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A Soil Health Card (SHC) for soil quality monitoring of agricultural lands in south-eastern coastal region of Bangladesh

S. M. Didar-Ul Islam[1*], Mohammad Amir Hossain Bhuiyan[1], Mohammad Mohinuzzaman[2,3], Md. Hassan Ali[2] and Shaila Rahman Moon[2]

Abstract

Background: The present study introduces an alternate tool of laboratory analysis named Soil Health Card (SHC) for soil quality monitoring and routine field observations by farmers.

Results: Different physicochemical and nutrient contents of soil, i.e. pH, electric conductivity, soil organic matter, organic carbon, total nitrogen, phosphorous, sulfur and boron were assessed by laboratory analysis collected from the different fields of Noakhali district of Bangladesh. These parameters were scored according to the soil fertility standards according to Bangladesh Agriculture Research Council. Results found that, the soil quality of all the studied fields are medium category. Again, a SHC was prepared using soil structure, subsurface compaction, aggregate stability, status of ground cover, soil smell, soil pH, color, organic matter content, drainage capacity, diversity of micro-life, earthworm contents, infiltration rate, soil aeration, crop coverage and leaf color. The result of SHC is interestingly similar to the laboratory experiment results.

Conclusions: Analyzing these two methods it was found that, the SHC is truly representative, much convenient, precise, coast effective and easily understandable to the marginal farmers. However, SHC can be an alternative to farmer for sustainable farm management.

Keywords: Agricultural land, Bangladesh, Nutrient, Soil Health Card (SHC), Soil quality

Background

Bangladesh is predominantly an agro-based country. The total cropped area is 15.085 million hectares with crop production of 37.266 million metric tons (Karlen et al. 1999; DAE-AIS 2013). Agricultural sector provides 29% of the country's Gross Domestic Production (GDP) and generates employment for 63% of the total labor force both directly and indirectly (Khan et al. 2015). Bangladesh has made a remarkable progress in the last three decades achieving self-sufficiency in food grains production due to substantial intensification of cropping, practicing high yield crop varieties, and expansion of irrigated areas and increased use of chemical fertilizers. Among the factors mentioned above, fertilizers contribute 50% of the total production (FRG 2012). But recently, declining or stagnation of major crop yields have been recorded due to cumulative effects of many soil-related constraints and climatic risks, i.e. depletion of soil organic matter, imbalanced use of fertilizers, nutrient mining, degradation of soil physical and chemical properties, erratic rainfall, temperature rise, droughts, floods, soil salinity, water salinity, tidal surges, water-logging, cyclone, scanty use of bio and organic fertilizers and poor management practices (Miah 2010; Sangral 2015; Islam et al. 2015; Islam and Bhuiyan 2016). Mineral N–P–K fertilizer additions, supported with the pesticides and herbicides leads to degrade the humic portion of soil, which gradually destroying the plant nutrition and soil fertility (Pettit 2006; Rahman et al. 2012). Moreover, excess use and exposure of pesticides and herbicides, leads to

*Correspondence: smdidarulislamju@gmail.com
[1] Department of Environmental Sciences, Jahangirnagar University, Dhaka 1342, Bangladesh
Full list of author information is available at the end of the article

environmental pollution and do harm human health a lot (Chitra et al. 2006). The overuse of chemical fertilizers and poor soil management contributed to surface and groundwater pollution in many regions in the developing countries which may cause human health hazard (Magdoff and Harold 2009). The overall degradation or pollution processes lead to decrease soil health of a farm soil.

Soil health is defined as an integrative property that reflects the level of ecosystem services, and the capacity of agricultural production (Kibble-white et al. 2008). Soil quality is considered as the main factor determining the total soil functions and health. For example, organic residue and root biomass from crop plants feed soil organisms and contribute to soil organic matter which in turn develops soil structure (Wander 2004). Both air and water occupy the pore spaces created within and between soil aggregates that means the clusters of sand, silt and clay particles which bound together by particle surface chemistry and microbial and plant exudates (Gugino et al. 2009). Thus if any major function disrupts then the total soil consequently will be affected. Poor soil quality usually provides a poor production of crops (Franzlubbers and Haney 2006; Idowu et al. 2008). Soil quality enrichment improves the capacity of a soil function within ecosystem and land use boundaries to sustain productivity, maintain environmental quality, and promote plant and animal health (Doran and Parkin 1994; Karlen et al. 1997).

