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Nutrient Potential Mapping of Soils for Tea Plants Through Laboratory and Geostatistical Approaches

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Abstract

The assessment of nutrient potential is crucial for enhancing tea production and achieving sustainable agricultural goals. Thus, the present study was carried out to assess and map the soil nutrient potential for tea plants through laboratory and geostatistical methods. A total of 74 random soil samples with 3 replications were collected from 0 to 9 cm (topsoil) and 9 to 18 cm (subsoil) depths from Oodaleah Tea Garden (OTG) which belongs to Fatikchhari Upazila of Chattogram District in Bangladesh. All the laboratory analyses were done following standard procedures and maps of individual soil indices were prepared through the Inverse Distance Weighted (IDW) interpolation technique using ArcGIS 10.7 software. The integration of maps for nutrient potential was performed following the Analytic Hierarchy Process (AHP). The mean concentrations of organic matter (OM), total nitrogen (TN), available phosphorus (AvP), available potassium (AvK), and available calcium (AvCa) were found higher at 0 to 9 cm compared to 9 to 18 cm soil depth with significant ($p < 0.05$) difference among the sampling sites. The maps of individual soil parameters revealed distinct spatial differences at 0 to 9 cm and 9 to 18 cm soil depths. The total study area covered 5.99 km^2. Integrated nutrient potential mapping showed that moderately suitable (44.15%) accounted for the largest proportion, followed by highly suitable (26.03%), generally suitable (21.67%), marginally suitable (7.06%), and unsuitable area (1.08%) of the tea plantation suitability evaluation. The integrated map of nutrient potential will aid in better management of the tea soils.

Keywords: Bangladesh; IDW interpolation; physico-chemical indices; soil map; tea plantation

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INTRODUCTION

Tea (*Camellia sinensis* L.) is an important cash crop and export item, which contributes about 1% to the gross domestic production of Bangladesh (Saha et al., 2015). Tea grows best in tropical and subtropical climatic conditions throughout the world including in Bangladesh, India, China, Japan, and the United Kingdom. Bangladesh accounts for 3% of the global tea production (Adhikary et al., 2019). Soil quality is considered one of the important factors affecting the production of tea. Assessing the quality of soils regarding nutrient potential is vital for sustainable agriculture to address the growing food demand (Vasu et al., 2020). Such factors as pH, texture, organic matter (OM), cation exchange capacity (CEC), total nitrogen (TN),

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available phosphorus (AvP), available potassium (AvK), and available calcium (AvCa) are important indicators for assessing the suitability of soils for crop cultivation (Xing et al., 2022). Tea can grow in a variety of soils, from light sandy soils to heavier silty loams or even silty clay loams. However, medium or light-textured soils of acidic nature are most suitable for optimal tea growth (Nath, 2014).

In the existing literature, although research related to the properties of tea soils on the aspects of nutrient status has been widely done (Islam and Sanaullah, 2011; Islam et al., 2013; Chien et al., 2019; Jahan et al., 2022; Ye et al., 2022), no information is available regarding mapping of nutrient potential of tea soils in Bangladesh based on laboratory analysis of field samples and geostatistical approaches. The land suitability for tea cultivation using geographic information system (GIS) has been carried out by several authors apart from Bangladesh (Xing et al., 2022; Sahu et al., 2023). However, based on such properties as OM, soil nutrients, and salinity, the soils of Bangladesh were mapped excluding the tea-growing areas (Huq and Shoaib, 2013).

Mapping soil attributes is a process to understand soil characteristics for sustainable land use management (Pereira et al., 2017; Rendana et al., 2022). In addition, the maps of tea soils would potentially help manage fertilizer and nutrient inputs, with a site-specific condition to prevent environmental hazards and lower input management costs. The geostatistical interpolation technique is an important mapping tool to predict the properties of soils at un-sampled locations based on the geographical coordinates against actual laboratory values (Khan et al., 2021; Leena et al., 2021). The Inverse Distance Weighted (IDW) interpolation is an important geostatistical technique to show the spatial variability in soil properties of an area (Roy et al., 2021; Chen et al., 2022). Moreover, the Analytical Hierarchy Process (AHP) is considered a tool for mapping land suitability with soil and climatic variables to improve agricultural productivity (Chiranjit and Swain, 2016).

It is difficult to understand the potentiality of soils of an area merely by examining the result of point sampling. When the data are displayed through a map by interpolating site-specific values, it is unambiguous to researchers and non-researchers. Moreover, if the soils of tea-growing areas are mapped at regular intervals, the changes in nutrients can be evaluated for sustainable management by policymakers and stakeholders. Building on the previous discussion, it is essential to analyze and develop maps to assess nutrient potential based on actual soil laboratory values and geostatistical methods for better tea soil management in Bangladesh. Therefore, the specific objectives of the current research were to assess the physical and chemical indices of tea soils (pH, OM, TN, AvP, AvK and AvCa) collected from different sites of a tea garden and to map the nutrient potential of soils for tea plants through IDW and AHP with the aid of GIS technique, focusing on soil indices.

