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Competitive Research Grant

Sub-Project Completion Report

on

Assessment of land degradation situation for improving soil quality and crop productivity using nuclear techniques

Project Duration

July 2017 toSeptember 2018

Soil Science Division
Bangladesh Institute of Nuclear Agriculture

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Acronyms

OC : Organic Carbon

SOC : Soil Organic Carbon

TN : Total Nitrogen

AP : Available Phosphorus

AS : Available Sulphur

AEZ : Agro Ecologocal Zone

BINA : Bangladesh Institute of Nuclear Agriculture

EC : Electrical Conductivity

Table of Contents

Executive Summary

Long-term changes in soil characters in the upper 100 cm layers of the different physiographic units were evaluated using 290 soil samples from 29soil series collected in 2017-18 in order to find out whether the soils have undergone any degradation in Bangladesh during 1967 to 2017. Changes in particle size distribution, soil pH, electrical conductivity, organic carbon, total nitrogen, available phosphorus; Exchangeable potassium, available sulphur, Exchangeable sodium and Exchangeable calcium contents were evaluated.

Over the 50years period, soil pH changed in all the physiographic units, showed a larger decline in the surface soil layers. Considerable variation was observed in the sand, silt and clay distribution of the different soil series in Bangladesh. The clay content decreased for most of the soil series and silt content increased for all depth sampled in 2017.Soil organic carbon (OC) decreased with the increased soil depth. OC ranged from 0.40 to 2.77% at surface layer and 0.31 to 1.63% at deeper soil. Highest OC found in Bharella and the lowest from Gopalpur series. C, N ratio in 83% soil samples was not more than 10 at surface layer and only one series Atwari was 11 at deeper layer. Total N (TN) content for these soils was very low to optimum, TN decreased with increased soil depth, ranged from 0.048 to 0.335% at surface layer and 0.04 to 0.16% at deeper layer.
Available P (AP) content for these soils was better than TN, 75.8% soil contained medium to very high AP at 0-10 cm depth and 44.8% at deeper soil. AP ranged from 3.6 to 69.8 ppm at surface layer. Highest AP was found in Pirgacha series and the lowest in Pritimpasha series. At deeper layer AP varied from 1.95 to 40.37ppm, Highest AP was also found in Pirgacha series and the lowest in Pritimpasha series at 0-100 cm depth. Like AP, 72.4% soils contained medium to high Available S (AS)at surface and 62% medium to optimum at deeper soil. AS ranged from 7.9 to 44.2 ppm at surface layer, highest AS was found in Ghior series and the lowest in Tarakanda series.55.1% of the studied soil contained medium to very high K and Na, 41.3% of it contained medium to high Ca.

The values of soil pH, AP, OC and TN contents were lowest in the highland and increased at the medium lowland and low land. The medium lowland had highest level of exchangeable Na, while exchangeable K and Ca levels were highest in the lowland position. Generally, the soils of Bangladesh are most degraded in OC, TN, exchangeable cations and clay contents. Available phosphorus changed positively or negatively at various physiographic units. The natural and anthropogenic effects played important roles in the trends and rates of soil degradation in Bangladesh during the period of more than 50 years from 1967.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: Assessment of land degradation situation for improving soil quality and crop productivity using nuclear techniques
2. Implementing organization: Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

Principal Investigator: **Dr. Md. Mahbubul Alam Tarafder**
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4. Sub-project budget (Tk):
   4.1 Total: 22,15,173.00 (Twenty two lakh, fifteen thousand, one hundred and seventy three
   4.2 Revised: 19,75,124.00 (Nineteen lakh, seventy five thousand, one hundred and twenty four)
5. Duration of the sub-project:
   5.1 Start date (based on LoA signed): 12 July 2017
   5.2 End date: 30 September 2018
6. **Justification of undertaking the sub-project:** Within the past few decades changes in various aspects in agriculture such as adoption of high yielding crop varieties along with increased irrigation and fertilization were observed over country. Many reports indicate that crop production is either stagnating or declining over time due to depletion of soil fertility. It is therefore necessary to evaluate changes in soil character over time 1967 to 2017 for the assessment of land degradation situation in Bangladesh.
7. Sub-project goal:
   Developing land degradation database for achieving food security and sustainable agricultural development by improving soil quality and crop productivity.

8. Sub-project objective (s):
   i. To monitor the changes of physical and chemical properties of soil from 43 soil series of Bangladesh within 50 years (1967-2017).
   ii. To develop national data base of fallout radionuclides (^{137}Cs, ^{210}Pb, ^{226}Ra, $^{210}Pb_{ex}$, ^{238}U, ^{40}K etc.) in soil with reference value and soil erosion/deposition rate over several time scales in Bangladesh.
   iii. To utilize nuclear techniques for short term changes by land use practice and the effectiveness of specific soil conservation measures/management system to sustain soil fertility and crop productivity.

9. Implementing location (s): All over the Bangladesh

10. Methodology:

Both laboratory and field studies were conducted according to the project purpose. However, the following approaches and methodologies were used to achieve the objectives of the proposed research project.

Collection, compilation and review of available literature, meteorological, fallout radionuclide and soil physical & chemical data of some selected AEZs of Bangladesh.

Collection of soil samples:

Soil Samples for nutrient depletion within 50 years (1967-2017):
To determine changes in soil characters, 29 samples were collected from 43 soil series (Table 1& figure

1) of same sites/points of the previous sampling locations by SRDI (1963-1975) and BINA (1967-1996 & 2001-2003) (RSS, 1963-75 and Ali 1997). Soil samples could not collect from 14 soil series due to building construction. Soil samples were collected at a regular interval of 10 cm from the surface to 100 cm depth in each profile. Soil samples were analyzed in the laboratory on the following parameters: soil texture, soil bulk density, soil moisture, soil pH, EC, SOC, N, P, K, S, Mg, trace elements and heavy metals. All samples wereair dried at room temperature and sieved through 2 mm sieve and weighed. Physical and chemical analysesof soil samples were done using standard analytical methods using Atomic absorption spectrophotometer, UV-visible spectro- photometer, Flame photometer etc.