The farmers of Bangladesh are not financially solvent. So monitoring of soil quality using a cost effective and convenient tool is a crying need to adopt sustainable development in agricultural practices nowadays for marginal farmers. Previously many authors, i.e. Romaniuk et al. (2014), Gong et al. (2015), Raiesi and Kabiri (2016), and Vasu et al. (2016) create a broader linkage between soil quality and sustainability using soil quality indexing approach fruitfully. Among them, soil quality test kits (Sarrantonio et al. 1996; SQTKG 1999), farmer-based scorecards (Romig et al. 1996) and soil resource management programs (Walter et al. 1997) focus on farmer-based evaluations regarding soil management practices and their effects on soil. Gugino et al. (2009) found that, soil quality assessment using different indicator is much easier for soil health monitoring of agricultural lands. This technique provides an aim to evaluate the tillage systems, detect and improve problem of fields, make baseline assessments of new ground or for precision agriculture systems and demonstrate that soil quality under current farming practices. As, laboratory analysis of soil is expensive, more time consuming and not convenient for marginal farmers so the present study aims to introduce an alternate method name SHC and its application for soil monitoring in agricultural lands using different indicators. The study also intended to compare SHC with laboratory analysis, its significance and develop it for farmer's usages for sustainable land management.

Methods

Study area

Noakhali district is located at the south-eastern coastal region of Bangladesh. Geographically it lies between 22°06′ and 23°17′ North latitudes and between 90°38′ and 91°35′ East longitude (Fig. 1). The total area of Noakhali is 3685.87 Sq. km and the population is 310808.3 million (BBS 2011). The annual average temperature of this district ranges from a maximum of 34.3 °C to a minimum of 14.4 °C and average annual rainfall is 3302 mm. The area represents an extensive flat, coastal and deltaic land, located on the tidal floodplain of the Meghna River delta, characterized by flat land and low relief. The area is influenced by diurnal tidal cycles and the tidal fluctuations vary depending on seasons, being pronounced during the monsoon season. The economy of Noakhali is depends on agriculture and they produce varieties of crops, namely local and hybrid rice, wheat, vegetables, spices, cash crops, pulses, betel leaves, peanuts, onion, oil seeds and others. 30% of the regional GDP comes from agriculture with 45% of the population employed in the sector (BBS 2011). Noakhali, being exposed to the Bay of Bengal is prone to multiple hazards. Cyclones are frequently occurring disasters, which hit the coastal villages every year. Sometimes, cyclones accompanied by tidal surge inundate the very remote coastal areas of the district and cause massive destruction. Along with these, annual flooding due to excessive rainfall and poor drainage systems has recently been devastating (Banglapedia 2016).

Sampling and laboratory analysis

Soil samples were collected during January 2016 from ten fields of the study area (Fig. 1) before land preparation from plough-depth maintaining the ideal soil sampling protocol (Gupta 2000). Five samples were collected from each fields and analyzed for pH, EC, OC, OM, TN, P, K, S and B in regional laboratory of Soil Resource Development Institute (SRDI), Noakhali. Soil pH was determined with the help of a glass electrode pH meter; the soil–water ratio was maintained as 1:2.5 according to Jackson (1962). To measure electric conductivity, EC1:1 method was used (Smith and Doran 1996). Organic carbon in soil sample was determined volumetrically by wet oxidation method of Walkley and Black (1934). The underlying principle is to oxidize the organic matter with an excess of 1 N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1 N NH_4FeSO_4. The amount of soil organic matter was calculated by multiplying the value of organic carbon with