MATERIALS AND METHOD

Study area

The soil samples were collected from Oodaleah Tea Garden (OTG) situated in the hilly region of Suabil Union of Fatikchhari Upazila in the Chattogram District of Bangladesh. The union covers an area of 7,208 acres whereas the OTG covers an area of 2,995.72 acres where the tea growing area is 1,903.35 acres. The region is situated at an altitude of 30 to 46 meters above sea level, characterized by low hill ranges and terraces. It experiences a tropical monsoon climate with an annual average rainfall of approximately 2,794 mm, with July being the wettest month. In this area, the soils are mainly yellowish to reddish brown. On flat land, the soil texture is predominantly clay loam, whereas, on hilly areas, it is mainly sandy loam to coarse sand, featuring broken shale or sandstone and mottled sand at varying depths (Absar et al., 2021). The soil sampling sites belonging to OTG are shown in Figure 1.

Collection and processing of soil samples

Soil samples were collected from depths of 0 to 9 cm and 9 to 18 cm at 37 randomly selected sites across the entire tea garden, with 3 replications at each site. While the number, length, area, and volume of tea roots can be influenced by factors such as the age of the tea plants, soil moisture, and tea variety (Niranjana and Viswanath, 2008; Sun et al., 2019), soil biological activity is largely intense in the upper soil layers (Biswas and Naher, 2019). Therefore, samples were collected at these depths of soil. To ensure comprehensive coverage of the whole area, sampling was conducted to represent the variability of soil properties within the study site. The moisture and pH of the soil samples were

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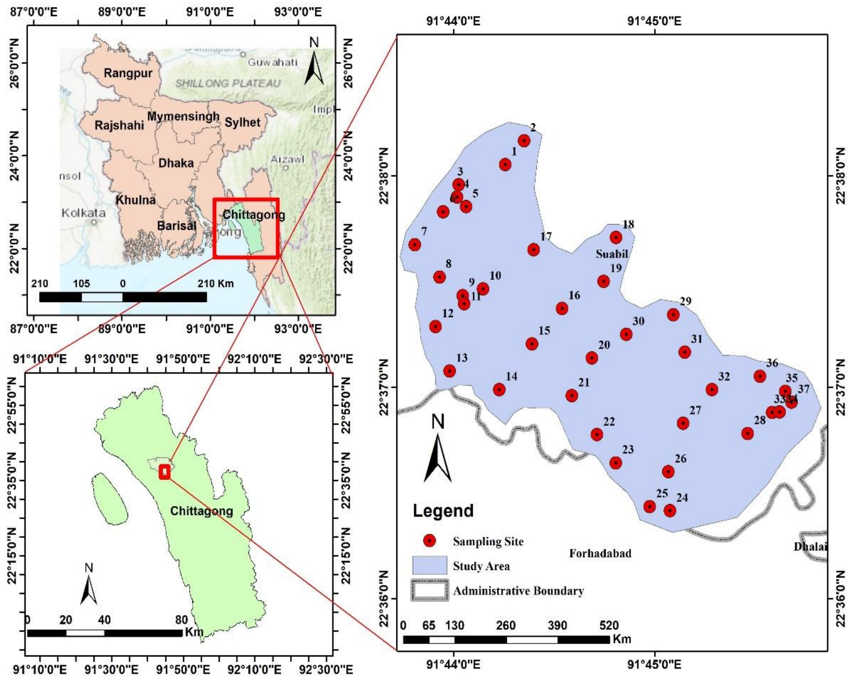

Figure 1. Location map of the sampling sites of OTG

determined immediately just after bringing the samples to the laboratory. The remainder portion of the soil samples were air dried for a few days, ground through a wooden hammer, and screened to pass through a 2 mm sieve to remove the roots and larger particles. The sieved soil samples were used for various physical and chemical property analyses.

Analyses of soil samples

Soil pH was measured after preparing the suspension at a 1:2.5 soil-to-water ratio (w/v) using a pH meter (Adwa, AD1020). The soil field moisture (FM) was assessed by gravimetric method after drying the soil samples in an oven at 105 °C for 24 hours (Huq and Alam, 2005). Soil separates were determined by the hydrometer method of Bouyoucos (1936) as described in Huq and Alam (2005) and the textural class was determined from Marshall’s triangular coordinates as devised by the United States Department of Agriculture (USDA, 1951). The organic carbon (OC) content was determined using the Walkley and Black wet oxidation method and soil OM was estimated indirectly by multiplying the OC content by the Van Bemmelen factor of 1.724 (Nelson and Sommers, 1982). The TN was determined by digesting soil samples with concentrated H_2SO_4, followed by distillation of the digests with strong alkali (40% NaOH) containing boric acid-mixed indicator in an erlenmeyer flask and the titration of the distillate with 0.01 N H_2SO_4 (Bremner and Mulnaney, 1982). The concentration of AvP was determined using the ascorbic acid blue color method with a UV-visible spectrophotometer (Shimadzu, UV1800) at a wavelength of 882 nm (Murphy and Riley, 1962) after extracting the soil samples with Bray and Kurtz-1 solution. The AvK and AvCa were determined using flame photometer (Jenway, PFP7 Flame Photometer) and ethylenediaminetetraacetic acid (EDTA) methods, respectively, after the soil samples were extracted with NH_4OAc at 1:5 ratio (w/v) by shaking for 30 minutes followed by filtration (Thomas, 1982).

