

## SOIL QUALITY CARDS FOR PARTICIPATORY SOIL QUALITY ASSESSMENT IN ORGANIC AND SMALLHOLDER AGRICULTURE

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**Abstract:** Healthy soil is the basis of high quality food production. Increased awareness toward safe and healthy environment further aggravated the significance of soil quality evaluation and adoption of rational management practices. Evaluation of soil quality is crucial but expensive task for organic growers and smallholder agriculture. Participatory approach in soil quality assessment, thus, can serve the purpose of soil quality assurance for quality production. Physical, chemical and biological soil quality parameters are identified through participatory discussion and they are integrated in a way familiar to farmers. Farmers evaluate their farm soils based on their existing knowledge, agro-ecological condition and farming system of the area. This approach bridges farmers' ideas with scientific facts with minimum financial investment. Initiatives have already been taken in this line, however, strengthening and institutionalization of the process is needed to replicate this practical technique. Preliminary work in Baccheuli, Chitwan, Nepal indicated the approach as practical, easy, cost effective and convincing to farmers. Moreover, this enhanced confidence to farmers of their soil quality and supported for further strengthening of organic and smallholder agriculture in Nepal.

**Key words:** soil quality, organic farming, sustainable agriculture, smallholder farmers

**Rezumat:** Fișe de proprietăți ale solului pentru evaluarea participativă a calității sale în agricultura organică practică în fermele mici. Un sol sănătos reprezintă baza pentru obținerea unei hrane de înaltă calitate. Creșterea gradului de conștiență cu privire la un mediu sănătos și sigur au mărit semnificația evaluării calității solului și adoptarea unor practici raționale de management. Evaluarea calității solului este vitală, dar reprezintă o sarcină costisitoare pentru cei care practică agricultura organică și pentru micii fermieri. Abordarea participativă în evaluarea calității solului poate astfel servi la asigurarea calității acestuia și implică a calității producției. Parametrii fizici, chimici și biologici de calitate sunt identificați prin discuții participative și sunt integrați într-un mod familiar fermierilor. Fermierii își evaluează solurile pe baza cunoștințelor dobândite, a condiției agro-ecologice și a sistemului agricol din zonă. Această abordare permite integrarea ideilor fermierilor cu datele științifice cu un efort financiar minim. Deja au fost lansate anumite inițiative, totuși este nevoie de instituționalizarea procesului pentru a aplica această tehnică practică la scară mare. Cercetarea preliminară din Baccheuli, Chitwan, Nepal a indicat această abordare ca fiind practică, facilă, eficientă financiar și foarte convingătoare pentru fermieri. Mai mult, a determinat creșterea gradului de încredere a fermierilor în calitatea solurilor lor și dus la întărirea agriculturii organice practicate de micii proprietari în Nepal.

**Cuvinte cheie:** calitatea solului, culturi organice, agricultură durabilă, mici fermieri

### Introduction

Scientific assessment of soil quality is essential to monitor sustainability of agricultural systems. However, soil quality itself is a complex subject, encompassing many valuable services to the human being and terrestrial ecosystems (Franzlubbers and Haney, 2006). Soil quality signifies the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries to sustain plant and animal productivity, to maintain or enhance water and air quality, and to support human health and habitation. Soil functions for maintenance of good soil quality include, sustaining biological activity in a soil in high equilibrium level with substantially high productivity, regulating water and solute flow; filtering and buffering, degrading, immobilizing and

detoxifying organic and inorganic contaminants in soil. This emphasizes storing and cycling of nutrients and other elements within the earth's biosphere; and ultimately provides support to the socioeconomic structures of the area (Seybold *et al.*, 1998).

Soils vary naturally in their capacity to function; therefore, quality is specific to its type. Soil quality, however, includes two distinct but interconnected parts: inherent quality and dynamic quality. Characteristics, such as texture, mineralogy, etc., are innate soil properties determined by the factors associated with soil forming processes. Collectively, these properties determine the inherent quality of a soil or its productive capability. Recently, soil quality has come to refer to its dynamic quality and

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defined as the changing nature of the soil affected from human use and management. Management practices, such as use of cover crops and organic manures can have a positive effect on soil quality, whereas, other management practices, such as rigorous tilling of soil in wet condition adversely affects soil by increasing the compaction (Friedman *et al.*, 2001).