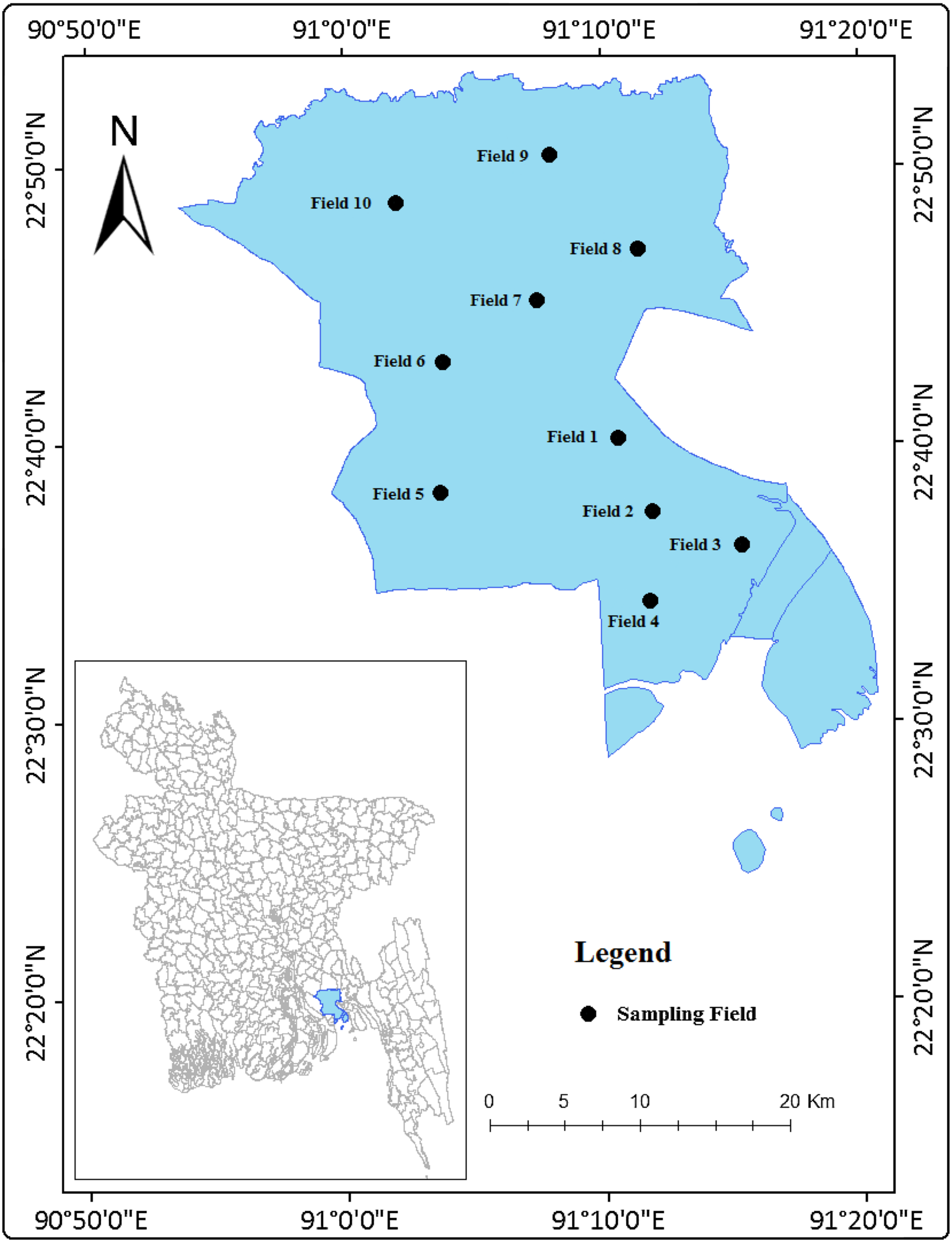

Fig. 1 Map of study area showing the sampling fields

the Van Bemmelen factor, 1.724 (Piper 1950). The total nitrogen in the soil was determined by Kjeldahl method by digesting soil sample at 390 °C in a digestion tube with 5 ml 98% conc. H_2SO_4 and 1.0 g catalyst mixture (K_2SO_4:$CuSO_4 \cdot 5H_2O$ = 10:1) by a digestion unit (Page et al. 1982).

Available phosphorus was extracted from the soil by shaking with 0.03 M NH_4F–0.025 M HCl solution at pH < 7.0 following the method of Bray and Kurtz (1945). The phosphorus in the extract was then determined by developing a color using ammonium molybdate-ascorbic acid solution to the extract. The intensity of blue color was measured at 890 nm wave length in spectrophotometer and available P was calculated with the help of standard curve. Potassium was determined by using flame photometer (Black et al. 1965).

Available S content of soil was determined by extracting the soil with S extracting solution. The extractable sulphur content was determined by developing turbidity by adding acid seed solution [150 ml conc. HNO_3, 550 ml glacial acetic acid and 7 ml sulphur stock solution-1 (1000 mg/L S) was mixed added water to volume 2 L] and turbidimetric reagent [20 g polyvinylpyrrolidone and 300 g $BaCl_2 \cdot 2H_2O$ up to 2 L volume with distilled water]. The intensity of turbidity was measured by spectrophotometer at 535 nm wave length following the extraction-turbidity method described by Fox et al. (1964). For measuring boron, at first nitrogen digester should turned on and was adjusted it to 150 °C. Then soil was digested with 0.01 M $CaCl_2$ solution in the ratio 1:2 into clean and dry digestion tubes with glass stopper in each. After first bubble, the temperature setting was reduced to 110 °C and boiled for exactly 5 min from the time was start. The digester was turned and placed the tubes in a vessel with cold water for 15 min and filtered on a dry filter into a dry plastic bottle and then Transferred 2.0 ml undiluted filtrate into another dry plastic bottle, added 4 ml buffer solution and 4 ml Azomethyl-H reagent and mixed. After 30 min the absorbance was measured at 420 nm on a spectrophotometer and calculated by using a standard curve (Petersen 2013).