Statistical analysis

All analytical data of soil samples were expressed on an oven-dried basis. The mean and standard deviation were determined using Microsoft Excel. In simple linear regression, clay content and OM were considered as independent, while OM and soil nutrients (TN, AvP, AvK and AvCa) were considered as dependent among the soil variables. On the other hand, soil OM was considered as an independent variable against soil nutrients (TN, AvP, AvK and AvCa) as for both topsoil and subsoil. The differences in the means of the soil parameters were tested by one-way analysis of variance (ANOVA) and the significance of the parameters was tested using the least significant difference multiple range test at $p < 0.05$ after one-way ANOVA through Statistical Packages for Social Sciences (SPSS) software.

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Table 1. Suitability class of soils for tea cultivation

Parameter	Highly suitable	Moderately suitable	Generally suitable	Marginally suitable	Unsuitable
pH	4.5-5.5	5.5-6.0	4.0-4.5	3.0-4.0	< 3.0 and > 6.0
OM (%)	> 2.7	2.0-2.7	1.0-2.0	0.5-1.0	< 0.5
TN (%)	> 2.0	0.15-2.0	0.10-0.15	0.05-0.10	< 0.05
AvP (ppm)	> 30	20-30	10-20	5-10	< 5.0
AvK (ppm)	> 200	120-200	80-120	50-80	< 50
AvCa (ppm)	> 220	150-220	90-150	50-90	< 50

Geostatistical mapping of the study area

To prepare the maps, the study area boundary was created as a shapefile, followed by a mapping exercise and data visualization using the IDW interpolation method of the spatial analyst toolbox of ArcGIS 10.7 software (Roy et al., 2021). To illustrate the spatial difference between topsoil and subsoil, maps were prepared based on the manual break method considering different ranges of the analytical values of each parameter as described by Sahu et al. (2023). The critical values were set at 4.5 to 5.8 for pH, 0.1% for TN, 1% for OM, 10 ppm for AvP, 80 ppm for AvK, and 90 ppm for AvCa (Alam, 2003). For map visualization, consistent color code was used to represent a specific range of values for both topsoil and subsoil.

Nutrient potential evaluation of soils for tea plants

The nutrient potential of soils for tea plants was evaluated by integrating maps developed with the AHP method. The area was categorized into 5 suitability classes: highly, moderately, generally, marginally, and unsuitable (Table 1) (modified from Chen et al., 2022).

RESULTS AND DISCUSSION

Physical indices of soils

The mean values of sand, silt, and clay of soils collected from different sites are shown in Table 2. Irrespective of the sampling sites, sand content ranged from 52.5 to 85.8%, silt from 6.1 to 33.6%, and clay from 6.1 to 22.2% at a depth of 0 to 9 cm, with mean values of 71.83%, 17.39%, and 10.78%, respectively. At 9 to 18 cm soil depth, sand content ranged from 48.8 to 85.8%, silt from 4.6 to 33.6%, and clay from 6.1 to 27.2%, with mean values of 69.4%, 17.03%, and 13.57%, respectively. Almost all of the soils of OTG were sandy loam in texture with some sandy clay loam, loamy sand, loam, and sand. This texture is consistent with findings reported by other studies on tea soils (Bishnu et al., 2009; Biswas and Motalib, 2012; Islam et al., 2014; Nath, 2014; Sanaullah et al., 2016; Chien et al., 2019). Sandy loam and sandy clay loam are considered to be the best for tea cultivation (Islam et al., 2013).

Regardless of the sampling sites, the FM ranged from 4.18 to 21.65% and 6.07 to 24.79% with a mean FM of 10.50% and 12.46% at 0 to 9 cm and 9 to 18 cm soil depths, respectively (Table 2). The higher mean FM in the subsoil compared to the topsoil aligns with the findings of Azizan et al. (2019). The lower moisture content in the topsoil might be due to low clay content and high exposure of the topsoil to sunlight causing high evapotranspiration. English et al. (2005) highlighted that soil porosity, texture, farm management, and vegetation significantly influence soil moisture content.

Chemical indices of soils

The maximum, minimum, and mean values of pH, OM, TN, AvP, AvK, and AvCa of soil samples at 0 to 9 and 9 to 18 cm depths of soil are provided in Table 3 and Table 4. There was a significant difference ($p < 0.05$) in topsoil and subsoil pH among the sampling sites. The subsoil pH of the tea garden was mostly between 4.5 and 5.5, which is considered optimum for tea cultivation (Yan et al., 2020; Rothenberg et al., 2022; Liu et al., 2023). Greater variability in pH was observed in the case of topsoil. Soil pH variation is influenced by the type and amount of fertilizers used, the rate of fertilizers applied, and soil management (Li et al., 2016). The greater acidification of both topsoil and subsoil could be attributed to the age of plantations in the tea garden. Han et al. (2007) stated that the pH of the soil declines with increasing tea cultivation period. The use of long-term inorganic fertilizers could also contribute to decreasing soil pH. Similar findings were stated by Baruah et al. (2013) and Yang (2021).

