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Research Article

Performance of Soil Quality: Indicator-Based GIS Analysis of Jamuna-Dhaleshwari and Surma-Kushiyara Floodplain Regions, Bangladesh

Tanbi Tanaya Sarker[1] , Sameena Begum[1, 2] , Md. Shohel Khan [3, 4,*] , Mohammed Abdus Salam[3] , Shehan Tawsif [5]

[1]Department of Geography and Environment, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh
[2]Department of Geography and Environment, Jagannath University, Dhaka-1100, Bangladesh
[3]Department of Environmental Science and Disaster Management, Noakhali Science and Technology University, Noakhali-3814, Bangladesh
[4]Institute of Bangladesh Studies, University of Rajshahi, Rajshahi-6205, Bangladesh
[5]Department of Geography and Environmental Studies, University of Rajshahi, Rajshahi-6205, Bangladesh
*Corresponding author, E-mail address: sajibicb@gmail.com

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ABSTRACT

Bangladesh is an agriculture based economic country formed by sediment deposition from upstream rivers. This riparian country covered with fertile soil that supports agricultural diversification. The study aimed to compare current soil quality of Jamuna-dhaleshwari (Manikganj) and Surma-kushiyara (Sylhet) floodplain physiographic regions to forecast about agricultural productivity. Soil quality was assessed through physical (soil texture and moisture), and chemical (pH, electrical conductivity (EC), salinity, soil nutrients (N, P, K), and organic matter content) indicators. A total of 36 soil samples in three different depths (0-15cm, 15-50cm, 50-100cm) from 12 sites were collected from Manikganj and Sylhet Districts. The average particle size and moisture content ratios of Manikganj: Sylhet were gravels (7.88:5.8), very coarse sand (6.85:8.53), coarse sand (7.45:13.2), medium sand (7.35:14), fine sand (6.12:16.4), very fine sand (24.3:19.9), silt (39.56:20.57), and clay (29.3:32.81), followed by, pH (7.61:6.31), and EC (0.24:0.18), respectively. The result revealed that the soil was bit alkaline for Manikganj, compared to range from alkaline to acidic in Sylhet and non-saline for both areas that was suitable for agriculture. The average concentration of nitrogen (N), phosphorous (P), potassium (K) nutrients in Manikganj and Sylhet Districts were 0.14%, 3.73 meq/100g, 0.07 µg/g; 0.16%, 3.11 meq/100g, 0.08 µg/g and organic matter were 3.65% and 4.7%, respectively. The results of nutrients in both areas indicated that nutrients were very poor but soil organic matter content was sufficient for agricultural activities. The study concluded that soil texture, pH, salinity and organic matter content in both areas were suitable for agricultural purposes, but a significant declined was found in soil moisture and nutrients quality. Finally, it was recommended that soils of Manikganj were more sustainable for agricultural activities.

Keywords : Soil quality; soil texture; organic matter; spatial distribution

1. Introduction

Soil quality is the functioning capability of soil within any ecosystem including land use patterns for sustaining productivity, maintaining conservational superiority, and developing floral and faunal health (Idowu et al., 2008; Bünemann et al., 2018). The relations between different biotic and abiotic components with soil fertility determined the potentiality of the production of healthful crops (Gong et al., 2015). This combination of soil characteristics and the output level of efficiency is also denoted as soil quality (Parr et al., 1992). Many soil indicators accelerates one another and correlated to each other (Arshad & Martin, 2002). The prime indicators of soil quality can be denoted as physical properties (soil texture, bulk density, moisture), and chemical properties (soil pH, salinity, soil nutrients (N,P,K), electrical conductivity) and organic matter (Arshad & Martin, 2002). The soil quality indicators in a sampling site could be compared with reference values or threshold levels for each soil quality (Bünemann et al., 2018). Soil pH, electrical conductivity (EC), nitrogen (N), phosphorus (P), potassium (K) and sometimes, zinc (Zn) and iron (Fe) contents of soil were mostly done to evaluate the fertility status or quality of soil but other physical and biological indicators were also necessary for complete soil quality assessment (Çelik et al., 2021).

Bangladesh is a land of agricultural diversity having a large part of its economy depend on it (Afrin et al., 2018). It's also called a country of rivers with its floodplain land as a contributor to vegetation and crop variations. The total agricultural land is around 9.10 million hectares in Bangladesh with 179% yearly mean cropping intensity (Khan et al., 2021a). The quality of soil may help in making decisions about agricultural production (Yang, 2017). Bangladesh is situated at the lower adjoin of three mighty river systems, i.e., Ganges River System (GRS), Brahmaputra River System (BRS), and Meghna River System (MRS). The BRS and the MRS are the main reasons for the creation of the Jamuna-dhaleshwari floodplain (JDF) and Surma-kushiyara floodplain (SKF) regions. They played a huge role in the creation of agricultural land and the quality of the soil of surrounding areas (Rashid, 1991).

Manikganj District is situated in JDF region, has non-calcareous alluvium and some calcareous dark grey and brown floodplain with texture of clay loamy soil (Datta & Subramanian, 1997) with sandy/silty, grey/olive and neutral to slightly alkaline whereas Sylhet District is located on SKF region with a texture of silty loam soil of non-calcareous and calcareous grey and brown floodplain soils. Loamy sand can also be detected in the brown hill soils with grey to dark grey, heavy clays, and strongly acidic (Brammer, 1996). Sylhet consisted of silty loamy soils whereas Manikganj had sandy loamy soils. The saline soils were found mostly at the southern parts of the country and the major parts of the country contained medium amount of organic matter but Sylhet District existed high amount of organic matter (Islam et al., 2017). This study was conducted in Manikganj and Sylhet Districts to compare current soil quality with selected indicators of JDF and SKF physiographic regions for forecasting agricultural production.

There have been many studies for soil quality in industrial areas, mining zones, agricultural lands, etc. (Islam, 2012; Hussain et al., 2013; Rahman et al., 2017; Shaibur et al., 2017; Ataullah et al., 2017; Hossain & Bin Salam, 2019). However the researchers supposed that there might be no research on comparing the soil quality between two different physiographic regions. The study would be helpful in forecasting agricultural productivity based on the result. The study aimed to compare current soil quality of Jamuna-dhaleshwari (Manikganj) and Surma-kushiyara (Sylhet) floodplain physiographic regions to forecast about agricultural productivity.

2. Methods

2.1 Study Area

Jamuna-dhaleshwari floodplain is the largest sub-classed left bank floodplain of the Brahmaputra-jamuna floodplain (Rashid, 1991) which is frequently flooded during the monsoon (June-October). The district Manikganj, situated mainly in this flood plain region in Dhaka Division. It comprises an area of 1383.06 km^2, located in between 23°38'-24°03'N latitudes and 89°41'-90°08'E longitudes. The Kaliganga River is one of the largest among several distributaries flowed from Jamuna River (Sayed & Haruyama, 2016).

Sylhet District is located between 24°36'-25°11'N latitudes and 91°38'-92°30'E longitudes, in the northeastern region of Bangladesh in Sylhet Division. This region is mainly situated in the SKF which consists the rivers flowing from eastern border near the *haor* basin occurs flash floods almost round the year in deep flooding in a very small number of days (Khan et.al., 2021b). The physical geography of Sylhet entails dominantly hills and a small number of depressions,regionally named as *beels* as well as *haors*.It is lithologically multifaceted with varied morphology and from top to bottom land scape of *Plio-miocene* age like *Khasi* and *Jaintia* hills with some small hillocks.The limestone depositions in several parts of this areaproved that the entire area was underneath the water in *Oligo-miocene* period (Rashid, 1991;Khan, 1991).The map of the study area was shown in Figure 1 with sampling points of two different locations.