Field observation for SHC preparation

In 2002 a group of Northern Rivers Region farmers develop a soil health monitoring tool named Northern Rivers Soil Health Card (NRSHC), based on United States Department of Agriculture (USDA) format. A major value of the exercise was the farmer involvement that allowed the card to be customized to fit the needs of the individual using it. It is simple and effective extension tool for soil quality monitoring using simple rating system that people can use to evaluate and monitor soil health or compare practice effects on soil health. In this process farmer participation was taken, which has facilitated engagement and increased awareness of soil health issues and enabled farmers to self diagnose and solve their own problems (Lobry de Bryun and Abbey 2003). To prepare SHC, soil health indicator of NRSHC method was used in this study. To prepare SHC ground cover percentage were assess using coat hanger quadrate, which put into the ground at random manner and estimated the proportion of bare soil within the frame and subtracted from 100% (NRSHC 2002). For the infiltration test, the infiltrometer tube was pushed to the soil up to 1–2 cm into the soil, avoiding cracks and other holes in the ground. The tube was filled with water and the time was recorded by stopwatch how far the water level had fallen up to 5 min. The rate of infiltration then counted by ratio of water level decrease and time elapsed to infiltrate the total water (NRSHC 2002). For counting the diversity of macro life, the coat hanger quadrate was put on the ground at the undisturbed area and avoid the movement of varieties of soil animals such as ants, beetles, spiders, slaters, millipedes, mites and others were noted (NRSHC 2002). To measure the root development 15 cm square hole of soil surface was cut from the ground. The soil was lifted out as one block placing on the plastic sheet for observing the plant root and recorded on the card (NRSHC 2002). For observing soil structure, a handful of soil away from the surface of the block was dug up. The size and arrangement of the soil 'aggregate or crumbs' were examined under firm finger pressure (NRSHC 2002). To examine the crumbs stability 3 or 4 pea-sized soil crumbs were taken from 5 cm depth for avoiding small stones. The crumbs were merged into 125 ml water at a small wide mouthed jar for 1 min. After 1 min the crumbs were broke apart or stay intact (NRSHC 2002). To count the earthworm content, the total soil block was broken into small crumbs for observation if any worms were found into a jar. Any worm that was longer than 25 mm recorded on the sheet and let them return to the hole (NRSHC 2002). To measure soil pH, two small samples of soil were taken from the side of the hole-one from 5 cm and another from 15 cm depth. These samples were color matched with pH kit. Leaf color and plant growth crop, trees or pasture at the soil test site were observed visually (NRSHC 2002). Organic matter was determined in two soil sample collected from the surface (topsoil) and 25 mm (subsoil) depth. The soil color from the two depths was compared. When the surface color similar to the subsoil color the smell of the soil sample was taken for differentiate. A sweet earthy smell indicates the soil was rich in organic matter (SQCDG 1999). For the seedling emergence about 100 sections of seeded rows were measured with tape and the height of several plants within the row was measured randomly (PNSQCG 2004). Drainage capacity was examined from the farmers interview that how many days rainwater needs to erase from the field totally after a heavy rain such 2,3,5 or 7 days. Below 1 day it prefers good, 2–3 days indicates the medium and 5–7 days indicates the poor drainage capacity of the field (NRSHC 2002).

Data interpretation and analysis

To evaluate soil quality, measured soil parameters in laboratory are scored according to Bangladesh Agricultural Research Council (BARC) soil fertility standard (FRG 2012). To prepare SHC, several important soil health indicators (Table 1) based on farmer's practical experience and knowledge of local natural resources were determined. The soil characteristics were classified in terms these indicators.

Results and discussion

Soil quality determination using laboratory assessment

The value of measured soil parameters and nutrients content in the studied fields are given in Table 2 with assumption based on FRG (2012). Soil pH is a measure of its acidity or alkalinity and is an important property because of its influence on the supply of nutrients (cations and anions) to plants, the chemical behavior of toxic elements and the activity of microorganisms. The pH of soil varied from 6.94 to 8.22 with a mean value of 7.67 which is slightly alkaline. On the cropping system, a change in pH may have effects on soil quality. Important factors affecting soil pH including; parent material, alkali salts, drainage system, weathering-erosion, types of fertilizers, proximity to metal ore smelters, and residual base saturation capacity (Arshad and Coen 1992).