Table 1: Name of soil series, location and agro-echological zones

Sl. no.	Series name	Location	AEZ
01	Atwari	Boda, District: Panchagarh	01
02	Jagdal	Birgonj, District: Dinajpur	01
03	Pirgacha	Rangpur Sadar, District: Rangpur	03
04	Kaunia	Rangpur Sadar, District: Rangpur	03
05	Chandra	Pirganj, District: Rangpur	03
06	Belabo	Pirganj, District: Rangpur	03
07	Ghior	Baraigram, District: Natore	05
08	Gopalpur	Kotwali, District: Pabna	12
09	Garuri	Mirpur, District: Kustia	10
10	Gopal pur	Mirpur, District: Kustia.	10
11	Garuri	Mirpur, District: Kustia	10
12	Amjhupi	Monirampur, District:Jessore	14
13	Jhalakati	Dumuria, District: Khulna	13
14	Ghior	Daulatpur, District: Khulna.	13
15	Ghior	Faridpur Sadar, District: Faridpur	12
16	Rathuria	Sibalay, District: Manikgonj	12,8
17	Sara	Sibalay, District: Manikgonj	12,8
18	Derma	Chandpara, District: Gazipur	28
19	Chhiata	Gazipur sadar. District: Gazipur.	28
20	Kalma	Savar, District: Dhaka	28
21	Noadda	Savar, District: Dhaka.	28
22	Khilgoan	Gulshan, District: Dhaka	28
23	Pagla	Savar, District: Dhaka.	28
24	Dhamrai	Dhamrai, District: Dhaka	28
25	Sonatala	Savar, District: Dhaka.	28
26	Sabhar	Dhamrai, District: Dhaka	28
27	Lokdeo	Madhupur, District: Tangail	28
28	Tarakanda	Gouripur, District: Mymensingh	09,08
29	Silmondi	Gouripur, District: Mymensingh	09,08
30	Siddhirgonj	Demra District: Dhaka.	28
31	Jalkundi	Demra, District: Narayanganj	28
32	Tippera	Laksham, District: Comilla	19
33	Burichang	Muradnagar, District: Comilla	19
34	Gumti	Daudkandi, District: Comilla	19
35	Phagu	Sylhet sadar Sylhet.	20
36	Goyainghat	Sylhet sadar, District: Sylhet.	20
37	Jhinaighati	Haluaghate, District: Mymensingh	09
38	Pritimpasa	Kulaura District: Moulvi Bazar	20
39	Bharella series	Comilla sadar, District: Comilla.	19
40	Mirsarai	Hathazari, District: Chittagong	23
41	Noapara	Raojan Chittagong.	23
42	Raojan	Patiya, District: Chittagong	23
43	Harta	Batiaghat, District: Khulna	13