Healthy soil is the foundation for high quality and surplus food production in sustainable manner. Thus, without understanding soil as a living, dynamic entity, and their complex inter-relationships, soil building process will not start functionally (Bot and Benites, 2005). Revitalization of the degraded land requires social, scientific, and ethical considerations. Soil, nutrients, and organic matter are being lost from Nepalese soils at the rate far exceeding the sustainable level (Pariyar, 2006) thus urging the need of rational soil management and assessment of the management approaches. Thus, renewed attention on developing locally led high-quality food production systems to achieve a global vision of environmental stewardship has been developed to attain sustainability in food production system in safe production environment. This paper presents various parameters for the participatory evaluation of the soil quality parameters especially focusing on the organic and smallholder agriculture along with few field experiences.

### Indicators of soil quality

Soil quality indicators vary greatly depending on land condition and management practices. Basically, they are divided into three main classes i.e. soil chemical, physical and biological properties or processes. Indicators of soil quality, however, should reflect the capacity of soil to produce healthy crop, cycling and retaining nutrients in soil and releasing them to roots for efficient plant production and storing carbon in soil and releasing it to the atmosphere in a dynamic balance that stabilizes atmospheric concentration of CO<sub>2</sub>; supplying plants with water, nutrients, and plant-growth promoting compounds; protecting water quality from nutrient and pathogenic contamination, providing physical stability and support for vegetation, buildings, and roads; enabling animal habitat and serving as a reservoir for biodiversity (microscopic and visible); buffering against toxic accumulation and transport of natural and synthetic compounds; filtering elements to protect animals, plants, and the environment from undesirable exposure (Magdoff and Weil, 2004).

More over these indicators should be:

- Easy to measure
- Detect changes in soil function
- Integrate soil physical, chemical, and

biological properties and processes

- Accessible to many users and applicable to field conditions
- Sensitive to variations in management and climate
- Encompass ecosystem processes and relate to process-oriented

Variety of soil properties or processes can be selected to indicate soil functional capabilities (Table 1). These set of indicators include soil physical and chemical conditions, and structure and function of highly active soil microbial communities that creates less stressful condition for plant growth (Franzlubbers and Haney, 2006).

**Table 1.**  
**Minimum data set of indicators for participatory soil quality assessment**

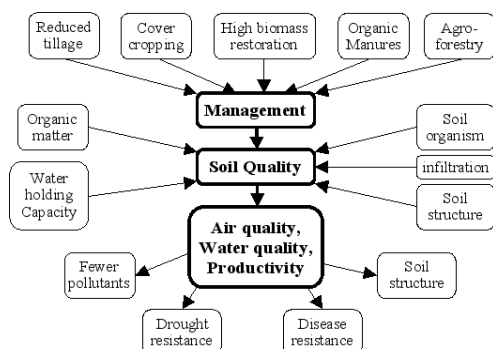
Indicator	Relationship to Soil Health
Soil organic matter (SOM)	Soil fertility, structure, stability, nutrient retention, soil erosion, and available water capacity
<b>Physical</b>	
Soil structure	Retention and transport of water and nutrients, habitat for microbes, and soil erosion
Depth of soil and rooting	Crop productivity potential, compaction, and plow pan
Infiltration and bulk density	Water movement, porosity, and workability, water holding capacity, Water storage and availability
<b>Chemical</b>	
pH	Biological activity and nutrient availability
Electrical conductivity	Plant growth, microbial activity, and salt tolerance
Extractable N, P and K	Plant available nutrients and potential for N and P loss
<b>Biological</b>	
Microbial biomass C and N	Microbial catalytic potential and repository for C and N
Potentially mineralizable N	Soil productivity and N supplying potential
Soil respiration	Microbial activity

(Seybold *et al.*, 1998)

### Soil quality assessment in organic and smallholder agriculture

Several organizations have been working for improvement of soil quality since decades by encouraging the best management practices to get rid of major soil problems such as erosion and nutrient depletion. As soil quality has emerged as a leading concept in natural resource conservation and protection, stronger emphasis is now being placed on the relationship between specific dynamic soil properties and soil performances (USDA-NRCS, 2001). Practices such as minimum tillage, and rational management of nutrient, pest, and pastureland (Figure 1) enhance the dynamic processes in the soil. For example, a typical method for improving soil quality by increasing organic matter involves reducing tillage and allowing the minimum erosion. Moreover, it stabilizes soil

respiration to escalate the biological activity and release the nutrients for better profitability, and, in long run, high resilience of smallholder farmers against environmental flux and associated disasters.