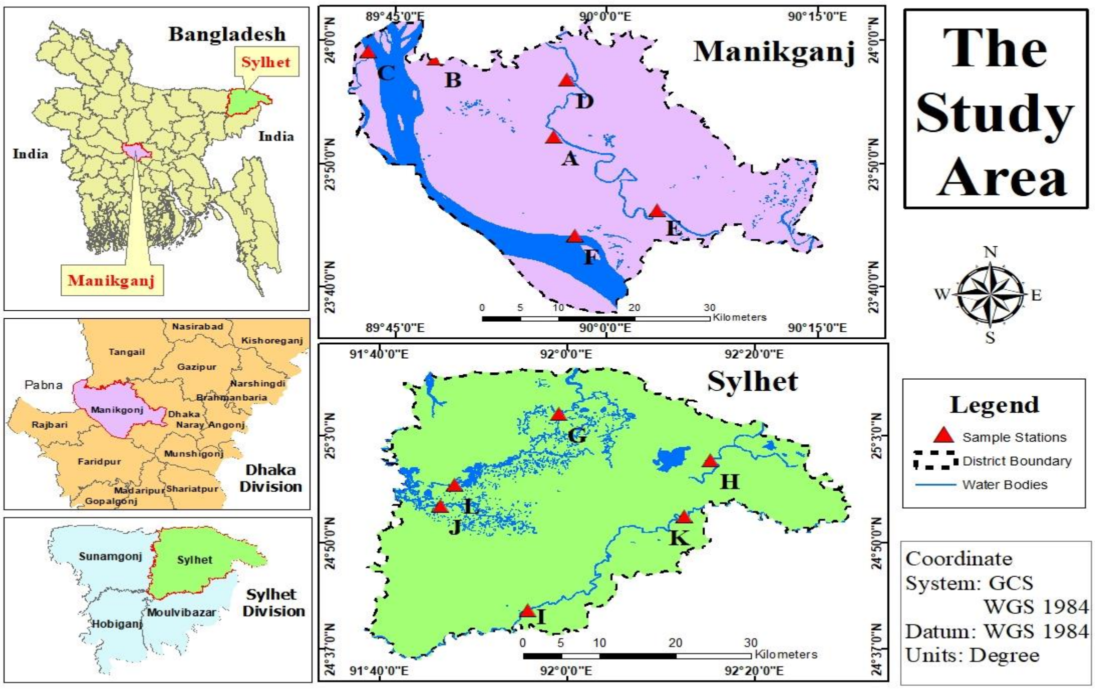


Figure 1. Study area and sampling stations of Manikganj and Sylhet District

2.2 Sampling

Soil profiles were dug in each site and soil samples were collected from 12 profiles (6 from riverside cultivation land of Manikganj and 6 from riverside cultivation land of Sylhet) for analysis. Soil samples were collected from depths of 0-15cm (topsoil, A1-L1), 15-50cm (mid soil, A2-L2), and 50-100cm (bottom soil, A3-L3) from each profile. The collected samples were warehoused in plastic bags and sent to the laboratory for physical experiments using typical methods. Sampling locations (Table 1) were geographically identified using global positioning system (GPS) in a map (Figure 1).

The samples were collected from July-August, 2019 and were tested between August and October, 2019.

Table 1. Geographical position of sampling stations

Sampling Stations	Geographical position	
	Longitude	Latitude
A (A1-A3)	89.93724E	23.86964N
B (B1-B3)	89.79701E	23.97537N
C (C1-C3)	89.71774E	23.98572N
D (D1-D3)	89.95365E	23.94731N
E (E1-E3)	90.06072E	23.76922N
F (F1-F3)	89.96225E	23.73557N
G (G1-G3)	91.98571E	25.09513N
H (H1-H3)	92.25567E	25.00035N
I (I1-I3)	91.93003E	24.69506N
J (J1-J3)	91.77587E	24.90779N
K (K1-K3)	92.20853E	24. 88556N
L (L1-L3)	91.79994E	24.95047N

2.3 Soil Quality Indicators

Soil particle size, soil texture, moisture, pH, electrical conductivity (EC), salinity, nitrogen (N), phosphorus (P), potassium (K), and organic matter (OM) contents were the indicators measured by the respective methods (Table 2) to compare with various critical limits to find the soil quality in this study.

Table 2. Methods of parameter/indicators in laboratory experiments

Parameter/ Indicators	Methods
Particle size	Sieve method
Soil texture	Hydrometer method and soil texture triangle
Moisture	Oven dry method
Soil pH	Digital pH meter
Electrical conductivity	Digital EC meter
Salinity	Digital EC meter
Soil nutrients (N, P, K)	Titrimetric Method
Soil organic matter	Combustion Method

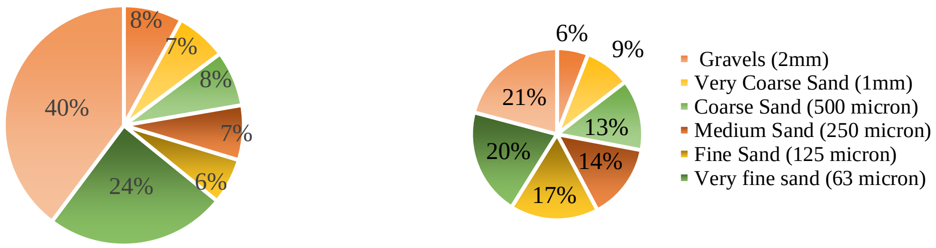
2.4 Statistical Methods and Geostatistical Analysis

Data were analyzed by using MS excel 2016. The spatial distribution of the indicators (moisture, pH, N, P, K, OM) were showed in maps using geostatistical analyst tools, inverse distance weightage interpolation method, in Arc GIS (version 10.3) software.

3. Results and Discussion

3.1 Soil Texture

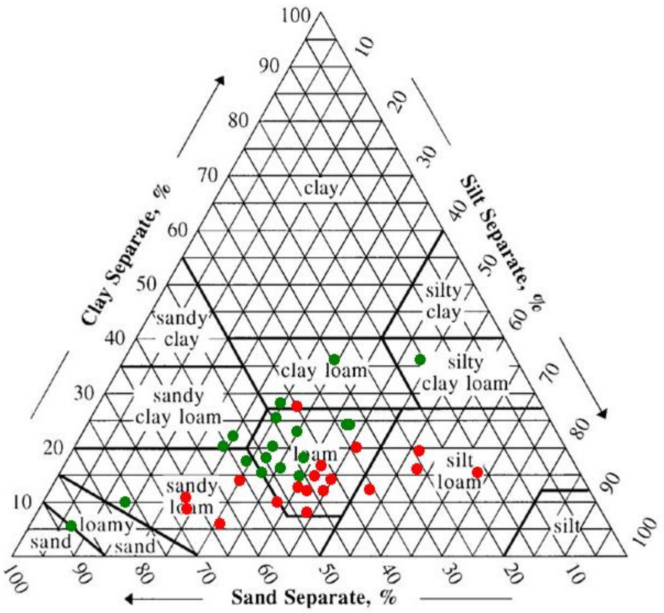
The combination of various proportions of sand, silt, and clay size particles in a soil sample is called soil texture. The *International System of naming soil separates* indicates clay particles as the smallest (<0.002mm); silt as a medium-size particle (0.002-0.02mm) and sand as the largest particle (0.02-2.0mm) which is divided into fine sand (0.02-0.2mm) and coarse sand (0.2-2.0mm). Soils that have large amount of clay were called fine-textured soils and the soils having larger particles were characterized as coarse-textured soils (Eluwole et al., 2018). Soil texture is important in identification of soil characteristics and suitability for different crops (Shaibur et al., 2017). A soil textural triangle was formulated (Figure 3) to specify and compare the soil textures of the Jamuna-dhaleshwari floodplain and the Surma-kushiyara floodplain.