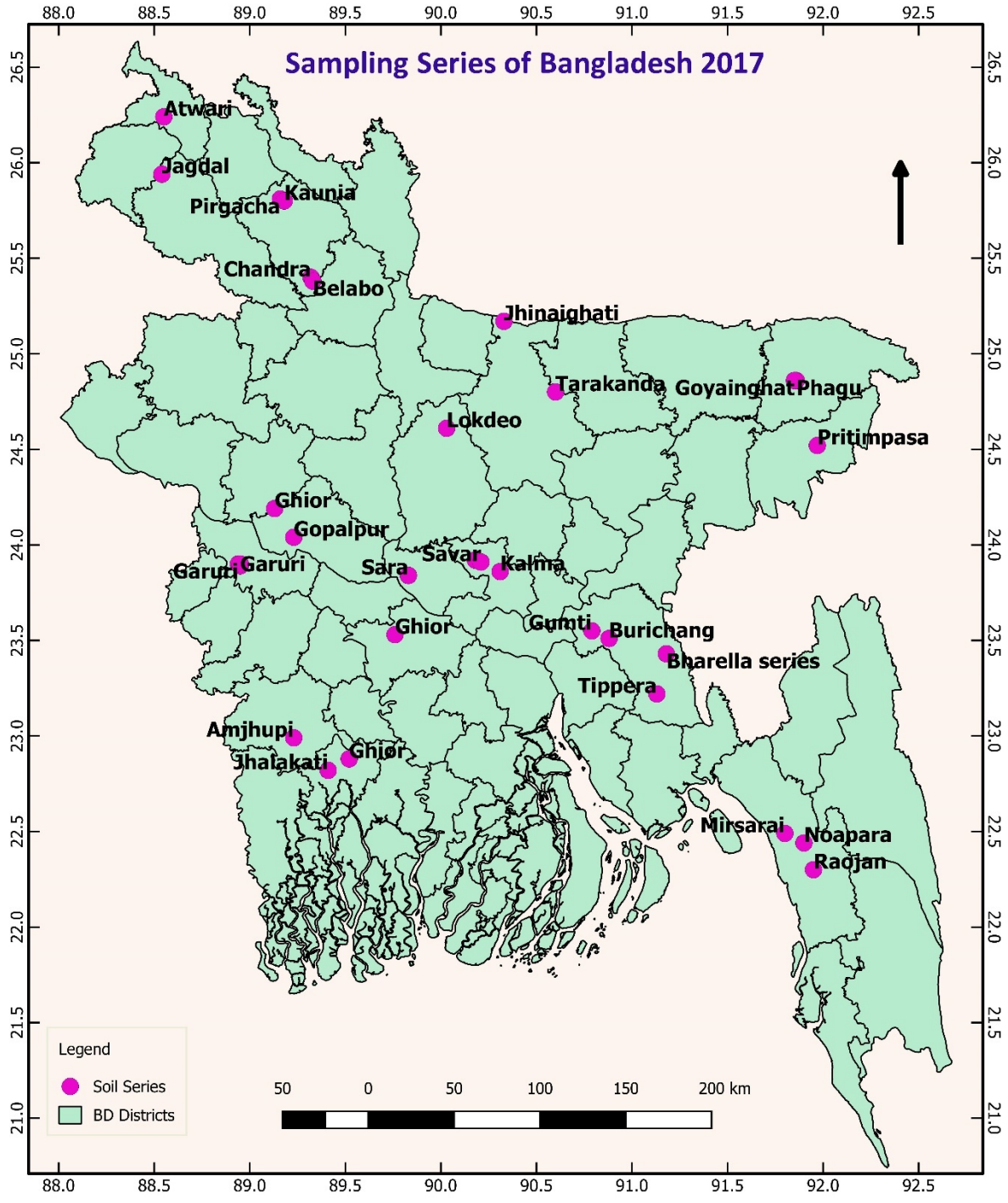

Fig 1: Soil sampling series of Bangladesh on 2017

11. Results and discussion:

Various physico-chemical properties of the 0-100 cm depths for the different soil series of Bangladesh are presented in Appendix 1-5. Changes in these characters were observed in most of the soil series over the period 1967 to 2017.

Soil pH:

Table 2 illustrates the pH value of the soil series and the changes at 0-10 cm and 0-100 cm soil layers during the period 1967-2017. Soil pH of the series is Strongly acidic to Slightly alkaline. At 0-10 cm depth 31% soil is strongly acidic, 27.6% slightly acidic, 17.2% neutral and 24.1% slightly alkaline. On the other hand, at 0-100 cm depth 3.4% soil is strongly acidic, 37.9% slightly acidic, 17.2% neutral and 41.4% slightly alkaline. Soil pH increased in both 0-10 and 0-100 cm depth at Atwary, Jagdal, Shara, Amjhupi, Ghior, Damrai, Savar bazar, Lokdeo, Goyanghat, Pritimpasha and Mirsai by 1.2 to 31.2%. Soil pH decreased in 0-10 cm and increased in 0-100 cm depth at Pirgacha, Chandra, Belabo, Rathuria, Tipera, Burichong, Phagu and Raojan. Soil pH increased in 0-10 cm and decreased in 0-100 cm at Kaunia and Ghior. In both depths soil pH decreased at Gopalpur, Garuri, Shara, Tarakanda, Gumti and Bharella. Soil pH showed a larger decline in the 0-10 cm layers compared to 0-100 cm layers in most of the series with some exceptions, where a reverse trend was observed. At 0-10 cm layers highest soil pH increased (31.2%) in Gior series, Ganges floodplain and highest decreased (20.3%) in Tarakanda, Brahmaputra floodplain.

Changes in pH in the 0-100 cm layers varied widely within the soils from different soil series. The increase in the value of soil pH was highest (18.9%) in Amjhupi and highest decrease (6.7%) in Gumti soil series. Mean value for Bangladesh showed an increase of 2.2% at 0-10 cm and 5.1% at 0-100 cm soil layer over the 50 years.

Table 2: Changes in soil pH within 0-10 cm and 0-100 cm layers of the different soil series during the period 1967-2017 in Bangladesh.

Profile no.	Series	Depth (cm)	pH		
			1967	2017	Change (%)
1	Atwary	0-10	5.8	6.1	5.3
		0-100	6.1	6.3	2.4
2	Jagdal	0-10	5.3	6.1	15.9
		0-100	5.6	6.5	15.7
3	Pirgacha	0-10	5.5	5.2	-5.1
		0-100	5.8	6.2	7.2
4	Kaunia	0-10	5.2	5.9	12.6
		0-100	6.0	6.0	-0.7
5	Chandra	0-10	5.3	5.0	-6.8
		0-100	5.4	5.9	10.0
6	Belabo	0-10	5.6	5.4	-2.9

Profile no.	Series	Depth (cm)	pH		
			1967	2017	Change (%)
		0-100	5.4	5.6	3.1
7	Ghior	0-10	7.4	7.5	1.5
		0-100	8.2	7.8	-5.6
8	Gopalpur	0-10	8.1	7.8	-4.4
		0-100	8.2	7.8	-4.4
9	Garuri	0-10	7.9	6.7	-15.0
		0-100	7.9	7.8	-1.3
10	Gopalpur	0-10	8.2	8.1	-1.6
		0-100	8.5	8.2	-3.6
11	Shara	0-10	8.0	8.1	1.2
		0-100	8.1	8.2	2.2
12	Amjhupi	0-10	6.6	7.5	13.0
		0-100	6.7	7.9	18.9
14	Ghior	0-10	6.0	7.9	31.2
		0-100	7.2	8.2	13.2
15	Ghior	0-10	6.6	7.1	8.7
		0-100	7.4	7.9	7.8
16	Rathuria	0-10	6.6	6.1	-8.2
		0-100	7.7	7.8	1.4
17	Shara	0-10	7.7	7.3	-4.7
		0-100	8.3	8.0	-4.1
24	Damrai	0-10	5.9	6.4	8.0
		0-100	6.7	7.4	10.6
26	Savar bazar	0-10	5.6	7.0	25.4
		0-100	6.5	7.1	9.3
27	Lokdeo	0-10	5.5	6.6	20.4
		0-100	5.9	6.9	15.5
28	Tarakanda	0-10	6.4	5.1	-20.3
		0-100	6.6	6.3	-3.9
32	Tipera	0-10	6.3	5.9	-7.0
		0-100	7.0	7.4	6.9
33	Burichong	0-10	5.8	5.7	-1.4
		0-100	6.7	7.6	12.9
34	Gumti	0-10	5.4	5.2	-3.9
		0-100	6.8	6.4	-6.7
35	Phagu	0-10	5.1	4.9	-4.3
		0-100	5.4	6.4	17.7
36	Goyainghat	0-10	5.1	5.2	2.2
		0-100	6.0	6.2	4.1
38	Pritimpasha	0-10	5.1	5.6	9.2
		0-100	4.9	5.5	10.8
40	Bharella	0-10	5.8	4.8	-17.4
		0-100	6.3	6.1	-2.7
41	Mirsarai	0-10	6.1	7.4	21.6
		0-100	6.7	7.3	10.2
43	Raojan	0-10	6.2	5.6	-9.2

Profile no.	Series	Depth (cm)	pH		
			1967	2017	Change (%)
		0-100	6.9	7.0	0.7

Table 3: Electrical conductivity (EC) in the 0-10 cm and 0-100 cm layers in the different soil series of 2017 in Bangladesh.