The OM and soil nutrients among the sampling sites differed significantly ($p < 0.05$) at 0 to 9 cm and 9 to 18 cm depths. There was also a significant difference ($p < 0.05$) in their concentration

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Table 2. Minimum, maximum, and mean values (%) of FM and soil separation at different soil depths

Soil depth (cm)	Description	FM (%)	Sand (%)	Silt (%)	Clay (%)
0-9	Minimum	4.18	52.50	6.10	6.10
	Maximum	21.65	85.80	33.60	22.20
	Mean	10.50	71.83	17.39	10.78
9-18	Minimum	6.07	48.80	4.60	6.10
	Maximum	24.79	85.80	33.60	27.20
	Mean	12.46	69.40	17.03	13.57

between the topsoil and subsoil. Irrespective of the sampling sites, the values of OM, TN, AvP, AvK, and AvCa were found in the range of 0.66 to 2.50%, 0.08 to 0.26%, 2.12 to 36.63 ppm, 26.08 to 232.74 ppm, 49.0 to 611.33 ppm with mean values of 1.35%, 0.14%, 10.82 ppm, 104.99 ppm and 173.91 ppm, respectively at 0 to 9 cm soil depth. On the other hand, at 9 to 18 cm depth of soil, the values of OM, TN, AvP, AvK, and AvCa were found in the range of 0.34 to 1.70%, 0.07 to 0.20%, 2.0 to 28.38 ppm, 28.28 to 172.58 ppm, 45.67 to 475.0 ppm with mean values of 0.96%, 0.11%, 3.81 ppm, 90.70 ppm and 140.08 ppm. The higher contents of OM, TN, AvP, AvK, and AvCa in the topsoil of both the tea gardens were similar to the findings of other researchers (Jin et al., 2005; Islam et al., 2014; Sanaullah et al., 2016). Muzib et al. (2023) observed a significant effect of soil depth on the concentration of available and total nutrients in tea soils. The higher OM and nutrient levels in the topsoil are likely due to the regular addition of organic manures to the surface, as plant and animal litter contribute essential resources to the upper soil layers (Kögel-Knabner, 2002).

Though the OM and TN in the topsoil were higher than the critical values for tea growth, their concentrations in the subsoil were not satisfactory. Moreover, AvP and AvK in both the topsoil and subsoil were found quite lower than that of the critical values set for tea cultivation. Several authors also reported that tea soils in different locations of Bangladesh were generally low in OM, TN, and other available nutrients, which did not fulfill the requirements for good tea plant growth (Biswas and Motalib, 2012; Islam et al., 2013; Alam et al., 2022). The application of mainly nitrogenous fertilizer in

Table 3. Descriptive statistics of soil samples at 0 to 9 cm depth

Description	pH	OM (%)	TN (%)	AvP (ppm)	AvK (ppm)	AvCa (ppm)
Mean	4.97	1.35	0.14	10.82	104.99	173.90
Median	4.90	1.39	0.14	5.55	87.20	15.53
Mode	4.89[a]	0.95	0.12[a]	28.05	68.56	78.00[a]
Variance	0.29	0.18	0.00	109.43	355.40	1,476.00
Skewness	0.59	0.42	1.05	1.12	0.62	1.85
Kurtosis	0.87	0.18	1.77	-0.09	-0.65	4.16
Range	2.70	1.84	0.18	34.51	206.66	562.33
Minimum	3.78	0.66	0.08	2.12	26.08	49.00
Maximum	6.48	2.50	0.26	36.63	232.74	611.33

Note: [a] = Multiple modes exist. The smallest value is shown

Table 4. Descriptive statistics of soil samples at 9 to 18 cm depth

Description	pH	OM (%)	TN (%)	AvP (ppm)	AvK (ppm)	AvCa (ppm)
Mean	4.89	0.96	0.11	3.81	90.70	140.08
Median	4.86	0.91	0.11	2.41	76.41	99.00
Mode	4.63[a]	0.60[a]	0.11	2.45	67.58[a]	54.33
Variance	0.31	0.11	0.00	24.52	213.90	1,118.00
Skewness	0.77	0.21	1.10	4.26	0.39	1.65
Kurtosis	2.08	-0.88	3.58	18.81	-1.22	2.15
Range	2.83	1.36	0.13	26.38	144.30	429.33
Minimum	3.81	0.34	0.07	2.00	28.28	45.67
Maximum	6.64	1.70	0.20	28.38	172.58	475.00

Note: [a] = Multiple modes exist. The smallest value is shown

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addition to the application of different sources of organic manures could be the reasons behind the high OM and TN levels (Loide, 2004; Zhong et al., 2010; Baruah et al., 2013; Islam et al., 2014; Zhang, 2018; Wang et al., 2022). Moreover, the application of only nitrogenous fertilizers for a long period can also lead to the deficiency of AvP, AvK, and AvCa by lowering soil pH (Jahan et al., 2022). However, regular application of dolomite as an acid-neutralizing agent in the surface soils in tea-producing areas might be the reason for a comparatively higher content of AvCa in the topsoil, which was in consistent with researchers' present findings.