(a) (b)

Figure 2. Average percentage of particle size (a) Manikganj Districtand (b) Sylhet District

The study resulted that Manikganj District consisted of higher percentage of silt and clay compared to Sylhet District (Figure 2). Sylhet region consisted of more fine sand than Manikganj. Plants grew well in Manikganj in loamy soil with more percentage of silt and clay than sand. Some of the soils in Sylhet were clayey and some sandy, which may be resulted in difficulties for agriculture compare to Manikganj District.



Note: The red dots indicate the soil texture of samples from Manikganj District and the green dots indicate the samples from Sylhet District.

Figure 3. Soil textural triangle of Manikganj and Sylhet District

Loamy soil but clay loam, silty clay loam, sandy clay loam, and loamy sand could only be presented in Sylhet whereas Manikganj had silty loam soil which was not available in Sylhet District (Figure 3). Loamy soils were known as to exist more moisture, nutrients, and organic matter than sandy soil and it would be better for water and air runoff and permeation compared to silty and clay dominated soils. This means the soil was favorable for the cultivation of crops. The percentage with textural classification was cited in Table 3.

Table 3. Percentages of sand, silt, and clay with textures in the study area

Sampling Stations	Sand	Silt	Clay	Texture
A	43.12	42.18667	14.69333	Loam
B	43.06667	46	10.93333	Loam
C	47.86667	39.86667	12.26667	Loam
D	61.33333	28.34667	10.32	Sandy loam
E	42.58667	38.18667	19.22667	Loam
F	32.13333	54.34667	13.52	Silty loam
G	41.17333	34.64	24.18667	Loam
H	45.78667	30.02667	24.18667	Loam
I	45.54667	30.69333	23.76	Loam
J	45.09333	36.53333	18.37333	Loam
K	40.82667	37.84	21.33333	Loam
L	72.37333	16.82667	10.8	Sandy Loam

3.2 Moisture Content

Soil moisture is an important factor in crop production because of its necessity in supporting plant growth. Plants should be died for less moisture contents and too much moisture led to root disease and waste of water.The widely accepted ideal moisture levels for three major types of soil is showed in Table 4. The study revealed that the average percentage of moisture was higher (32.81%) in Sylhet District compared to Manikganj District (29.37%) showed in fig. 4(a). The percentage of individual moisture contents of soil samples were shown in fig. 4(b) that claimed 100% sampling stations showed dangerously low (<42%) moisture content which might recommended that soils needed irrigation and to be rise in moisture level for better cultivation and plant growth in both study areas.

Table 4. Percentages of ideal moisture levels (Laurenzi, 2018)

Soil type	No irrigation needed	Irrigation to be applied	Dangerously low soil moisture
Fine (Clay)	80-100	60-80	<60
Medium (Loamy)	88-100	70-88	<70
Coarse (Sandy)	90-100	80-90	<80

3.3 Soil pH

Soils can be acidic, alkaline, or neutral. Soil pH indicates the type of the chemical reactions occurring in the soil. The pH value ranges from 0-14 where 7 is the neutral. Values <7 and >7 depicted acidity and alkalinity, respectively. The soil pH 6.5-8.5 was good for agricultural cultivation (Shaibur et al., 2017) and too acidic/alkaline was unsuitable for good crop production. Soil with pH <5.5 and >9.5 were considered very acidic and very alkaline (Yang, 2017), respectively.

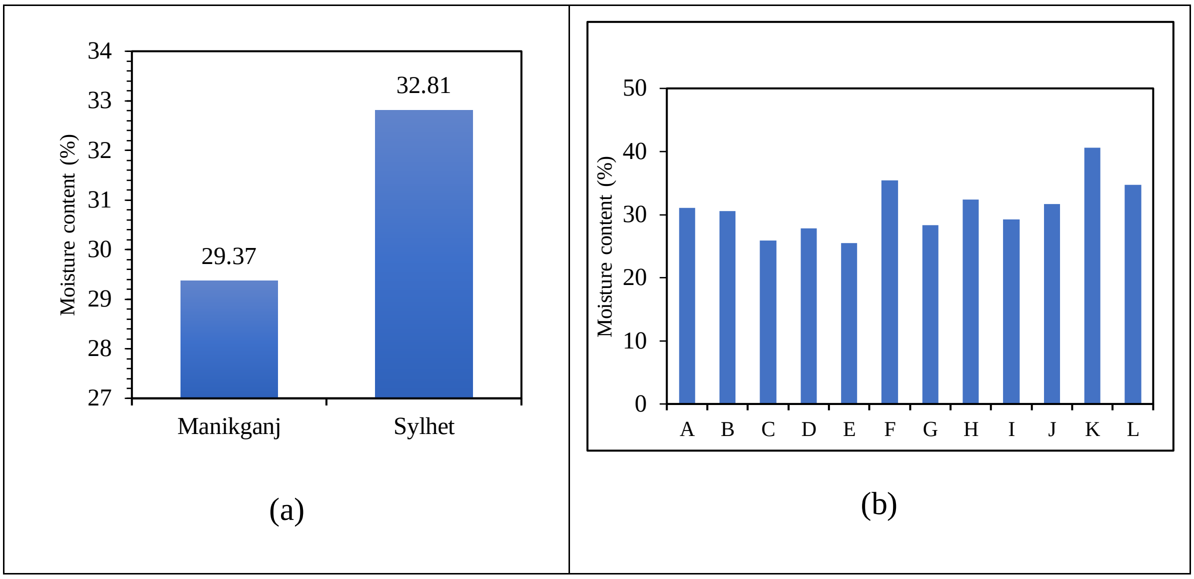


Figure 4. Average (a) district wise (b) individual sample wise moisture content in the study area. Note: Individual sample (Table 3)

