or due to erosion	20
Roots	The presence of fine roots	70
Acidity	Determined by tasting	40

in *Tapos* and *Pal* owned more land overall (*sawah* and *kebun*) than respondents from *Donok*. In *Donok*, all the *sawah* land was irrigated, which allowed a maximum of three crops per year and gave higher and more reliable rice yields. In all areas, land management and the crops grown are relatively similar among fields.

Soil management of *kebun* by farmers consisted of tillage practices or breaking up the soil, then removing the weeds and planting. Coffee and corn were planted and sometimes intercropped with vegetables. Farmers in *Tapos* and *Pal* have more buffalos and goats than farmers in *Donok*. Most farmers applied manure from the livestock to maintain soil fertility.

Farmer Knowledge of Soil Classification

Farmers used certain soil properties (Table 2) to distinguish soil productivity or soil fertility. Criteria used for classifying soils are: soil organic matter (SOM), fallow vegetation, color, earthworm/casting, the presence of sand and clay, structure, depth of the roots, stickiness, subsoil, roots and acidity. Farmers mentioned a number of processes and actions that affect soil properties, for example soil erosion, tillage, cover crops and the use of manure. Farmers observed the soil as a dynamic system that can be manipulated to create a better environment for crops. More experienced, older farmers are capable of further subdividing these nine types into sub-classes and groups by taking into consideration parent material, weed species, consistency and water retention.

Texture and color are predominant characteristics used by farmers to distinguish soils. Brown-black and black soils were the most frequently cited soil color. Red-yellow, yellowish-red or red soil was identified by 55% of the farmers. The most recognized soil texture was clay soil, which was mentioned by 41 farmers (45%) (Table 3). Sandy and silty soils were identified by eight and two

Table 3: Soil classification identified by farmers

Soil classes	No. of farmers referring to the soil class	Percentage (%)
Black soil (*tanah hitam*)	75	68
Brown soil (*tanah coklat*)	65	59
Red soil (*tanah merah*)	20	18
Red-yellow soil (*tanah merah kekuningan*)	55	50
Gray soil (*tanah abu-abu*)	10	9
Clay soil (*tanah liat*)	45	41
Sandy soil (*tanah berpasir*)	8	7
Stony soil (*tanah berbatu*)	11	10
Silty soil (*tanah berdebu*)	2	2

Table 4: Soil fertility classes based on soil color determined by farmers

	Percentage of farmers referring to soil fertility status	
Color	Fertile	Infertile
Black	90	10
Brown	85	15
Light brown	45	55
Mixed brown-black	85	15
Mixed brown-red	20	80
Red	0	100
Yellow-red	2	88
Yellow	0	100
Dark gray	75	25

farmers, respectively, which represented the soil classes least selected by farmers. Similar soil classification is also found in other parts of the world (Kerven *et al*., 1995; Sandor and Furbee, 1996; Talawar and Rhoades, 1998). As expected, farmers use texture as a significant criterion to classify soil. Soil science also regards soil texture as a major soil characteristic influencing other properties like structure, consistency, water retention, permeability and drainage (Talawar and Rhoades, 1998). However, most farmers only focus on properties of surface soils and pay little attention to soil profiles. This phenomenon is similar to Mexican farmers as described by William and Ortiz-Solorio (1981).

The farmers listed the soils in order of fertility (Table 4). Generally, the darker soils were considered to be more fertile than yellow or red soils. This finding is similar to the results by Sandor and Furbee (1996) who indicate that local farmers often prefer one soil as being superior in productivity. Farmers observed that the origin of black soil is from the high content of humus or organic matter or decomposed plant residues. However, some farmers indicated that black soil was not always productive because of poor drainage. The farmers generally considered red, yellow and light gray soils to be inferior to black and brown soils.

Soils are also classified by their structure, grain-like soils with large aggregates represent better soils and powdery or structureless soils with no large aggregates indicate degrading soils. This is an important characteristic used by farmers to observe the process of soil restoration during fallowing. More large soil aggregates were found under long fallow (> 5 years) compared to short fallow (< 3 years) (Handayani *et al*., 2006).

Topographic position also plays an important role in local classification. Hill tops or *puncak* are identified as containing poor soils, while the quality of hillsides or *lereng* depends on how steep the slope is. The more fertile soils are concentrated in the flat areas or *lembah* which have the accumulation of nutrients from hillside soils. Inherently fertile soils or *tanah lapar* or hungry soils are distinguished from *tanah rusak* or bad soils, which are soils degraded by inappropriate management. Farmers mentioned that the former are likely to respond to fertilizer applications, while the latter needs to be restored to recover lost attributes.