Soil electrical conductivity (EC) is a measurement that correlates soil properties that affect crop productivity including soil texture, cation exchange capacity, drainage conditions, organic matter level, salinity and sub-soil characteristics. On the other hand, the electrical conductivity of soils varies depending on the amount of soil moisture. Generally EC has good relationship with soil particle size and texture (Grisso et al. 2009). The EC of the samples ranges from 0.79 to 6.67 dS/m with a mean of 2.75 dS/m (Table 2).

Organic matter (OM), an important properties derived from the decomposition of plants and animals. A wide variety of organic carbon in soils range from freshly deposited litter, i.e. leaves, twigs, branches, etc. to highly decomposed forms, i.e. humus (Schumacher 2002). OM defines the total carbon storage, fertility and stability of a particular soil mass (Brady and Weil 2005). Potential benefits of increased microbial biomass and their activities includes; increased soil aggregate formation and stability, enhanced plant litter decomposition, increased nutrient cycling and transformations, slow-release storage of organic nutrients, and pathogen control (Lagomarsino et al. 2009; Nautiyal et al. 2010). Organic matter contents of the studied field were found 0.34–2.54% which indicates low to medium percentage of OM.

Soil nutrients are the indicator of soil total productivity and agrochemical quality. Their levels and transformations are critical to soil health (Kibble-white et al. 2008). Organic C and N controls soils microbial catalytic potential and indicates the early warming of management effect on organic matter (Brady and Weil 2005). Soil organic C and total N of the studied samples varied from 0.20 to 1.48% and 0.02 to 1.12%, respectively which are very low.

P and K are the most essential nutrients for plant growth. P range from 1.75 to 36.52 μg/g with a mean value of 8.21 μg/g. Except one sampling field all the sampling fields contain very low phosphorus. Potassium (K) concentrations from 0.15 to 0.33 meq/100 g fall into low to medium range according to the FRG (2012). S is less available but important for soil structure and plant growth (Northern Rivers Soil Health Card-Perennial Horticulture (NRSHCPH) 2010). S content varied from 18.75 to 262.95 μg/g, with a mean value of 138. 60 μg/g indicates high range. B is also substantial micronutrient that occurs in very high levels compared to optimum (1.15–3.04 μg/g). From the Bangladesh Agricultural Research Council (BARC) soil fertility standard (FRG 2012) it is found that soil quality is medium (Table 3).

Physical observation and preparing Soil Health Card (SHC)

The SHC is used to evaluate the status of soil quality and their changes in soil that are affected by field management. A single card covers a specific eco-region characterized by comparable natural resources and farming conditions (USDA-NRCS 1998). The card is developed to assess the soil health through field observations of soil physical, chemical and biological properties (Romig et al. 1996). It provides a qualitative assessment of soil health, and evaluates ratings that do not represent an absolute measure. For farm management soil quality and soil health is recommended to assist farmers to evaluate the effects of their management decisions on soil productivity. The purpose of SHC is not only useful for comparing soil types with one-another, rather to assess each soil's ability to function within its capabilities and outer limitations. Brejda and Moorman (2001) stated that soil quality cannot be measured without some sensitive indicators. A soil quality indicator is a measurable soil property that affects the capacity of a soil to perform a specified function. For the evaluation of soil quality parameters it is desirable to select indicators that are directly related to soil quality (Wang and Gong 1998). The use of scorecards

Table 1 Indicators and their selected criteria for the preparation of Soil Health Card (SHC) according to Northern Rivers Soil Health Card (NRSHC) (2002) based on USDA