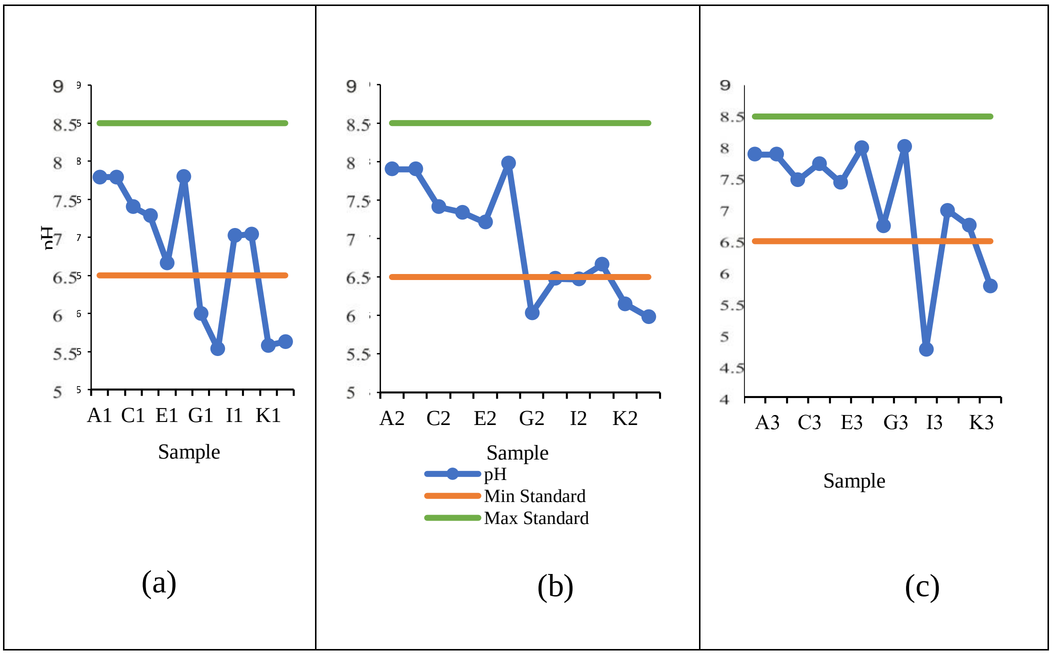


Figure 5.Variations of pH value in (a) top soil, (b) mid soil and (c) bottom soil in the study area. Note: Sample stations (Table 3)

The variation of pH in top soil, mid soil, and bottom soil of both Manikganj (Sample A-F) and Sylhet (Sample G-L) can be noticed distinctly (Figure 5). The pH values of soil from Sylhet District tend to be lower than the minimum standard in comparison to the soil from the Manikganj District. The average pH value of soil in Manikganj is 7.61 and Sylhet is 6.31 which resulted that

Manikganj had alkaline and Sylhet had acidic soil. The pH level is considered good in Manikganj compare to Sylhet because all of the samples from Manikganj District were within the standard limit but in Sylhet some samples were lower than minimum standard, evensome areas were high acidic to high alkaline. Plants roots were unable to absorb nutrients when the pH level is high, and when it is too low, they absorb too much nutrients which causes it to die (Kumar et al., 2019).

3.4 Electrical Conductivity and Salinity

Electrical conductivity (EC) of soil is the measurement of its electricity conducting ability in a solution which also deduct its salinity levels. EC increases with the increase of amount of salt in any solution. The salts form ions in water, so, EC of a solution provides a measure of total amount of salts (Yang, 2017). When the value >0.75 ds/m, is considered hazardous for plants and organisms. Plant growth is affected by soil salinity because of the osmotic tension is increased in soil due to increasing salinity and it becomes more difficult to absorb water from the soil (Van Tan et al., 2020). The average EC value of soil was greater in Manikganj (0.24 ds/m) compared to Sylhet (0.18 ds/m) and the average percentage of soil salinity is also greater in Manikganj (0.04%) compared to Sylhet (0.02%). So, the soil of Manikganj is much more saline than that of Sylhet. This type of non-saline soil is considered perfect for plant growth and agriculture for both areas (Hossain & Bin Salam, 2019) and does not affect soil nutrients and plant growth in any way.

3.5 Soil Nutrients

Soil contains the major mineral nutrients for plant growth are divided into two separate macro and micronutrients. The macronutrients have two groups which are primary and intermediate nutrients (Kumar et al., 2020). Plants need large amount of primary nutrients (Datta & Subramanian, 1997) which are nitrogen (N), phosphorus (P), and potassium (K). The average available N (%), P (meq/100g), K (µg/g) nutrients ratios in Manikganj: Sylhet were 0.14:0.16, 3.73:3.11 and 0.07:0.08, respectively (Figure 6). The results concluded the low amount of nutrients available in the soil in both study areas.

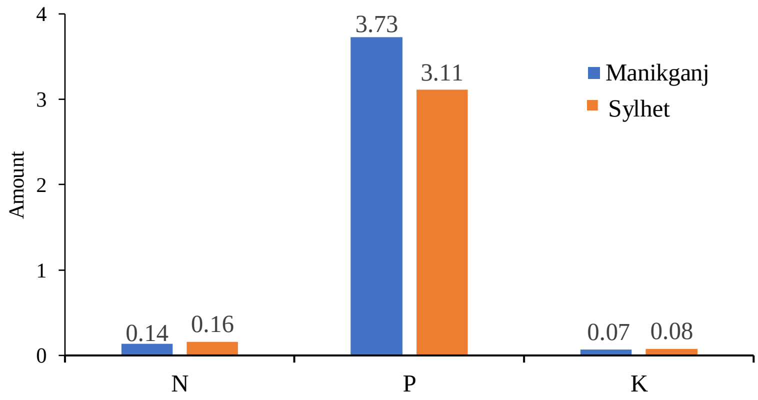


Figure 6. Average nitrogen (%), phosphorous (meq/100g) and potassium (µg/g) nutrients

The available N, P and K nutrients ranged from 0.13%-0.18%, 0.77-9.21 (meq/100g) and 0.05-0.12 (µg/g), respectively in both areas. The low amount of N may be resulted in reduced growth and less chlorophyll production. The low amount of pin soil might reduce, growth occurs, turn leaves darker green or purplish, and older leaves might become brown as they died. The low amount of K in soil might be responsible to make leaf margins appear spotted and leaf surfaces might have chlorotic (yellowing) spots and might develop weak stems, collapsing easily (Gondwe et al., 2020).

Table 5.Available N,P and K by sampling stations in the study area

Sampling stations	Nitrogen (N) (%)	Phosphorous (P) (meq/100g)	Potassium (K) (μg/g soil)
A	0.13	3.60	0.07
B	0.13	5.38	0.06
C	0.14	3.21	0.05
D	0.13	3.69	0.06
E	0.17	3.32	0.09
F	0.14	3.20	0.09
G	0.14	3.26	0.07
H	0.16	9.21	0.07
I	0.18	2.40	0.07
J	0.16	1.82	0.10
K	0.17	1.17	0.12
L	0.14	0.77	0.05

3.6 Organic Matter

Soil organic matter (OM) is one of the main factors that controls the major properties of soil (Fazekašová & Fazekaš, 2020) and plays a vital role in maintaining soil quality because it helps in the structural maintenance and development of soil, acts as a storage of nutrients and organic carbon, and maintains the biological activities (Hussain et al., 2013) and soil organic matter contains plant or animal tissue in several phases of decay (Agronomy Fact Sheet, 2008). Most prolific cultivated soils ranged between 3-6% organic matter contents.

Table 6. Standard levels for organic matter (BARC, 2012)

Class	Organic matter (%)
Very High	>5.5
High	3.5-5.5
Medium	1.8-3.4
Low	1.0-1.7
Very Low	<1.0

The average value of the organic matter in Manikganj (3.6497%) was lower than Sylhet (4.7126%). Figure 7 showed the variation in organic matter content throughout all the samples in various depths of soil. The percentage of OM in soils from Manikganj tends to be nearer to critical value whereas in Sylhet it tends to be nearer maximum standard value. This meant that the soil of Sylhet had more water infiltration, water holding capacity, and ability to hold soil nutrients than Manikganj and also enriched with food for living organisms. However both areas were favorable for plant growth and agriculture as adequate percentage of organic matter existed in the soil (Ye et al., 2011). The spatial distribution of organic matter content in soil samples from both areas were presented in Figure 8. The soil organic content in some areas ranged from medium to high ranges with

2.14-5.21% in Manikganj and considered as low to very high ranges with 1.00-6.17% in Sylhet (Table 6).