Profile no.	Series	Depth (cm)	EC (dS/m)
1	Atwary	0-10	0.06
		0-100	0.04
2	Jagdal	0-10	0.08
		0-100	0.06
3	Pirgacha	0-10	0.08
		0-100	0.03
4	Kaunia	0-10	0.03
		0-100	0.03
5	Chandra	0-10	0.21
		0-100	0.07
6	Belabo	0-10	0.04
		0-100	0.04
7	Ghior	0-10	0.44
		0-100	0.39
8	Gopalpur	0-10	0.27
		0-100	0.31
9	Garuri	0-10	0.48
		0-100	0.35
10	Gopalpur	0-10	0.23
		0-100	0.20
11	Shara	0-10	0.19
		0-100	0.23
12	Amjhupi	0-10	0.26
		0-100	0.27
14	Ghior	0-10	0.78
		0-100	0.67
15	Ghior	0-10	0.29
		0-100	0.18
16	Rathuria	0-10	0.22
		0-100	0.22
17	Shara	0-10	0.19
		0-100	0.16
24	Damrai	0-10	0.19
		0-100	0.19
26	Savar bazar	0-10	0.27
		0-100	0.21
27	Lokdeo	0-10	0.20

Profile no.	Series	Depth (cm)	EC (dS/m)
		0-100	0.20
28	Tarakanda	0-10	0.43
		0-100	0.19
32	Tipera	0-10	0.15
		0-100	0.12
33	Burichong	0-10	0.11
		0-100	0.18
34	Gumti	0-10	0.07
		0-100	0.05
35	Phagu	0-10	0.08
		0-100	0.09
36	Goyainghat	0-10	0.04
		0-100	0.05
38	Pritimpasha	0-10	0.02
		0-100	0.02
40	Bharella	0-10	0.26
		0-100	0.20
41	Mirsarai	0-10	0.13
		0-100	0.13
43	Raojan	0-10	0.33
		0-100	0.35

Particle size distribution in the surface 0-10 cm layers and the 0-100 cm layers of the different soil series is shown in Table 4. At 0-10 cm depth 48.3% is clay soil,10.3% Silt clay, 27.6% Silt clay loam, 10.3% Silt loam and 3.4% Sandy clay; at 0-100 cm depth 3.4% is silt, 89.7% Silt loam and 6.9% Sandy loam.

From the Table 4, considerable variation was observed in the sand, silt and clay distribution of the different soil series sampled in 1967 and 2017. The clay content decreasedat 0-10 cm depthin all the soil series and for 0-100 cm depth, most of the series and silt content increasedat 0-10 cm and 0-100 cm depth in all the studied samples collected in 2017.

At the series level, the status of particle size distribution in 1967 and 2017 sampled soils showed relatively higher decrease in Sand and clay content and increase in silt content. Sand content decreased in the surface 0-10 cm layers in most of the series, as Autoary, Jagdal, Pirgacha, Chandra, Belabo, Ghior, Gopalpur, Garori, Gopalpur, Shara, Amjupi, Rathuria, Shara, Saver, Logdu, Tarakanda, Tipera, Burichong, Gomoti, Fagu, Guailghat, Pritompasha, Verella, Mirsorai and Raojanseries. The surface 0-10 cm layers showed relatively lower decrease in sand content than the 0-100 cm layers with few exception (Table 4). A relatively higher enrichment of clay content in 0-100 cm layers was also observed in the Kaunia, Ghior, and Saver series during the period 1967-2017.

Silt content increased in both 0-10 cm and 0-100 cm layers in all soil series. (Table 4).

Clay content (>30%) in the surface 0-10 cm layers in most of the series, as Jagdal, Pirgacha, Kaunia, Belabo, Ghior, Gopalpur, Garori, Shara, Amjupi, Ghior, Ghior, Rathuria, Shara, Damry, Saver, Logdu, Tarakanda, Tipera, Burichong, Gomoti, Fagu, Guailghat, Pritompasha, and Verellaseries. The surface 0-10 cm layers showed relatively higher decrease in clay content than the 0-100 cm layers with few exception (Table 4). A relatively higher enrichment of clay content in 0-100 cm layers was also observed in the Atwary, Bharella and Mirsarai series during the period 1967-2017. The lower clay content near the surface of many wet-cultivated soils is probably due mainly to their weathering associated with alternate flooding and drainage, as described by Brinkman (1970). Another process that can contribute to loss of clay from the surface soil is its removal in the surface water during puddling when muddy water overflows from the higher to the lower fields. An opposite process of enrichment with clay-size particles in the surface soils is sometimes brought about by irrigation with muddy water (Moormann and Breemen, 1978).

Table 4: Particle size distribution in the 0-10 cm and 0-100 cm layers in the different soil series of 2017 in Bangladesh.