Soil quality indicators	Poor (score 1, 2)	Medium (score 3, 4)	Good (score 5, 6)
Soil structure	A large no. of clods found, very poor granular structure	Few clods found, irregular granular structure	No clods found, good granular and crumb structure present
Subsurface compaction	Tightly bonded layers, Interlayer lines cannot be identified easily, a lot of turbulent mixing found	Firm soil, interlayer lines are visible with small turbulent mixing	Loose soil, Interlayer lines can be distinguished easily
Aggregate stability	Aggregate took more than 5 min to break	Aggregate broke apart within 2 min	Aggregate broke apart within 1 min
Ground cover	Less than 40%	40–60%	More than 60%
Soil smell	Highly stagnant muddy smell identified	Little earthy or no smell identified	Fresh earthy smell identified
Soil pH	Less than 5	5–5.5	5.6–8
Organic matter and soil color	Topsoil is light brown in color; color is getting lighter with increasing depth. OM is irrecoverable or can be recovered after a lot of managements	Topsoil is normal brown in color with irregular sign of black portion. OM can be recovered easily	Topsoil and subsoil both are black/deep brown in color
Drainage capacity	Soils drain and dry very slowly; fields remain water logged after simple rain	Soils drain and dry slowly; fields' remains water logged only after heavy rains	Soils drain and dry very quickly; fields remain as usual even after heavy rains
Diversity of macro life	Less than 3 varieties found in naked eye	3–6 varieties found naked eye	More than 6 varieties found in naked eye
Roots and residues	Roots are found only in top soil, no visible residue decomposition found	Roots are found within 8 cm below the surface, little residue decomposition found	Roots are found more than 8 cm below the surface, noticeable residue decomposition found
Earthworm content	Less than 3 in number present	3–6 in number present	More than 6 in number present
Infiltration rate	It takes more than 5 min to infiltrate or no infiltration occurs	It takes 3–5 min to infiltrate	It takes 1–2 min to infiltrate
Soil aeration	No available aeration chance. Soil grains are packed tightly	Moderate permeability chance for air. Inter-granular space is visible	Efficient aeration is possible. Soil has available spaces between two grains
Seedling emergence	Seedlings are irregular in size	Seedlings of each cluster are even in size	Almost all seedlings are even in size
Crop coverage and leaf color	Poor crop growth, yellow/purple/light green in color	Moderate crop growth, green in color	Healthy crop growth, dark green in color

Table 2 Soil physicochemical and nutrient contents from laboratory analysis

Field sample no.	pH	EC	OM	OC	TN	P	K	S	B
	–	dS/m	%	%	%	μg/g	meq/100 g	μg/g	μg/g
Field-1	7.86	1.02	1.17	0.68	0.06	5.49	0.26	56.81	1.17
n = 5	SA	NS	L		VL	VL	M/Opt	VH	VH
Field-2	8.22	0.79	0.34	0.20	0.02	5.73	0.32	18.75	1.15
n = 5	SA	NS	VL		VL	VL	Opt/H	M	VH
Field-3	8.00	4.33	1.17	0.68	0.06	6.91	0.30	254.93	1.69
n = 5	SA	SS	L		VL	VL/L	Opt	VH	VH
Field-4	7.86	6.67	0.83	0.48	0.04	36.52	0.30	144.86	2.27
n = 5	SA	SS	VL		VL	H/VH	Opt	VH	VH
Field-5	7.98	1.27	2.27	1.32	0.11	10.18	0.33	80.43	1.78
n = 5	SA	NS	M		L	L	Opt/H	VH	VH
Field-6	7.92	1.52	1.58	0.92	0.08	6.54	0.22	78.51	1.83
n = 5	SA	NS	L		VL	VL/L	M	VH	VH
Field-7	7.45	6.08	2.41	1.40	0.12	1.75	0.19	262.95	2.39
n = 5	SA	SS	M		L	VL	M	VH	VH
Field-8	6.94	2.19	2.54	1.48	0.12	2.95	0.17	202.25	2.41
n = 5	Nu	FS	M		L	VL	L/M	VH	VH
Field-9	7.48	0.94	1.99	1.16	0.10	3.35	0.19	88.26	2.52
n = 5	SA	NS	M		L	VL	M	VH	VH
Field-10	6.96	2.61	1.79	1.04	0.09	2.59	0.15	198.22	3.04
n = 5	Nu	FS	M		VL	VL	L	VH	VH
Max	8.22	6.67	2.54	1.48	0.12	36.52	0.33	262.95	3.04
Min	6.94	0.79	0.34	0.20	0.02	1.75	0.15	18.75	1.15
Mean	7.67	2.75	1.61	0.94	0.08	8.21	0.25	138.60	2.025

SA slightly alkaline, *Nu* Neutral, *VL* very low, *L* low, *M* medium, *H* high, *VH* very high, *Opt* optimum, *NS* non saline, *FS* few saline, *SS* slightly saline

for on-farm soil quality assessment is emphasized where qualitative observations of soil health are scored to obtain an overall measure of soil quality (Kinyangi 2007; Romig et al. 1996). Two primary reasons for developing scorecards were to promote an increased awareness regarding soil resources and to encourage landowners and operators to "look below ground" when they are evaluating their soil management practices (Karlen et al. 1999). The soil characteristics were classified in terms of the descriptive indicators (Table 1) which were interpreted on a graded scale in Table 4. By scoring all the measured indicators in fields, it was found that the percentage of total score of the studied fields were 83.34, 45.24, 59.53, 50.00, 50.00, 61.91, 71.43, 76.19, 61.91 and 50.00% respectively indicating that except Field 1, soil health quality of all the fields are medium in character (Table 4). This on-farm assessment of soil quality and health is recommended to assist farmers to evaluate the effects of their management decisions on soil productivity.