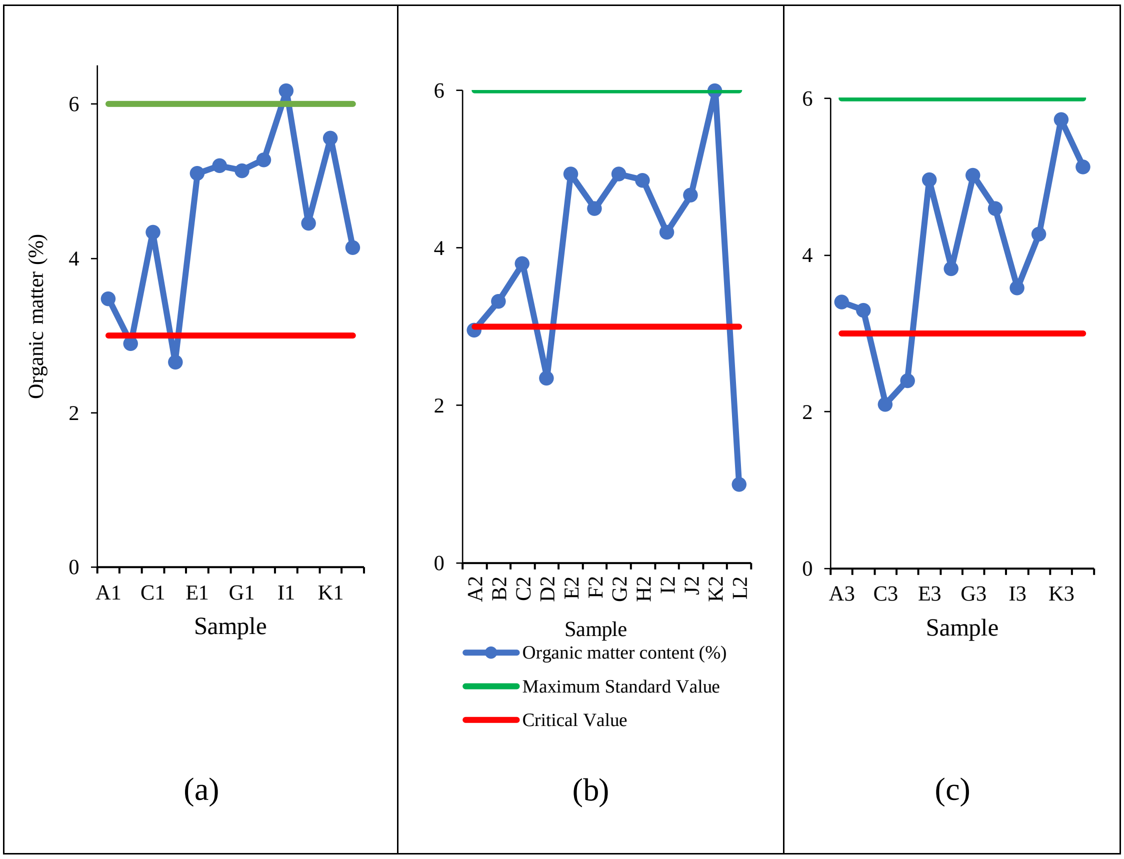


Figure 7. Organic matter content in (a) top soil, (b) mid soil and (c) bottom soil in the study area

3.7 Summary of the Indicators

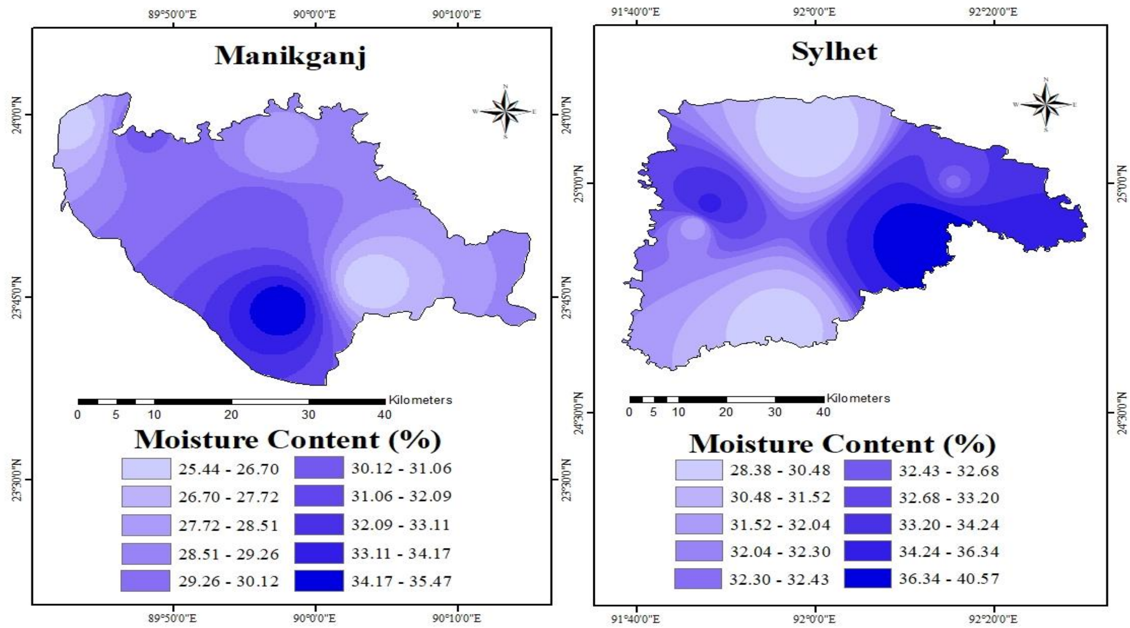
The result of various indicators like moisture content, pH, EC, salinity, N, P, K and OM were summarized with mean, standard deviation, maximum and minimum values of soil quality indicators (Table 7). The table resulted that moisture content in both areas had relatively high standard deviation meant the data points were distributed over a large range of values (Rahman et al., 2017) and the soil samples had a lot of variability with moisture content. The amount of P and OM content in soil from Sylhet showed a relatively higher level of standard deviation.

Table 7. Descriptive statistics of the measured soil quality indicators of Manikganj and Sylhet District