Profile no.	Series	Depth (cm)	Sand (%)		Silt (%)		Clay (%)	
			1967	2017	1967	2017	1967	2017
1	Atwary	0-10	37.0	15.84	46.3	72.06	16.7	12.10
		0-100	39.0	11.82	46.6	68.84	**14.7**	**19.33**
2	Jagdal	0-10	42.7	33.32	38.5	56.72	18.8	9.96
		0-100	48.0	24.56	32.5	58.44	19.5	17.00
3	Pirgacha	0-10	68.6	46.90	21.4	49.51	10.0	3.59
		0-100	62.0	65.67	24.0	33.65	14.1	0.68
4	Kaunia	0-10	24.9	36.63	55.9	58.47	19.2	4.90
		0-100	42.1	51.35	43.0	44.67	14.9	3.98
5	Chandra	0-10	54.2	8.99	31.8	78.61	14.0	12.41
		0-100	44.6	7.47	30.1	74.38	25.3	18.16
6	Belabo	0-10	44.6	19.86	31.5	70.58	23.9	9.54
		0-100	38.3	8.23	27.1	76.66	34.6	15.10
7	Ghior	0-10	12.9	2.96	38.9	77.50	48.2	19.53
		0-100	29.2	2.17	37.6	78.68	33.2	19.16
8	Gopalpur	0-10	9.2	8.64	59.7	83.42	31.1	7.93
		0-100	36.5	9.74	40.1	82.68	23.4	7.59
9	Garuri	0-10	5.1	5.28	38.7	74.31	56.2	20.41
		0-100	22.7	4.78	39.2	74.87	38.1	20.36
10	Gopalpur	0-10	57.0	15.21	26.8	71.73	16.2	13.05
		0-100	47.6	19.66	29.2	66.65	23.3	13.69
11	Shara	0-10	16.6	20.84	36.6	70.81	46.8	8.35
		0-100	35.1	15.03	31.5	70.77	33.4	14.20
12	Amjhupi	0-10	5.1	3.87	63.9	78.52	31.0	17.61
		0-100	13.8	1.63	53.3	78.29	32.9	20.09
14	Ghior	0-10	*2.7*	6.94	40.2	70.36	57.1	22.70
		0-100	17.5	1.13	41.6	72.22	41.0	26.65
15	Ghior	0-10	3.2	3.78	35.0	64.78	61.8	31.44

Profile no.	Series	Depth (cm)	Sand (%)		Silt (%)		Clay (%)	
			1967	2017	1967	2017	1967	2017
		0-100	5.2	16.53	45.9	69.04	48.9	14.43
16	Rathuria	0-10	19.4	1.33	46.1	79.52	34.5	19.15
		0-100	8.7	3.04	54.9	81.06	36.4	15.90
17	Shara	0-10	48.2	3.38	37.0	86.27	14.8	10.35
		0-100	26.8	10.86	50.7	82.18	22.5	6.96
24	Damrai	0-10	8.2	16.37	55.5	70.95	36.3	12.67
		0-100	48.9	8.16	35.8	75.78	16.3	16.05
26	Savar bazar	0-10	4.8	15.88	56.2	78.50	39.0	5.62
		0-100	25.8	11.20	50.6	76.33	23.6	12.47
27	Lokdeo	0-10	18.8	10.73	57.8	79.21	23.2	10.04
		0-100	26.1	13.34	50.9	76.35	22.9	10.30
28	Tarakanda	0-10	47.0	19.93	29.1	72.54	23.9	7.53
		0-100	61.9	27.85	23.7	66.48	14.4	5.67
32	Tipera	0-10	28.5	5.74	60.5	86.88	11.0	7.39
		0-100	44.6	3.09	45.2	87.75	10.2	9.16
33	Burichong	0-10	18.2	2.48	50.7	88.05	31.1	9.47
		0-100	19.6	8.22	52.2	82.31	28.2	9.47
34	Gumti	0-10	10.6	0.80	55.6	90.75	33.8	8.45
		0-100	37.9	17.15	42.7	74.90	19.4	7.95
35	Phagu	0-10	0.1	3.16	30.7	68.56	69.2	28.27
		0-100	17.1	2.66	36.2	68.73	46.7	28.61
36	Goyainghat	0-10	29.1	5.51	51.6	84.30	19.3	10.20
		0-100	24.1	2.05	51.9	76.41	24.1	21.54
38	Pritimpasha	0-10	57.6	36.62	32.6	58.32	9.8	5.07
		0-100	30.1	22.75	39.3	63.28	30.6	13.97
40	Bharella	0-10	31.7	15.13	46.2	72.75	22.1	12.10
		0-100	50.4	4.95	28.0	71.33	21.6	23.71
41	Mirsarai	0-10	40.5	16.54	37.5	67.59	22.0	15.86
		0-100	40.5	19.06	38.0	65.97	21.5	14.97
43	Raojan	0-10	33.3	11.19	47.1	71.54	19.6	17.27
		0-100	37.7	1.78	39.4	74.34	22.9	23.88

Organic carbon (OC):

Table 5 showed the concentration of OC among the soil series, organic carbon content for these soils was very low to high. At 0-10 cm depth 3.4% soil was very low, 24.1% low, 55.2% medium and 17.2% was high. Soil organic carbon decreased with the increased soil depth. At 0-100 cm depth 65.5% soil was very low, 31.0% low, 3.4% medium and there was no medium OC in 0-100 cm depth. OC ranged from 0.40 to 2.77% at surface layer. Highest OC found in Bharella and the lowest from Gopalpur series. At deeper layer OC varied from 0.31 to 1.63%, only one sample from Atwary was medium and the rest were low to very low. Lowest OC was recorded from Shara at 0-100 cm depth.

C, N ratio:

C:N is presented in Table 5. Among the series 83% is not more than 10 and 17% is good in C:N at 0-10cm depth, at 0-100 cm depth only one series Atwari was good in C:N and the rest series was not good.

Table 5: OC (%) and C:N in the 0-10 cm and 0-100 cm layers in the different soil series of 2017 in Bangladesh.