Regression analysis of soil attributes

In regression analysis of topsoil, clay content as an independent variable had an insignificant relationship with other variables except for AvP with a linear regression coefficient (R^2) value of 0.166 (Table 5). As for subsoil, all the dependent variables (TN, AvP, AvK, AvCa) except for OM showed insignificant R^2 ($p > 0.05$) with the dependent variable clay. Similarly, OM as an independent variable had a significant ($p < 0.05$) relation with that of the TN and AvK as the dependent variables in the case of topsoil. However, all the dependent variables (TN, AvP, AvK, AvCa) showed insignificant R^2 ($p > 0.05$) with OM as for subsoil. As for topsoil, the significant relationship of OM with that of TN in this study was in support of the findings of Chien et al. (2019) suggesting the replenishment of soil OM pool by the addition of organic manures on the soil surface.

Among the soil variables, the percentage of clay was considered as an independent variable. In contrast, OM and soil nutrients were considered dependent variables because the rate of OM decomposition and the capacity of soil to supply nutrients largely depends on the percentage of clay. Several studies highlighted that the clay contents can be used as a tool for the estimation of OM decomposition as well as the supply of nutrients because of their high charge and specific surface area (Wei et al., 2014; Soinne et al., 2021). On the other hand, soil OM was considered as an independent variable for soil nutrients (TN, AvP, AvK, and AvCa) because soil OM strongly regulates the storage as well as the availability of nutrients in soils, and the concentration of soil nutrients varies with the variation of soil OM. Several studies also stated that the soil OM contributes to soil chemical fertility, being a reserve of nutrients through releasing by mineralization and retaining by adsorption and/or fixation of nutrients on its charges (Gerke, 2022; Chenu et al., 2024).

Geostatistical mapping of tea soils

Figure 2 shows the pH maps of the topsoil and subsoil of OTG. The topsoil showed more variability in pH compared to the subsoil. A significant portion of the tea garden exhibited topsoil pH levels either below 4.5 or above 5.5. In contrast, the majority of the subsoil had a pH ranging between 4.5 and 5.5 (represented in orange). Only a small area of the subsoil had a pH either below 4.5 (indicated in red) or above 5.5 (depicted in green).

In terms of OM content, opposite results were found for topsoil and subsoil (Figure 3). While the maximum area of the topsoil had OM in the range of 1.01 to 1.50% (yellow color), subsoil had OM with the range of 0.51 to 1.00% (orange color) followed by 1.01 to 1.50% (yellow color). Similarly, Figure 4 clearly shows higher TN content in the topsoil compared to subsoil. In the study area, the majority of the topsoil had TN levels above 0.10% (indicated in light and dark green), with only a small portion showing TN levels between 0.051% and 0.10% at the 0 to 9 cm

Table 5. Regression analysis of soil variables

Variables		Topsoil			Subsoil		
Independent	Dependent	R^2	F	*p*-value	R^2	F	*p*-value
Clay	OM	0.070	2.654	0.112	0.125	4.986	0.032
	TN	0.002	0.079	0.780	0.072	2.722	0.108
	AvP	0.166	6.946	0.012	0.008	0.272	0.605
	AvK	0.015	0.516	0.477	0.035	1.258	0.270
	AvCa	0.000	0.014	0.907	0.009	0.324	0.573
OM	TN	0.151	6.242	0.017	0.094	3.630	0.065
	AvP	0.004	0.149	0.702	0.010	0.351	0.558
	AvK	0.142	5.808	0.021	0.013	0.451	0.506
	AvCa	0.044	1.615	0.212	0.051	1.888	0.178

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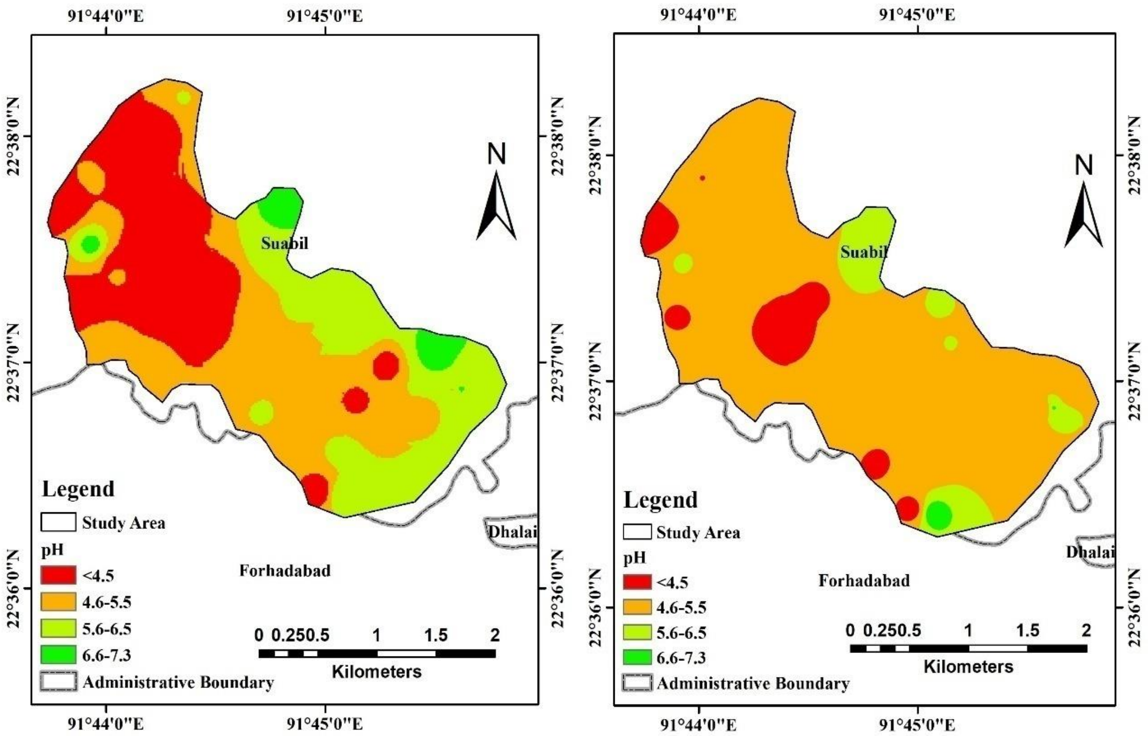