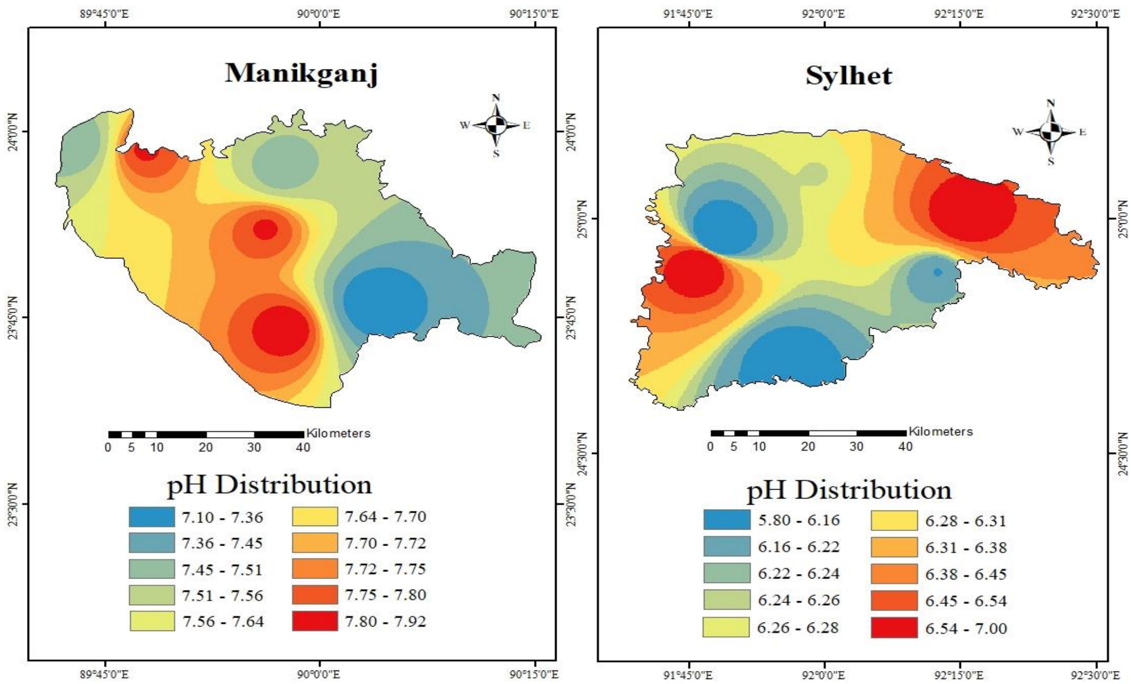
Parameters	Moisture content (%)	pH	EC (ds/m)	Salinity (%)	Nitrogen (N) (%)	Phosphorous (P) (meq/100g)	Potassium (K) (µg/g soil)	Organic matter (%)
Manikganj District								
Mean	29.37	7.61	0.24	0.04	0.14	3.73	0.07	3.65
Standard deviation	5.48	0.35	0.10	0.05	0.02	1.70	0.02	0.996
Maximum	42.63	8	0.41	0.1	0.19	8.17	0.12	5.21
Minimum	17.12	6.66	0.13	0	0.11	1.01	0.03	2.14
Sylhet District								
Mean	32.81	6.31	0.18	0.02	0.16	3.11	0.08	4.71
Standard deviation	6.07	0.75	0.11	0.04	0.03	3.69	0.03	1.15
Maximum	44.38	8.02	0.49	0.1	0.24	15.42	0.16	6.17
Minimum	22.33	4.76	0.06	0	0.10	0.13	0.03	1.00
Critical limit	<60	pH<5.5 pH>8.5	>0.75	-	0.12	5	0.12	3

3.8 Geostatistical Analysis

The spatial distribution of various soil quality indicators was showed in different varieties in two different areas (Figure 8). The percentage of moisture was higher in southern part in which it decreased to eastern part to northern part for Manikganj District but it was higher in 'K' and "L' sampling stations and decreased from these stations to the other sampling stations in Sylhet. The pH level decreased from southern to northern and eastern also for Manikganj but it was higher in two sampling stations named 'J' and 'H' respectively, in Sylhet. Available N content was higher in north-west zone and decreased to south eastern for both areas. This also represented that higher N based crops were dominated in this area.



(a)



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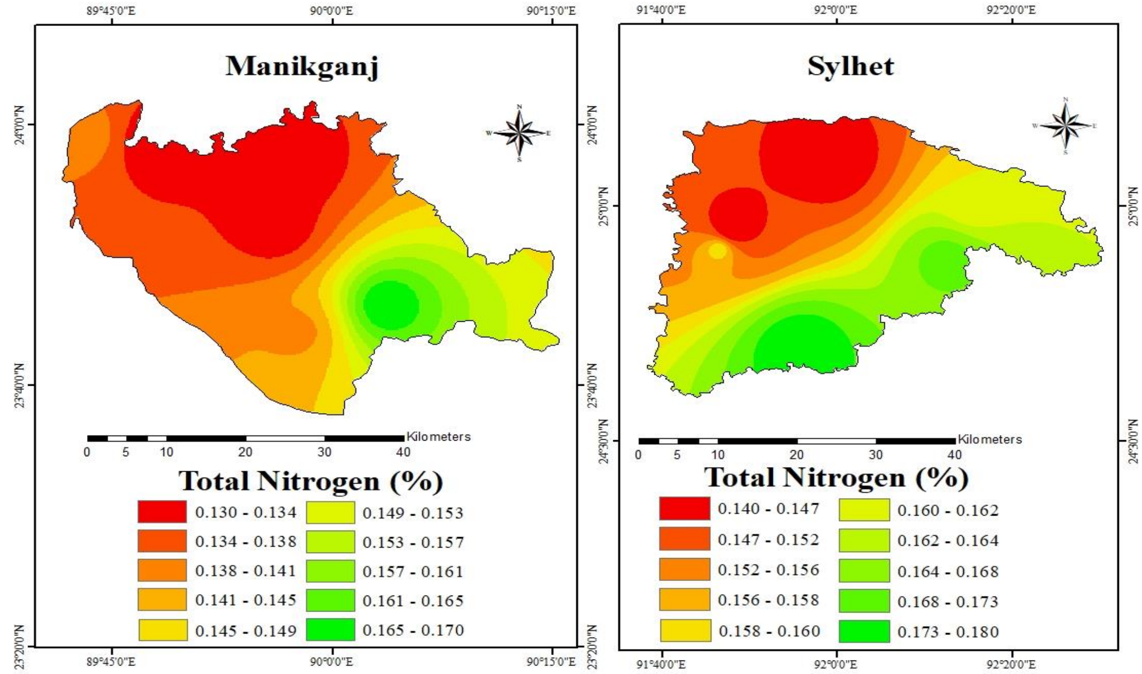
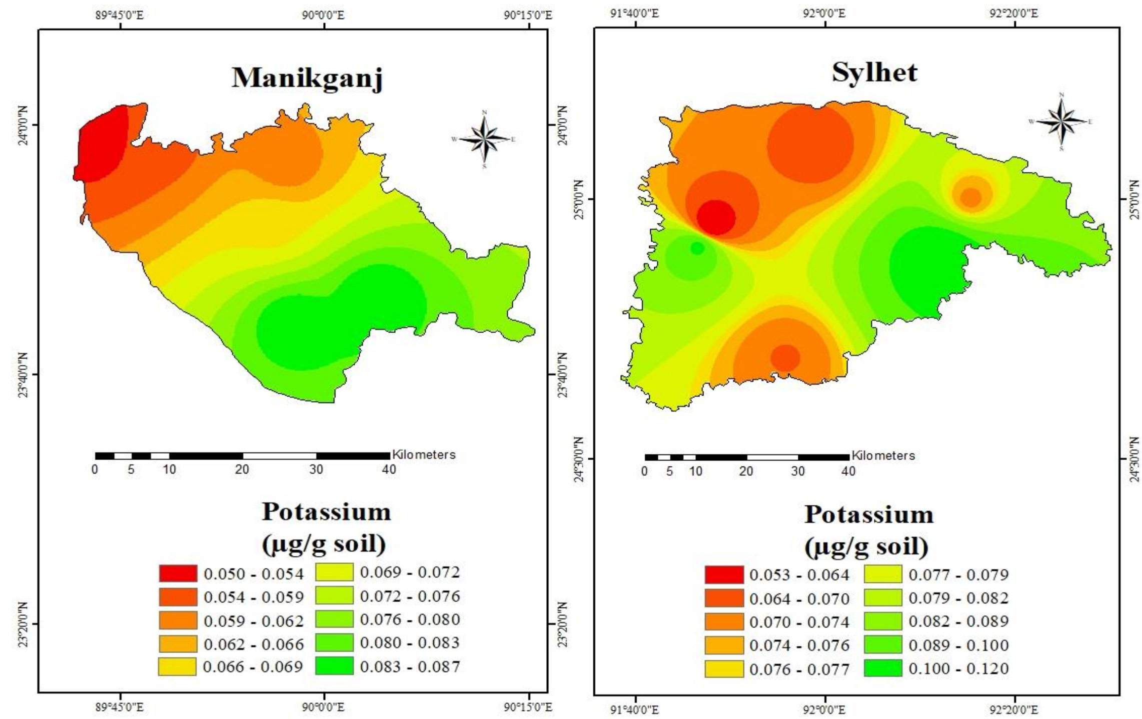
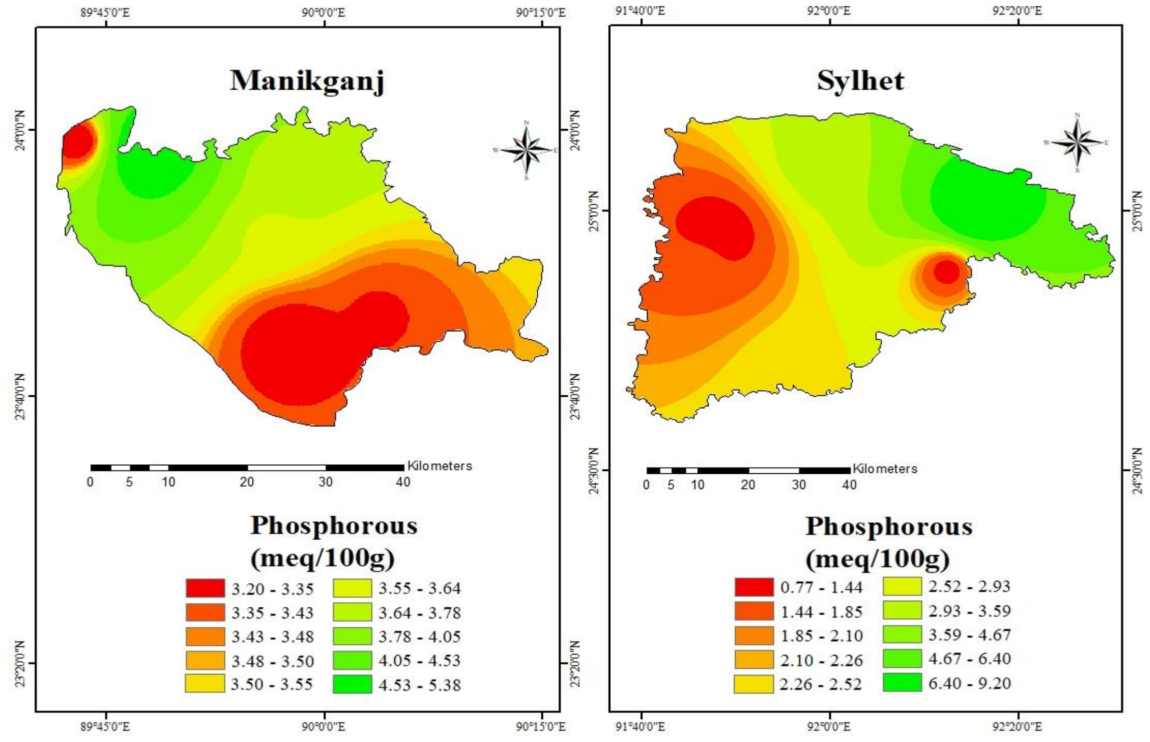