Profile no.	Series	Depth (cm)	OC (%)	C:N
1	Atwary	0-10	2.46	9
		0-100	1.63	11
2	Jagdal	0-10	0.84	8
		0-100	0.33	5
3	Pirgacha	0-10	1.11	23
		0-100	0.32	9
4	Kaunia	0-10	0.67	5
		0-100	0.35	5
5	Chandra	0-10	1.27	7
		0-100	0.47	5
6	Belabo	0-10	1.19	10
		0-100	0.46	9
7	Ghior	0-10	1.55	8
		0-100	0.60	7
8	Gopalpur	0-10	0.40	6
		0-100	0.35	6
9	Garuri	0-10	1.35	7
		0-100	0.64	5
10	Gopalpur	0-10	0.87	8
		0-100	0.37	7
11	Shara	0-10	1.03	7
		0-100	0.50	5
12	Amjhupi	0-10	1.36	7
		0-100	0.48	4
14	Ghior	0-10	1.83	7
		0-100	0.76	5
15	Ghior	0-10	1.35	6
		0-100	0.39	6
16	Rathuria	0-10	1.11	7
		0-100	0.43	4
17	Shara	0-10	0.84	35
		0-100	0.31	8
24	Damrai	0-10	1.12	9
		0-100	0.50	7
26	Savar bazar	0-10	1.51	10
		0-100	0.56	7
27	Lokdeo	0-10	0.59	8
		0-100	0.32	6
28	Tarakanda	0-10	1.63	8
		0-100	0.43	6
32	Tipera	0-10	2.39	8
		0-100	0.63	5

Profile no.	Series	Depth (cm)	OC (%)	C:N
33	Burichong	0-10	2.50	9
		0-100	0.59	4
34	Gumti	0-10	0.91	6
		0-100	0.43	4
35	Phagu	0-10	2.39	11
		0-100	0.66	5
36	Goyainghat	0-10	1.71	8
		0-100	0.58	4
38	Pritimpasha	0-10	1.27	7
		0-100	0.47	5
40	Bharella	0-10	2.77	8
		0-100	0.79	4
41	Mirsarai	0-10	1.27	19
		0-100	0.41	8
43	Raojan	0-10	1.75	8
		0-100	0.59	5

Total Nitrogen (TN):

Among the soil series, TN content for these soils was very low to optimum at 0-10 cm depth and very low to low at 0-100 cm (Table 6). At 0-10 cm depth 13.8% soil was very low, 41.4% low, 27.6% medium and 17.2% was high. TN decreased with the increased soil depth. At 0-100 cm depth 51.7% soil was very low and 48.3% was low. TN ranged from 0.048 to 0.335% at surface layer. Highest TN was found in Bharella series and the lowest from Pirgacha series. At deeper layer TN varied from 0.04 to 0.16%, Highest TN was found in Rathuria series and the lowest from Pirgacha series at 0-100 cm depth.

Available Phosphorus (AP):

AP content for these soils was very low to very high at surface and deeper soil (Table 6). At 0-10 cm depth 6.9% soil was very low, 17.2% low, 17.2% medium, 17.2% optimum and 41.4% was very high. AP content decreased with the increased soil depth. At 0-100 cm depth 17.2% soil was very low and 37.9% was low, 13.8% medium, 13.8% optimum, 6.9% high and 10.3% was very high. AP ranged from 3.6 to 69.8 ppm at surface layer. Highest AP was found in Pirgacha series and the lowest from Pritimpasha series. At deeper layer AP varied from 1.95 to 40.37%, Highest AP was found also in Pirgacha series and the lowest from Pritimpasha series at 0-100 cm depth.

Exchangeable potassium (Ex. K):

Exchangeable K content for these soils was very low to very high at surface and deeper soil (Table 6). At 0-10 cm depth 13.8% soil was very low, 31% low, 31% medium, 6.9% optimum, 10.3% high and 6.9% was very high. At 0-100 cm depth 17.2% soil was very low and 37.9% was low, 31% medium, 10.3% optimum and 3.4% high. Exchangeable K ranged from 0.06 to 0.42 meq% at surface layer, highest Exchangeable K was found in Garuri series and the lowest from Lokdeo series. At deeper layer Exchangeable K varied from 0.05 to 0.37 meq%, highest meq% was found in Amjhupi series and the lowest from Pritimpasha series at 0-100 cm depth.

Available sulphur (AS):

AS content of these soils were very low to high at surface but very low to optimum at deeper soil (Table 6). At 0-10 cm depth 3.4% soil was very low, 24.1% low, 48.3% medium, 17.2% optimum, and 6.9% was high. At 0-100 cm depth 3.4% soil was very low and 34.5% was low, 58.6% medium and 3.4% optimum. AS ranged from 7.9 to 44.2 ppm at surface layer, highest AS was found in Ghior series and the lowest from Tarakanda series. At deeper layer AS varied from 7.3 to 40.5 ppm, highest AS was found in Amjhupi series and the lowest from Gumti series at 0-100 cm depth.

Table 6: Total N (%), available P (ppm), Exchangeable K (meq/100g) and available S (ppm) in the 0-10 cm and 0-100 cm layers in the different soil series of 2017 in Bangladesh.

Profile no.	Series	Depth (cm)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100 g)	Available S (ppm)
1	Atwary	0-10	0.277	13.47	0.076	22.770
		0-100	0.15	10.66	0.08	21.03
2	Jagdal	0-10	0.101	68.16	0.082	21.010
		0-100	0.06	20.03	0.09	21.77
3	Pirgacha	0-10	0.048	106.84	0.33	16.080
		0-100	0.04	40.37	0.13	17.74
4	Kaunia	0-10	0.126	50.11	0.18	21.010
		0-100	0.07	32.16	0.12	19.26
5	Chandra	0-10	0.173	34.56	0.37	25.200
		0-100	0.09	13.54	0.16	20.50
6	Belabo	0-10	0.123	32.71	0.09	18.480
		0-100	0.06	6.54	0.13	15.12
7	Ghior	0-10	0.204	22.73	0.19	44.15
		0-100	0.09	6.10	0.24	25.47
8	Gopalpur	0-10	0.061	9.74	0.14	21.34
		0-100	0.06	5.53	0.18	26.04
9	Garuri	0-10	0.207	42.29	0.42	19.4
		0-100	0.12	11.05	0.25	13.2
10	Gopalpur	0-10	0.11	16.61	0.19	12.5