Table 5: Farmers' appraisal of factors affecting soil degradation

Factor	Mentioned by % farmers (n = 90)
Tillage practices	88
Erosion by water	75
Lack of fallow	65
Lack of manure	65
No conservation practices	50
Soil mining	49
Unsuitable crops	40
Deforestation and overgrazing	30
Lack of crop rotation	20
Lack of cover crops	20

In Kenya, soil classification was based on soil color, texture and heaviness of working (Mango, 2000). Indicators to assess soil fertility included crop yields, soil color, compactness, soil odor and the composition of vegetation. In another part of Kenya, farmers used criteria such as ease of tillage, soil moisture retention, the presence of weeds and invertebrates to distinguish soil productivity (Murage *et al*., 2000). In northern Ethiopia, three different soil types are distinguished by farmers according to yield, topography, soil depth, color, texture, water holding capacity and stoniness (Corbeels *et al*., 2000). In southern Rwanda, soils are classified by their agricultural potential and tillage properties into nine major soil types based on criteria such as soil productivity, soil depth, soil structure and soil color (Habarurema and Steiner, 1997).

Farmer Knowledge of Soil Erosion

Farmers understand that soil fertility is closely related to soil erosion and the slope. On eroded hill tops and steep slopes, shallow and stony soils, called *tanah berbatu*, dominate, while on the flat tops of hills, concave slopes and feet of hills, deep soils with clay soil, *tanah liat*, prevail. The valley bottom has dark soil and dominates in clay texture as well. Soil erosion was mentioned by all farmers, its main impact being on soil texture, depth and the appearance of subsoil. This finding is different compared to the results of Steiner (1998), who reported that farmers in Rwanda did not mention erosion as the major cause for soil degradation. In this study, farmers believed that soil erosion depends on the steepness of slope.

Farmers are aware of inappropriate soil management increasing soil degradation. They observe tillage practices (frequency and inappropriate tillage), soil erosion, lack of fallow and limited manure application as the major causes for declining soil fertility (Table 5). Limited fallow is due to land shortage which consequently reduces the areas of fertile soils and increases soil erosion. During cultivation, hoeing causes soil disturbance and increases decomposition of soil organic matter, thus creating more soil erosion. Frequent tillage removes topsoil and accumulates it on the lower part of the field, causing the upper parts of the fields to become unproductive. Although farmers realize the negative effects of frequent tillage, they see no alternative, as hoeing downslope is the only practical way of tilling steep slopes.

Farmers realize that soil types influence the way soil should be managed, for example, sandy soils need to be treated differently from clay soils. The primary indicator of the best soil is organic matter content because it is a major source of plant nutrients. Manure is regarded as the principal soil amendment to improve soil productivity.

When farmers were asked to describe the process of soil erosion, about 80% of farmers were aware of the negative impacts of run off. This result is compatible with reports of farmer perceptions of soil erosion in Africa (Reij *et al*., 1996; Steiner, 1998). Seventy percent of the farmers attributed knowledge of soil erosion to extension agents, representatives of government-sponsored project and soil scientists at local universities that promoted soil conservation. The other 30% of the farmers learned about soil erosion from their parents or from personal observation. Most farmers (85%) have little interest in soil conservation and only about 15% of farmers have adopted soil conservation practices using vegetative methods. This is due to limited funds.

Farmer Knowledge of Soil Fertility

The majority of the farmers (90%) reported declining soil fertility and crop yields on sandy soils, red soils and red-yellow soils. They noticed a lighter color and coarser texture of soils near the village, indicating a decrease in soil organic matter. Farmers attributed these changes to the increase in the area of permanent cultivation or long-term continuous cropping, the decrease of fallow fields, the limited inputs of manure from livestock and soil erosion. Only 8% of the farmers felt that there had been a decline in fertility in *sawah* and 95% of them believed that *kebun* soils had lost fertility (these soils gain low input fertilizers). In addition, the Javanese ethnic group reported no declines in soil fertility on their fields, which was attributed to constantly high inputs. Farmers described the process of declining soil fertility level after opening the new land or forest with the lowest soil fertility after 5 years of cultivation and often characterized by the spread of *Imperata cylindrica* or cogon grassland. After cropping for 5 years, farmers observed that some of the field will need to be rested as fallow (*lahan tidur*) until shrubs such as *Chromolaena odorata* or *Lantana camara* dominate. Farmers also noticed the development of darker soil under *Chromolaena odorata*. Both vegetations are considered the best indicators that the soils are ready to cultivate again after fallowing. Previous findings from De Foresta and Schwartz (1991) showed *Chromolaena odorata* is an important component of natural fallow systems in Africa. It contributes to the maintenance of soil organic matter, weed suppression, soil fertility and soil erosion control. Sharma *et al*. (2005) observed that *Lantana* has become the dominant species and contributes to soil organic matter maintenance in deforested areas.

Many researchers have also noted the use of weed growth and weed species as indicators of soil fertility. For example, weeds are used to identify areas of good agricultural potential (Barrios *et al*., 1994), environmental conditions (Handayani *et al*., 2006) and to detect the process of soil restoration following intensive cultivation (Corbeels *et al*., 2000; Handayani *et al*., 2006; Mango, 2000).