Manikganj
Total Nitrogen (%)
0.130 - 0.134
0.134 - 0.138
0.138 - 0.141
0.141 - 0.145
0.145 - 0.149
0.149 - 0.153
0.153 - 0.157
0.157 - 0.161
0.161 - 0.165
0.165 - 0.170
Kilometers
0 5 10 20 30 40
Sylhet
Total Nitrogen (%)
0.140 - 0.147
0.147 - 0.152
0.152 - 0.156
0.156 - 0.158
0.158 - 0.160
0.160 - 0.162
0.162 - 0.164
0.164 - 0.168
0.168 - 0.173
0.173 - 0.180
Kilometers
0 5 10 20 30 40

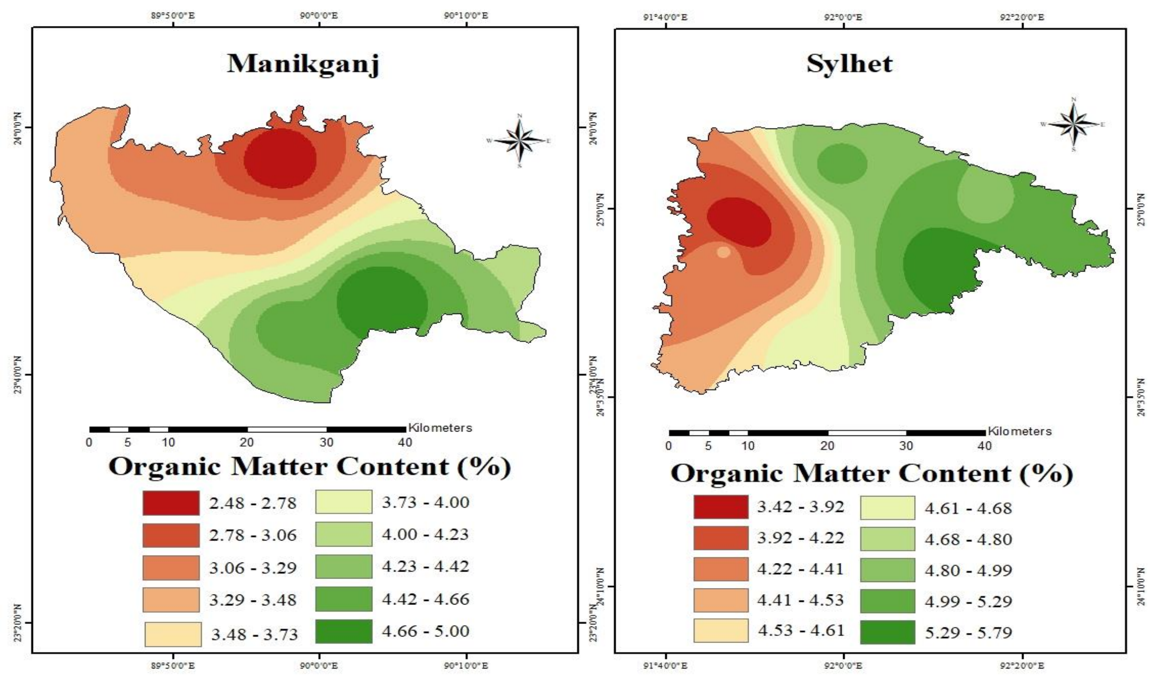
(c)


Manikganj
Potassium (µg/g soil)
0.050 - 0.054
0.054 - 0.059
0.059 - 0.062
0.062 - 0.066
0.066 - 0.069
0.069 - 0.072
0.072 - 0.076
0.076 - 0.080
0.080 - 0.083
0.083 - 0.087
Kilometers
0 5 10 20 30 40
Sylhet
Potassium (µg/g soil)
0.053 - 0.064
0.064 - 0.070
0.070 - 0.074
0.074 - 0.076
0.076 - 0.077
0.077 - 0.079
0.079 - 0.082
0.082 - 0.089
0.089 - 0.100
0.100 - 0.120
Kilometers
0 5 10 20 30 40

(d)



(e)



(f)

Figure 8. Spatial distribution of (a) moisture content, (b) pH, (c) total nitrogen, (d) potassium, (e) phosphorous and (f) organic matter content in Manikganj (left) and Sylhet (right) Districts

The amount of P decreased from south eastern to north western part of Manikganj but same as from western part to southern part of Sylhet. This also resulted that P dominated crops would be more suitable in this region. K and OM were similarly distributed in Manikganj but OM decreased from western to eastern areas of Sylhet. K were decreased from north to southern and great variations in eastern part of Sylhet District. The maps showed that there was noticeable relationship among N, P, K and OM contents (Figure 8). It was observed that where there was low amount of N and K, there was high P content. Areas with high amount of organic matter contained higher N, K but lower amount of P. The maps also demonstrated the regions which had comparatively higher moisture, N, P, K and organic matter content which would mean better agricultural activities in those areas.