Comparison among traditional and laboratory analysis

From the scoring of studied parameters, it is found that the soil quality is medium according to laboratory analysis (Table 3). Here it should be noted that the scoring of soil chemical parameters were conducted according to Bangladesh Agricultural Research Council (BARC) fertility standard (Hassan et al. 2012), and according to the SHC soil quality of the studied fields is also medium except Field 1 (Table 4). The comparison among the two methods is presented in Fig. 2. Nevertheless it can be said that this Soil Health Card (SHC) assessment is truly representative and may be an alternative for laboratory assessment method.

Benefits of using Soil Health Card (SHC)

(a) Coasting: cost effectiveness is a major factor for determining soil quality in the field. The total cost required for the two assessment methods are presented in Table 5, and it is found that SHC preparation is much cheaper than the assessment of soil quality by laboratory analysis. So the SHC preparation technique is more cost-effective than any other conventional methods.

(b) Flexibility and time duration: to prepare SHC only field work is essential. But for the assessment of soil quality by measuring physicochemical parameters

Table 3 Physicochemical tests scoring of the collected soil samples according to BARC-FRG (2012)

Field no.	pH[a]	Soil salinity by $EC_{1:1}$ method (dS/m)[a]	OM (%)[a]	TN (%)[a]	P (μg/g)[a]	K (meq/100 g)[a]	S (μg/g)[a]	B (μg/g)[a]	Total score[b]	Percentage (%)	Category
Field-1	5	1	2	1	2	3	6	6	26	54.17	Medium
Field-2	5	1	1	1	2	4	3	6	23	47.92	Medium
Field-3	5	3	2	1	2	4	6	6	29	60.42	Medium
Field-4	5	3	1	1	6	4	6	6	32	66.67	Medium
Field-5	5	1	3	2	2	4	6	6	29	60.42	Medium
Field-6	5	1	2	1	2	3	6	6	26	54.17	Medium
Field-7	5	3	3	2	1	3	6	6	29	60.42	Medium
Field-8	4	2	3	2	1	2	6	6	26	54.17	Medium
Field-9	5	1	3	2	1	3	6	6	27	56.25	Medium
Field-10	4	2	3	1	1	2	6	6	25	52.08	Medium

[a] Here, score 1 = very poor, score 2 = poor, score 3 = medium, score 4 = optimum, score 5 = high, score 6 = very high

[b] Here, poor = <40%, medium = 40–80%, good = >80% indicates the scoring of fields in the assessment of physico-chemical standards

Table 4 Scoring of soil quality indicators according to the Soil Health Card (SHC)

Field no.	Land use	Subsurface compaction[a]	Aggregate stability[a]	Ground cover[a]	Soil smell[a]	Soil color[a]	Microorganism diversity[a]	Earthworm content[a]	Total score[b]	Percentage(%)	Category
Field-1	Paddy field	5	5	6	6	5	4	4	35	83.34	Good
Field-2	Paddy field	2	2	4	2	4	3	2	19	45.24	Medium
Field-3	Paddy field	3	3	4	4	4	4	3	25	59.53	Medium
Field-4	Vegetable	5	5	2	5	2	1	1	21	50.00	Medium
Field-5	Vegetable	3	3	5	2	3	3	2	21	50.00	Medium
Field-6	Paddy field	5	5	6	2	5	2	1	26	61.91	Medium
Field-7	Paddy field	5	5	6	5	2	4	3	30	71.43	Medium
Field-8	Paddy field	5	5	6	5	4	4	3	32	76.19	Medium
Field-9	Paddy field	2	2	6	2	4	6	4	26	61.91	Medium
Field-10	Paddy field	2	2	4	4	5	3	1	21	50.00	Medium

[a] Here, score 1 = very poor, score 2 = poor, score 3 = medium but not efficient, score 4 = medium and quite efficient, score 5 = good, score 6 = very good

[b] Here, poor = <40%, medium = 40–80%, good = >80% levels are followed in catagorising the percentage of the total score assessed by investigating the overall field condition

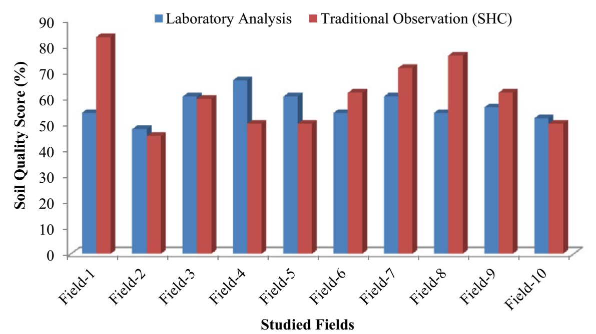

Fig. 2 Comparison between SHC and laboratory analysis test scores

Table 5 Comparison of total costing for laboratory assessment and SHC preparation