Profile no.	Series	Depth (cm)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100 g)	Available S (ppm)
		0-100	0.06	8.94	0.15	26.5
11	Shara	0-10	0.138	11.48	0.11	20.2
		0-100	0.10	7.03	0.16	19.5
12	Amjhupi	0-10	0.187	22.68	0.23	27.4
		0-100	0.11	6.03	0.30	40.5
14	Ghior	0-10	0.281	43.74	0.38	19.4
		0-100	0.14	13.81	0.37	20.9
15	Ghior	0-10	0.224	12.69	0.33	11.8
		0-100	0.06	6.60	0.16	13.8
16	Rathuria	0-10	0.161	29.35	0.17	21.7
		0-100	0.16	9.18	0.20	18.2
17	Shara	0-10	0.124	20.87	0.14	25.0
		0-100	0.06	7.33	0.13	17.8
24	Damrai	0-10	0.121	4.74	0.08	17.1
		0-100	0.07	5.02	0.09	21.6
26	Savar bazar	0-10	0.149	11.09	0.07	10.5
		0-100	0.08	8.90	0.08	16.7
27	Lokdeo	0-10	0.076	16.51	0.06	9.2
		0-100	0.06	15.05	0.05	13.1
28	Tarakanda	0-10	0.202	32.20	0.07	7.9
		0-100	0.06	15.86	0.05	9.4
32	Tipera	0-10	0.286	8.94	0.21	24.9
		0-100	0.11	5.57	0.10	16.2
33	Burichong	0-10	0.285	14.35	0.13	31.9
		0-100	0.11	6.46	0.06	21.2
34	Gumti	0-10	0.161	35.88	0.16	16.4
		0-100	0.10	14.73	0.13	7.3
35	Phagu	0-10	0.213	4.99	0.25	33.5
		0-100	0.12	7.94	0.16	21.7
36	Goyainghat	0-10	0.225	26.13	0.16	18.3
		0-100	0.13	16.39	0.11	17.9
38	Pritimpasha	0-10	0.176	3.59	0.08	33.5
		0-100	0.10	1.95	0.05	21.5
40	Bharella	0-10	0.335	26.27	0.187	39.2
		0-100	0.15	11.32	0.18	25.9
41	Mirsarai	0-10	0.066	4.96	0.07	26.2
		0-100	0.05	32.03	0.06	25.8
43	Raojan	0-10	0.208	8.08	0.17	32.7
		0-100	0.11	5.87	0.18	25.4

Exchangeable Na:

Among the soil series, Exchangeable Na content for these soils was very low to very high at surface and deeper soil (Table 7). At 0-10 cm depth 10.3% soil was very low, 34.5% low, 13.8% medium, 6.9% was high and 34.5% was very high. At 0-100 cm depth 10.3% soil was very low, 31% low, 10.3% medium, 17.2% was high and 31% was very high. Exchangeable Na ranged from 0.09 to 2.76 meq% at surface layer. Highest Exchangeable Na was found in Ghior series and the lowest from Tarakanda series. At deeper layer Exchangeable Na varied from 0.11 to 2.71 meq%, Highest Exchangeable Na was found in Ghior series and the lowest from Pirgacha series at 0-100 cm depth.

Exchangeable Ca:

Among the soil series, Exchangeable Ca content for these soils was very low to very high at surface and deeper soil (Table 7). At 0-10 cm depth 41.4% soil was very low, 17.2% low, 13.8% medium, 3.4% was optimum, 3.4% was high and 20.7% was very high. At 0-100 cm depth 27.6% soil was very low, 27.6% low, 3.4% medium, 10.3% was optimum, 3.4% was high and 27.6% was very high. Exchangeable Ca ranged from 0.29 to 9.79 meq% at surface layer. Highest Exchangeable Ca was found in Ghior series and the lowest from Tarakanda series. At deeper layer Exchangeable Ca varied from 0.30 to 12.15 meq%, Highest Exchangeable Ca was found in Amjhupi series and the lowest from Pirgacha series at 0-100 cm depth.

Table 7: Exchangeable Na (meq/100g) and Exchangeable Ca (meq/100g) in the 0-10 cm and 0-100 cm layers in the different soil series of 2017 in Bangladesh.

Profile no.	Series	Depth (cm)	Exch. Na (meq/100g)	Exch. Ca (meq/100g)
1	Autoary	0-10	0.24	1.128
		0-100	0.27	1.13
2	Jagdal	0-10	0.18	0.941
		0-100	0.21	1.35
3	Pirgacha	0-10	0.17	0.564
		0-100	0.11	0.30
4	Kaunia	0-10	0.24	0.752
		0-100	0.20	0.75
5	Chandra	0-10	0.24	0.564
		0-100	0.22	1.03
6	Belabo	0-10	0.24	0.564
		0-100	0.23	0.79
7	Ghior	0-10	0.34	0.521
		0-100	0.40	8.71
8	Gopalpur	0-10	0.23	8.471
		0-100	0.30	8.80
9	Garori	0-10	0.81	6.518
		0-100	0.89	8.07

Profile no.	Series	Depth (cm)	Exch. Na (meq/100g)	Exch. Ca (meq/100g)
10	Gopalpur	0-10	0.87	8.381
		0-100	0.84	7.97
11	Shara	0-10	0.94	7.557
		0-100	0.90	8.30
12	Amjupi	0-10	0.94	9.785
		0-100	0.95	12.15
14	Ghior	0-10	2.76	8.972
		0-100	2.71	11.25
15	Ghior	0-10	0.84	8.391
		0-100	0.88	8.80
16	Rathuria	0-10	0.41	3.643
		0-100	0.67	6.83
17	Shara	0-10	0.46	3.643
		0-100	0.61	5.46
24	Damry	0-10	0.14	2.216
		0-100	0.15	2.65
26	Saver	0-10	0.21	1.575
		0-100	0.29	2.16
27	Logdu	0-10	0.19	1.146
		0-100	0.28	1.84
28	Tarakanda	0-10	0.09	0.286
		0-100	0.17	1.07
32	Tipera	0-10	0.67	4.39
		0-100	0.65	4.77
33	Burichong	0-10	0.42	2.50
		0-100	0.40	2.17
34	Gomoti	0-10	0.75	3.14
		0-100	0.72	3.27
35	Fagu	0-10	0.37	1.67
		0-100	0.53	2.42
36	Guailghat	0-10	0.59	0.91
		0-100	0.49	1.73
38	Pritompasha	0-10	0.32	0.83
		0-100	0.18	0.83
40	Verella	0-10	0.79	5.03
		0-100	0.68	5.09
41	Mirsorai	0-10	1.66	1.64
		0-100	1.72	1.58
43	Raojan	0-10	0.81	1.09
		0-100	1.19	1.77