3.9 Comparison of Soil Indicators Between the Regions

The variation of different indicators between two floodplain regions of the study were summarized and compared with other similar studies conducted in various regions of Bangladesh (Table 8). The result showed that both Manikganj and Sylhet District had loamy soil like the Sitalakhya Floodplain and Jaintia Hills in Meghalaya, India. The higher organic matter percentage resulted that the soil of Sylhet had higher infiltration capacity, water holding capacity compared to Manikganj. The soil was also enriched with food for living organisms but both areas were enough to favorable for plants development and agriculture as they had existed sufficient amount of organic matter in the soil (Chen & Hseu, 1997). The pH value of soil in JDF region showed similarity with Ganges River floodplain soil and was higher compared to SKF soils which showed quite similarity to Barapukuriya and Sitalakhya floodplain. EC was higher in JDF compared to SKF and the values were very little consistent with EC values from Ganges River floodplain soil. Salinity in soil was also higher in JDF compared to SKF but there was not much salinity data found near these regions. The percentage of nitrogen, organic matter and potassium were higher in Sylhet District compared to Manikganj District. The results of nitrogen content were quite consistent with Tangail District and Barapukuriya coal mine area. Phosphorous content was higher in JDF compared to SKF and they were quite similar to Jaintia Hills, Tangail District and Tamabil areas. Potassium contents in the soils of both areas showed similarity to Tangail District and Tamabil areas. Organic matter content is quite consistent throughout the regions though it was found a bit higher in Sylhet.

Table 8. Comparison of soil indicators between various regions of Bangladesh

Study Area	*ST	*MC (%)	pH	*EC (ds/m)	*S (%)	*N (%)	*P (meq/100g)	*K (μg/g)	*OM (%)	Sources
Jamuna-dhaleshwari floodplain (Manikganj)	Loamy	29.37	7.61	0.24	0.04	0.14	3.73	0.07	3.65	This study
Surma-kushiyara floodplain (Sylhet)	Loamy	32.81	6.31	0.18	0.02	0.16	3.11	0.08	4.7	This study
Ganges River floodplain (Jashore)	Silty loamy and silty clay loamy	-	7.47	0.81	-	0.38	129.14	74.34	0.73	Khan et al. (2021a)
Madhupur tract (Tangail)	-	-	5.61	-	-	0.12	7.37	0.18	2.24	Kumar et al. (2020)
Jaintia Hills, Meghalaya, India	Loamy	32.49	5.5	0.028	-	0.369	3.550	0.612	2.59	Lamare & Singh (2020)
Dumuria Upazilla (Khulna)	Silt loamy	-	6.47	1.7	0.11	1.95	8.14	62.64	1.32	Hossain & Bin Salam (2019)
Tangail District	-	-	5.33	-	-	0.08	5.83	0.19	1.74	Kumar et al. (2019)
Tamabil coal stockpile (Sylhet)	-	-	4.93	-	-	0.28	6.48	0.31	3.57	Howladar et al. (2018)
Sitalakshya River (Dhaka)	Loamy		6.6-6.97	65.7 - 99.83	-	-	-	-	0.43 - 0.66	Bhuyan et al. (2018)

Study Area	*ST	*MC (%)	pH	*EC (ds/m)	*S (%)	*N (%)	*P (meq/100g)	*K (µg/g)	*OM (%)	Sources
Barapukuria coal mining industrial area (Dinajpur)	-	-	5.74	-	-	0.12	23.20	5.95	2.14	Rahman et al. (2017)
Shyamnagar (Satkhira)	Silty clay loamy	-	6.5-7.50	7.97-15.34	4.21 - 8.02	0.034 - 0.091	0.02-0.08	0.001 - 0.002	0.87-1.82	Shaibur et al. (2017)

Note : *ST, MC, EC, S, N, P, K and OM indicate as soil texture, moisture content, electrical conductivity, salinity, nitrogen, phosphorous, potassium and organic matter, respectively.

The quality of soil in Manikganj showed less variation with the soil of Sylhet. The average loamy soil found in both areas were good for cultivation of crops. The available moisture in the soil of both the areas is less than the standard amount needed for cultivation. The pH of the soil indicated that the soil of Manikganj is alkaline and nearly all the samples showed quite same pH value which is favorable for agriculture. The soil of Sylhet was acidic showing much variation in pH value throughout the area. This might be a limitation of cultivation in Sylhet. The nutrients (N,P,K) were present in very less amount in the soil from both the areas. The results indicated that soil texture, pH, salinity and organic matter content in both areas were suitable for agricultural purposes, but a significant decline was found in soil moisture and nutrients quality. Both areas need supervision for increasing their moisture level and nutrient contents for better agricultural activities in these areas. The textural classification result (Table 9) showed that total silt and clay particles (tested by hydrometer) were higher in Manikganj District (55.0%) compared with Sylhet District (51.5%). The overall assessment showed that soil of Manikganj is more fertile than that of Sylhet. Therefore, Jamuna-dhaleshwari floodplain region is better for cultivation of different agricultural crops.

Table 9. Comparison of textural classification (average values) in two regions

Methods	Jamuna-dhaleshwari floodplain (Manikganj District)	Surma-kushiyara floodplain (Sylhet District)
Particle size (%) by sieve	Gravels (7.88), very coarse sand (6.85), coarse sand (7.4), medium sand (7.3), fine sand (6.1), very fine sand (24.27), silt and clay (39.56)	Gravels (5.81), very coarse sand (8.53), coarse sand (13.2), medium sand (14), fine sand (16.4), very fine sand (19.9), silt and clay (20.57)
Soil texture (%) by hydrometer	Sand (45), silt (41.5), clay (13.5)	Sand (48.5), silt (31.1), clay (20.4)

4.Conclusion

Soil nutrients are essential for growing plants. Deficiency or excessive concentration of macro/micro elements of the nutrients may be harmful for agricultural cultivation. The crop production rate depended upon the optimum level of soil nutrients. The quality of soil may reduce due to low percentage of organic matter and excess/absent of moisture content but all indicators were required at optimum/reference level for better production of crops. The soil of Manikganj was more loamy compare to Sylhet. Jamuna-dhaleshwari floodplain region is better for agricultural practices and this should be reason for increasing the cropping intensity and cropping pattern.

Conflict of Interest

The authors declare that there is no conflict of interest with any financial, personal, other people or organizations related to the material in this article.

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