**Fig. 1 Relationship between soil management practices, soil quality, and environmental quality**

Participatory assessment of soil quality is required to evaluate and improve soils in organic and smallholder agriculture as all the components and interactions of a soil system are viewed together by linking biological, physical, and chemical properties of soil (Franzlubbers and Haney, 2006). This integrated approach leads to more comprehensive solution to assessing soil properties independently (USDA-NRCS, 2001). Participatory approach includes use of soil health/quality card, use of soil quality test kit, or simple laboratory analysis techniques for soil quality evaluation depending on the need and capacity of farmers, farming system situation and local knowledge, so that this is accessible to the smallholder agriculture and newly emerging organic sector in Nepal.

### Soil quality cards

Smallholder agriculture and newly developing organic sector demands the development of simple, easy and less costly techniques of soil quality evaluation of their farms. Moreover, hazards of chemicals used in sophisticated laboratory analysis to the environment cannot be overlooked. The soil quality cards contain farmer-selected soil quality indicators and associated ranking descriptions typical to local producers (Table 2) that can be assessed even without the aid of technical or laboratory equipments (USDA-NRCS, 2001).

Soil quality cards integrate physical, biological, and chemical properties in the ways that are familiar and accessible to farmers. For example, use of terms like tilth that refers to the physical structure of soil and also depends on biological properties that makes the evaluation more sensible. Similarly, soil color is an indicator of soil organic matter and thereby predicts many biological and chemical processes in

soil. Selection of these properties as indicated by farmers and preparation of data set in the form of cards usable by farmers or field workers can be the best solution to know and monitor soil quality of agricultural farms. Directions for the use of card are designed in each card for farmers and field technicians' easy understanding. Qualitative score of each of the indicators based on farmer's judgment along with other important data, like management practices, fertilizer rates, pest management, manure application etc. provides best insight on soil quality (USDA-NRCS, 2001).

### Experiences of participatory assessment in Chitwan, Nepal

Soil quality evaluation is rarely practiced in Nepalese agriculture. Government service for the assessment of soil physical and chemical quality parameters is not effective in a practical sense. Private laboratories established with the objective of serving society became unable to serve their purpose because of the extremely high running cost i.e. not affordable to smallholder farmers. Organic agriculture is in the edge because of the several challenges including quality assurance of the products and its production environment. We realized the need of evaluation of soil quality of organic farms, especially small farms as an initiative toward participatory soil quality assessment. In this first level assessment, soil quality cards were not fully developed as described in previous sections, however, some important parameters of soil quality have been set through group discussion, evaluation technique for these parameters discussed and soil quality was evaluated in joint effort of farmers, field technicians and experts.

Thirty three farmers of the Tharu Organic Producer Women Group, Bachheuli, Chitwan (Photo 1) were selected for the participatory evaluation of soil quality of their farms.



**Photo 1. Farmers of the Tharu Organic Producer Women Group, Bachheuli, Chitwan**

One day orientation meeting was conducted focusing on the importance of soil quality evaluation in small organic farms and evaluation techniques (Photo 2).



**Photo 2. The orientation meeting on soil quality**

Quality parameters were set based on the discussion of the group members to evaluate their soils. Soil color, texture and structure were observed

on the field of each participant farmers and ranked verbally as good, fair, and worse.

Soil chemical quality preferably condition of major nutrients were tested using soil testing field kit and measured on five qualitative scales i.e. very high, high, medium, low and very low.

Qualitative estimate of major nutrients of thirty three farms indicated variable nutrient status in the observed area. Fifteen farms were very low, nine farms were low and nine were medium in available nitrogen content. None of the soils registered surplus in nitrogen nutrition of the crop. However, soils were medium to high in terms of plant available phosphorus and potassium supply.