Farmer Knowledge of Soil Management

Farmers had complex ecological knowledge particularly about soil, but there is variation among farmers on the depth of knowledge. The individual preferences depend on the farmer's capacity to enact successful agricultural performances and to exploit an evolving range of opportunities. These are based on the use of their local knowledge, as well as on their communication and creative capacities. Table 6 shows different soil management practices that are commonly applied by farmers on their *kebun*. In general farmers were aware of important factors enhancing soil fertility such as fallowing the land (87%), the use of soil amendments (90%), the use of legume and compost (100%). On an individual basis, knowledge is obtained from personal experiences and overlapping communication pathways, both of which are influenced by social factors, including age, gender and family ties. Uncertainties arise when the knowledge is incomplete and incapable of dealing with risks outside of community partial perspective, which creates a plurality of perspectives (Kerven *et al*., 1995). The traditional belief system and its associated practices are not equally spread and appear to be eroding in importance in many locations, especially among the younger generations who chose different professions besides farming and in semi-urban areas that have limited agricultural fields.

Farmers recognized several constraints in land productivity. Table 6 shows that only 5% of the farmers used mineral fertilizers and 20% of them applied vegetative conservation methods. In other circumstances, farmers relied on their local knowledge of soil characteristics and plant indicators to focus efforts in their planting strategies on addition of nutrients with the goal of maximizing nutrient

Table 6: Soil management practices for *kebun*

Soil management practice	Farmers (%)
Fallow:	87
(a) Short (1-2 years)	75
(b) Long (3-5+ years)	35
The use of manure from livestock	90
Mineral fertilizers	5
Nitrogen-fixing crops	100
Ash from burning	60
The use of crop residues after harvest	90
Composting organic materials	100
The use of vegetative conservation method	20

cycling. For example, farmers value fertile niches around earthworm holes, earthworm casts, Pterydophyta and *Chromolaena odorata*. The importance of these practices has been widely qualified in numerous scientific studies (Esse *et al*., 2001; Fujisaka *et al*., 2000; Hiernaux *et al*., 1999; Wezel *et al*., 2000).

A similar dynamic nature of soil fertility is viewed by farmers in northern Ethiopia who see their land moving between *reguid* (fertile soils), *mehakelay* (moderately fertile soils) and *rekik* (poor soils) types depending on how it is managed (Corbeels *et al*., 2000) and weeds (Handayani *et al*., 2006; Sharma *et al*., 2005). In addition, Schmidt *et al*. (1993) reported that land management is the key to increasing the soil fertility beyond its inherent levels. This fits with the view expressed by some researchers that soil fertility is a human-made technical attribute rather than inherent soil property (William and Ortiz-Solorio, 1981; Karlen *et al*., 2003). In the interview, we found that farmers would describe long-term soil management strategies for each of their individual fields and then show fields that had been infertile 5 years ago but through careful management had been made fertile.

CONCLUSIONS

This study shows that farmers in Bengkulu, Indonesia have a well-defined and comprehensive set of knowledge of soil classification, soil erosion, soil fertility and soil management. Generally, farmers observed soil characteristics by seeing, feeling or smelling their soils based on their own experiences during cultivation in the fields. Farmers recognized the importance of texture, color, fallow vegetation and soil organic matter to classify the soil, but only texture and color were most used. Soil classes are divided into nine categories, namely *tanah hitam* (black soil), *tanah coklat* (brown soil), *tanah merah* (red soil), *tanah merah-kekuningan* (red yellow soil), *tanah abu-abu* (gray soil), *tanah liat* (clay soil), *tanah berpasir* (sandy soil), *tanah berbatu* (stony soil) and *tanah berdebu* (silty soil). One interesting finding from this study was the importance of environmental factors mentioned as indicators by farmers. These included factors such as flooding and landslides during the rainy season (November to February), frequent earthquakes and crop destruction by wild pigs, all of which would affect soil productivity and make farmers think of alternative ways to better manage the soils.

Farmers observe soil fertility as a dynamic process integrating the soil properties, its agricultural requirements (i.e., crops) and environmental factors (i.e., soil erosion, soil management). They see themselves as active participants who can change soil fertility. Farmers claimed that soil can be restored eventually, but only the topsoil. They indicated that fertile soils are black, brown and mixed brown-black. They were also aware of the effects of inappropriate tillage practices, erosion, limited fallow and limited manure applications on soil. Farmers (> 90%) utilized compost, manure and crop residues as soil amendments and legumes during crop rotations. Short fallow (2 years) is a common practice to restore the soil fertility after five years continuous crop production.

This study provides additional insights into qualitative soil knowledge. Distinctions among soils were made primarily on the basis of readily observable classes of soils. Therefore, local soil terminologies often do not provide sufficient information for technology development. However, folk knowledge of soils would facilitate the exchange of empirical farmer knowledge and scientific knowledge to enhance participative rural development projects. In summary, the combination of local, scientific and technical knowledge of soil will help extension workers and scientists work more closely with farmers.

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