Figure 2. pH map of topsoil (left) and subsoil (right) of OTG

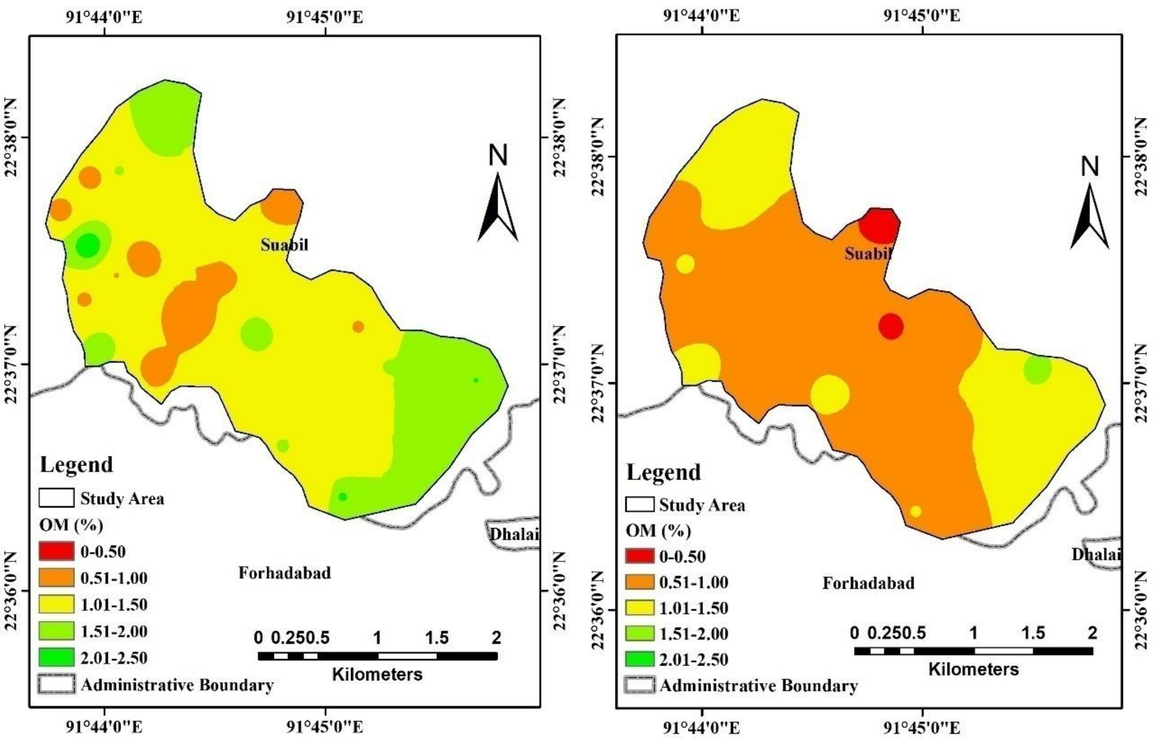

Figure 3. OM map of topsoil (left) and subsoil (right) of OTG

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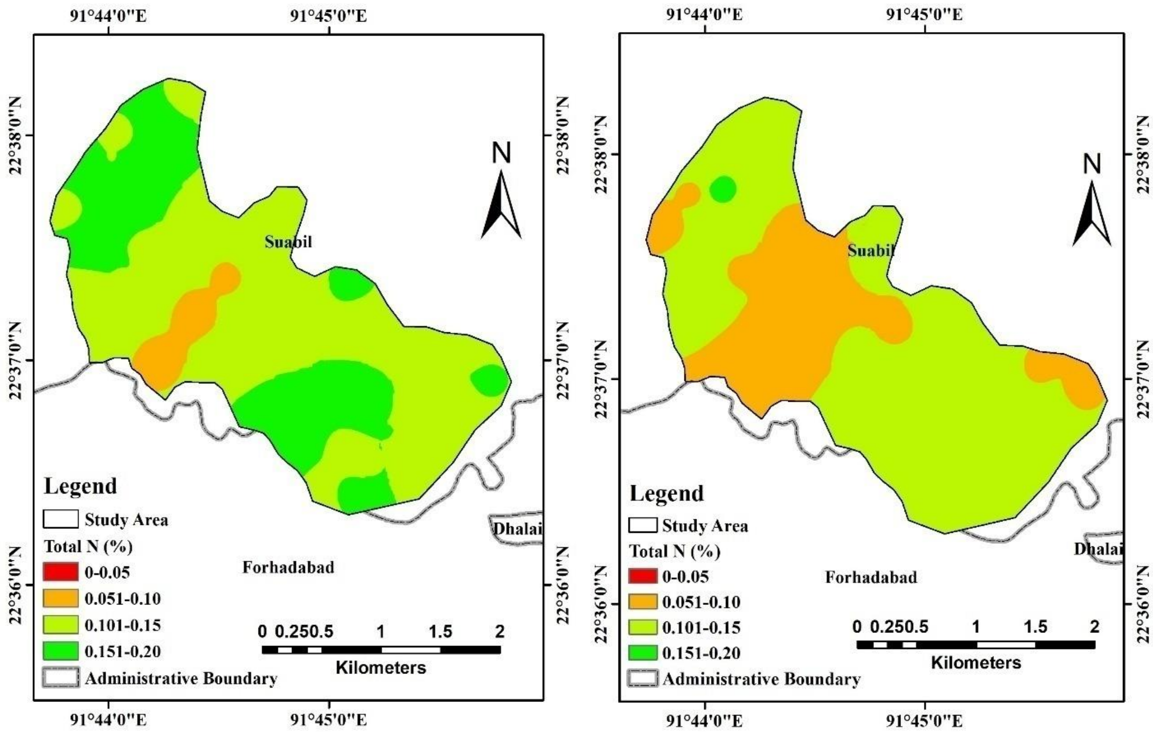