**Table 2.**

**Soil quality card template for assessing soil quality indicators**

INDICATOR	SOIL QUALITY RANKING			SCORING		
	Low	Medium	High	L	M	H
Earthworms	Few worms per shovel, no casts	More worms per shovel, some casts	Many worms per shovel, many casts			
Soil Organisms	Few insects, worms, fungi, or soil life	Some insects, worms, fungi, soil life	Soil full of variety of organisms			
Smell	Swampy smell	Little or no smell	Fresh earthy smell			
Surface OM	No visible roots or residue	Some residue	Lots of roots /residue in various stages of decomposition			
Residue Dec.	Very slow or rapid decomposition	Some visible, non-decomposed residue	Residue at various stages of decomposition			
Compaction	Hard layers, tight soil, restricted root penetration, roots turned awkwardly	Firm soil, slightly restricted root penetration, moderate shovel resistance beyond tillage layer	Loose soil, unrestricted root penetration, no hardpan, mostly vertical root plant growth			
Workability	Many passes and horsepower needed for good seedbed, soil difficult to work	Soil works reasonably well	Tills easily and requires little power to pull implements			
Soil Tilth/ Structure	Soil clods large and difficult to break, crusting, or soil very powdery	Moderate porosity, some crusting, small clods, soil breaks with medium pressure	Soil crumbles well, friable, porous			
Soil Aggregates	Soil surface is hard, clumps and does not break apart, very powdery	Soil crumbles in hand, few aggregates	Soil surface has many soft small aggregates which crumble easily			
Porosity	Few worm and root channels	Weak plow pan, some new and old root and worm channels	Many worm and root channels, many pores between aggregates			
Crusting	Soil seals easily, seed emergence inhibited	Some surface sealing	Soil surface open or porous all season			
Water Infiltration	Water on surface for long period of time after rain or irrigation	Water drains slowly after rain or irrigation, some ponding	No ponding after heavy rain or irrigation, water moves steadily through soil			
Drainage	Excessive wet spots in field, ponding, root disease	Some wet spots in field and profile, some root disease	Water is evenly drained through field and soil profile, no evidence of root disease			
Water Holding Capacity	Plant stress immediately following rain, soil requires frequent irrigation	Crops are not first to suffer in area from dry spell, soil requires average irrigation	Soil holds water well for long time, deep topsoil, crops do well in dry spells, soil requires less than average irrigation			
Erosion	Obvious soil deposition, large joined gullies	Some deposition, few gullies, some colored Runoff	No visible soil movement, no gullies, clear or no runoff			
Crop Vigor	Stunted growth, uneven stand, discoloration, low yields	Some uneven or stunted growth, slight discoloration, signs of stress	Healthy, vigorous, and uniform stand			
Plant Roots	Poor growth, brown or mushy roots	Some fine roots, mostly healthy	Vigorous, and healthy root system, good color			
Root Mass	Very few roots, mostly horizontal	More roots, some vertical, some horizontal	Many vertical and horizontal roots, deep roots			

Only one farm had high plant available phosphorus and four farms were low in its supply, the rest of 28 farms were medium in phosphorus supply. Similarly, twelve farms were very high, thirteen high and seven farms were medium in potassium supply. Only one farm was low in available potassium supply (Figure 2).

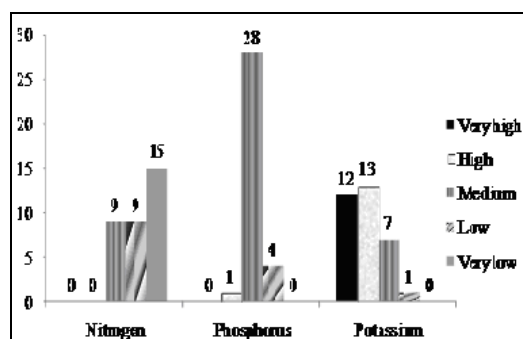


Fig. 2 Field assessment of soil chemical quality in Bachheuli, Chitwan, Nepal

Similarly, participatory evaluation of twenty-four farms of Women Farmers' Group, Pithuwa, Chitwan following the same orientation and test procedure as in Bachheuli and setting three scales i.e. high, medium and low in the measurement of major nutrients showed that most soils (21 farms) were low in available nitrogen. However, phosphorus was medium in fourteen farms and potassium was medium in sixteen farms. Similarly, one farm was high in phosphorus whereas seven farms were high in potassium. Phosphorus supply was low in nine farms examined during this evaluation. The tested soils were neutral to moderately acid in pH (pH range of 5.5 to 7). Discussion at the time of result dissemination of the analysis concluded the need of sustainable management practices to upgrade soil quality especially through application of well-decomposed organic manures, crop residue, and green manures. Nitrogen should be enriched and the phosphorus and potassium, which are medium to high in status, should be maintained or improved in the soils.

### Conclusions

Soil quality is the intricate subject as soil varies naturally in their capacity to function. Soil quality

assessment is a tool used to evaluate the effects of management system on the health of the soil.

Sets of techniques are available to assess the soil quality in farmers' field. Participatory soil quality evaluation technique is a low cost technique of examining soil with the active involvement of farmers. These techniques serve for the assurance of soil quality, confidence to the farmers and indirectly to the sustainability of agricultural system. Moreover, this adds strength in promotion of organic agriculture as good quality soil gives good harvest, habitable and safe environment, and increases confidence to the smallholder farmers to join the organic agriculture movement.

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