12. Research highlight/findings:

- The soils of Bangladesh are most degraded in organic carbon, total nitrogen, exchangeable cations and clay contents.
- Over the 50 years period, soil pH changed in all the physiographic units, showed a larger decline in the surface soil layers. The clay content decreased for most of the soil series, but silt content increased for all depth.
- Soil organic carbon decreased with the increased soil depth. OC ranged from 0.40 to 2.77% at surface layer and 0.31 to 1.63% at deeper soil.
- C, N ration inmost soil lower than the standard value.
- TN content for these soils was very low to optimum, TN decreased with the increased soil depth, ranged from 0.048 to 0.335% at surface layer and 0.04 to 0.16% at deeper layer. 55.2% soil contain low to very low TN.
- 75.8% soil contain medium to very high AP at 0-10 cm depth and 44.8% at deeper soil. AP ranged from 3.6 to 69.8 ppm at surface layer, and 1.95 to 40.37ppm at deeper soil.
- 72.4% soilscontain medium to high ASat surface and 62% medium to optimum at deeper soil. AS ranged from 7.9 to 44.2 ppm at surface layer.
- 55.1% soil contain medium to very high exchangeable K and Na, 41.3% soil contain medium to high exchangeable Ca.
- The values of soil pH, available phosphorus, organic carbon and total nitrogen contents were lowest in the highland and increased to the medium lowland and lowland, the medium lowland
- Exchangeable K andCa levels were highest in the lowland position.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Executive table, Chair, File cabinet, Desktop computer, Laser Printer, UPS (offline), Scanner, Camera,	1,75,000.00	Executive table, Chair, File cabinet, Desktop computer, Laser Printer, UPS (offline), Scanner, Camera,	1,75,000.00	
(b) Lab &field equipment	Light Balance (1200g), UPS (online for GS), pH meter, Micropipette	2,95,000.00	Light Balance (1200g), UPS (online for GS), pH meter, Micropipette	2,95,000.00	
(c) Other capital items	Chemicals	5,00,000.00	Chemicals	5,00,000.00	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	255266	255266	255266	0	100	
B. Field research/lab expenses and supplies	850000	795272	749604	45668	94	
C. Operating expenses	319907	295000	252654	42346	86	
D. Vehicle hire and fuel, oil & maintenance	200000	257141	250000	7141	97	
E. Training/workshop/seminar etc.	0	0	0	0	0.0	
F. Publications and printing	90000	22812	0	22812	0.0	
G. Miscellaneous	30000	21220	21220	0	100	
H. Capital expenses	470000	470000	446380	23620	95	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	**Major technical activities performed in respect of the set objectives**	**Output (i.e. product obtained, visible, measurable)**	**Outcome (short term effect of the research)**
To monitor the changes of physical and chemical properties of soil from 43 soil series of Bangladesh within 50 years (1967-2017).	0-100 cm soil samples have collected from 29 soil series to monitor the changes of physical and chemical properties of soil within 50 years.	Generated information could be use as an index of soil fertility management planning for sustainable crop production.	Soil test based fertilizer calculation will decrease up to 10% fertilizer miss use
To develop national data base of fallout radionuclides (^{137}Cs, ^{210}Pb, ^{226}Ra, ^{210}Pb$_{ex}$, ^{238}U, ^{40}K etc.) in soil with reference value and soil erosion/ deposition rate over several time scales in Bangladesh.	Two field experiments have completed to know the fallout radionuclides (^{137}Cs, ^{210}Pb, ^{226}Ra, ^{210}Pb$_{ex}$, ^{238}U, ^{40}K etc.) concentration in soil with reference value and soil erosion/deposition rate at Khagrachari.	Developed a national database of FRN and rate of soil erosion	Soil and nutrient loss could be minimized.
To utilize nuclear techniques for short term changes by land use practice and the effectiveness of specific soil conservation measures/management system to sustain soil fertility and crop productivity.	Two field experiments have been completed to know the effect of land use practice in soil erosion reduction and the effectiveness of specific soil conservation measures/management system.	Approaches to soil sampling, isotopic analysis, and modeling for assessment of soil erosion, soil quality, and land degradation relevant to management.	Best soil and crop management practices for erosion control and soil fertility restoration for sustained agricultural production.

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication			
Information development			
Other publications, if any			

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

ii. Generation of new knowledge that help in developing more technology in future

Updated status soil physico-chemical properties will help to save fertilizer cost with improved crop production

iii. Technology transferred that help increased agricultural productivity and farmers' income

To know the nutrient status and apply judicious fertilizer to increase yield and fermer's income.

iv. Policy Support

This data will help policy makers to know the nutrient status and recommend fertilizer requirement for crops.

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring (description & output of consultation meeting, monitoring workshops/seminars etc.):

ii) Field Monitoring (time& No. of visit, Team visit and output):

I. Lesson Learned/Challenges (if any)

i) The soils of Bangladesh are most degraded in OC, TN, exchangeable cations and clay contents.

ii) Soil pH, AP, OC and TN contents were lowest in the highland and increased at the medium lowland and lowland.

iii) The natural and anthropogenic effects played important roles insoil degradation in Bangladesh