Issues	Cost (in BDT) for laboratory assessment	Cost (in BDT) for SHC preparation
Transportation	1000	500
Field equipments total cost (rent)	550	550
Sampling bag and plastic sheet	150	N/A
Lab test (chemical)	1700	N/A
Lab test (physical)	500	N/A
Team organizations with farmers and others (3 members)	N/A	600
Total cost	3900 (49.29 US $)	1650 (20.85 US $)

one has to work both in field and laboratory. In the SHC assessment method no need to sample preparation, which saves the time. The farmers do not need to go to the soil testing office to collect their soil quality data that provides farmers comfortless. So assessment of soil quality by SHC method is much flexible time effective than another one.

Conclusion

Soil Health Card (SHC) is a qualitative assessment tool which can be easily prepared by farmers that can be effective for assessing soil health from routine field observations. It is an initiative for farmers to manage their soil for productivity and for environmental protection. In this study SHC was used to compare with laboratory experiment and found that, the SHC score in percentage was 83.34, 45.24, 59.53, 50.00, 50.00, 61.91, 71.43, 76.19, 61.91, 50.00% which were very similar to the laboratory studied parameters score and the field soil quality is medium category for agricultural use. A farmer can perform a full grade of necessary field management with assistance of this card without any disturbance and long term use of this health card will provide a fruitful soil quality changing trends. This will help farmers to run a sustainable farming system that refers to a complex ecosystem with non-linear dynamics.

Abbreviations

BARC: Bangladesh Agricultural Research Council; B: boron; EC: electric conductivity; GDP: Gross Domestic Product; HCl: hydrochloric acid; H_2SO_4: sulfuric acid; K: potassium; $K_2Cr_2O_7$: potassium dichromate; NRSHC: Northern Rivers Soil Health Card; OC: organic carbon; P: phosphorus; SHC: Soil Health Card; OM: organic matter; S: sulfur; TN: total nitrogen; USDA: United States Department of Agriculture.

Authors' contributions

SMDI literature review, field survey, data analysis and manuscript preparation. MAHB overall management of the field survey and reviewing the manuscript. MM financial support and reviewing the manuscript. MHA field survey and laboratory analysis. SRM field survey and laboratory analysis. All authors read and approved the final manuscript.

Author details

[1] Department of Environmental Sciences, Jahangirnagar University, Dhaka 1342, Bangladesh. [2] Department of Environmental Science and Disaster Management, Noakhali Science and Technology University, Sonapur 3814, Bangladesh. [3] Institute of Surface Earth System Science, Tianjin University, Tianjin, China.

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Author's information

SMDI: Research student at Department of Environmental Sciences, Jahangirnagar University, Bangladesh. He completed B.Sc. (Hon's) and MS in Environmental Sciences from Jahangirnagar University in 2012 and 2013 respectively. His interested areas of research are Coastal Crisis and Management, Hydrology, and Soil Science.

MAHB: Professor and Head of the Department of Environmental Sciences, Jahangirnagar University, Bangladesh. He attended his graduation and master's program in Geological Sciences from Jahangirnagar University, and Ph.D. from Okayama University, Japan. Throughout his career he achieves the 'William Greenwood Award 1999' by Association of Geoscientists for International Development, Brazil; 'Geomorphologist Award 2009' by the International Association of Geomorphologists and 'BAS-TWAS Young Scientists Prize and Gold Medal 2014' by Bangladesh Academy of Science (BAS) and The World Academy of Science (TWAS), Italy. His area of research is on Environmental Geochemistry, Soil Science, Environmental Pollution, Remote Sensing and GIS, Disaster management, Hydromorphology and Climate Change.

MM: Assistant professor in the Department of Environmental Science and Disaster Management, Noakhali Science and Technology University, Bangladesh. He is now perusing Ph.D. at Institute of Surface Earth System Science, Tianjin University, China. He is expert on Environmental Science, Water and Soil Science.

MHA and SRM: Masters student of the Department of Environmental Science and Disaster Management, Noakhali Science and Technology University, Bangladesh. The life purpose of them is to fight against environmental degradation in Bangladesh through sustainable natural resources management.

Competing interests

The authors declare that they have no competing of interests.

Availability of data and materials

Data was generated by author's own attempt by field sampling and laboratory analysis.

Consent for publication

All authors read the manuscript and agree for publication.

Ethics approval and participant consent
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