Figure 4. TN map of topsoil (left) and subsoil (right) of OTG

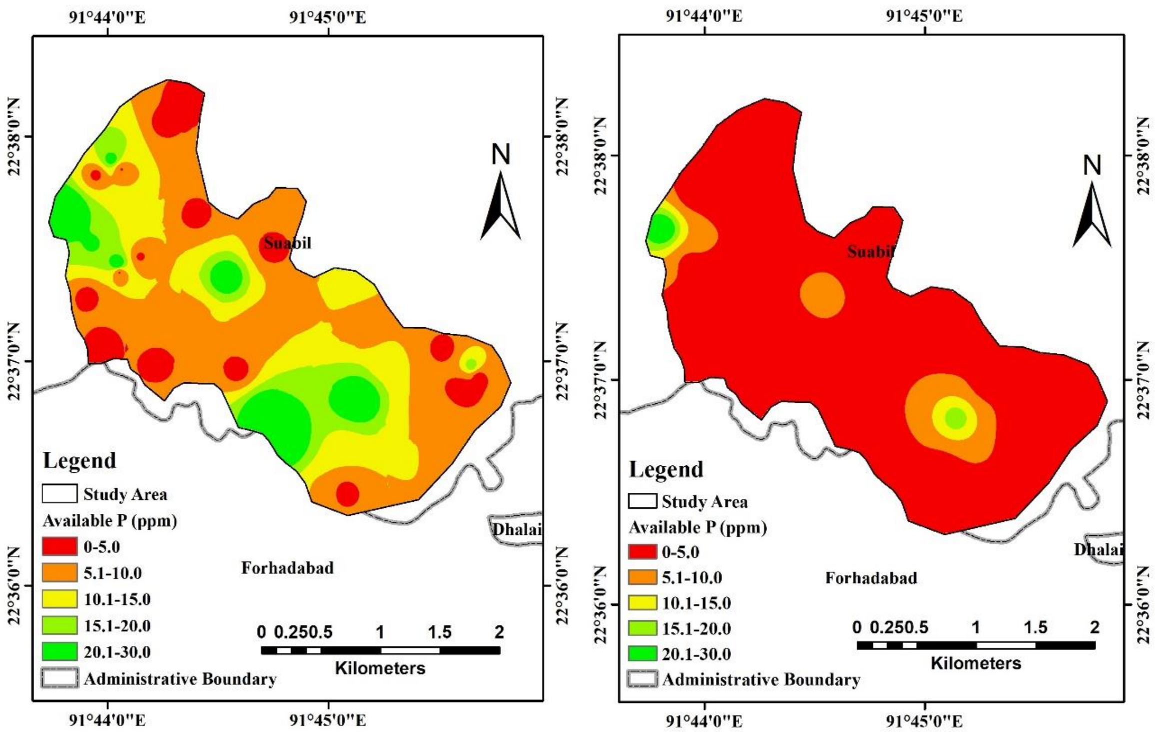

Figure 5. AvP map of topsoil (left) and subsoil (right) of OTG

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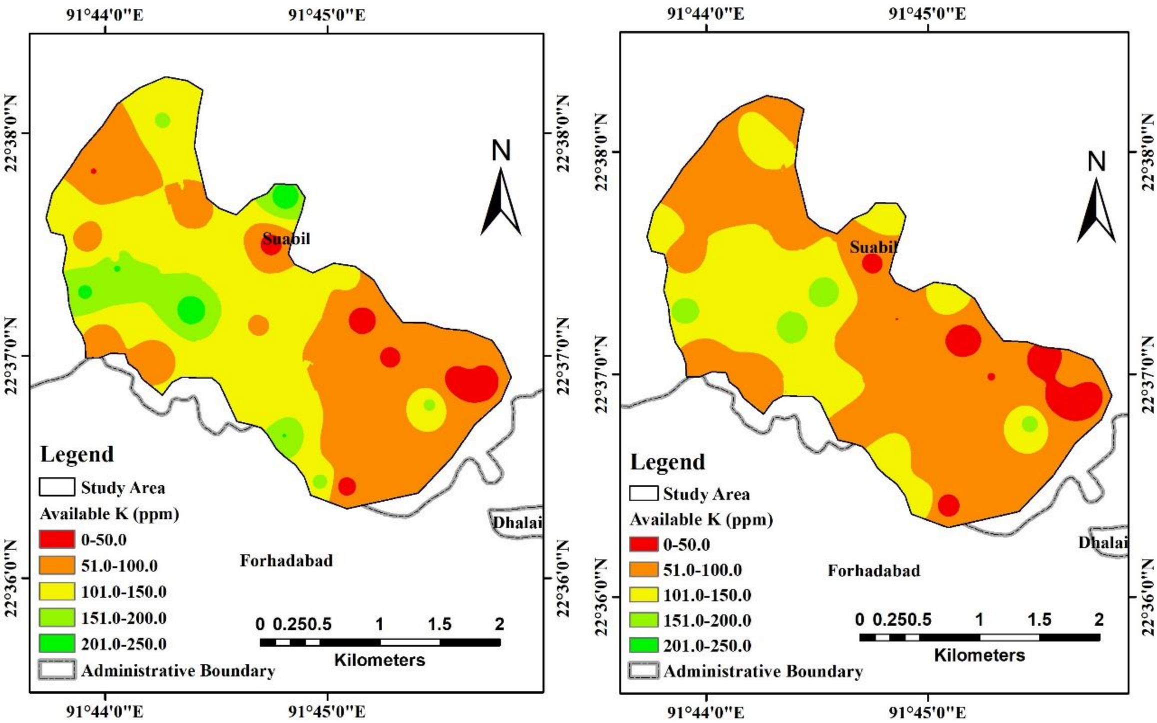

Figure 6. AvK map of topsoil (left) and subsoil (right) of OTG

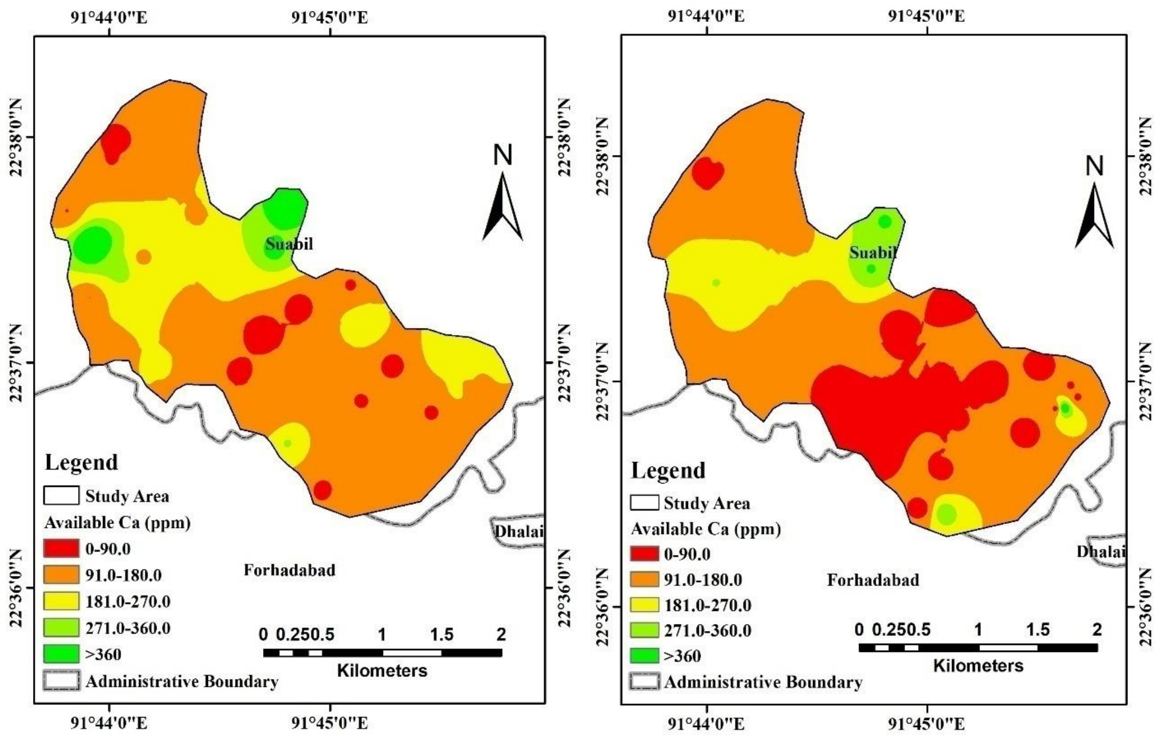

Figure 7. AvCa map of topsoil (left) and subsoil (right) of OTG

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depth. Conversely, a significant portion of the subsoil exhibited TN levels ranging from 0.051 to 0.10% at the 9 to 18 cm depth.

Though AvP content was highly variable at 0 to 9 cm soil depth, almost all of the area had AvP below 5 ppm (red color) at 9 to 18 cm soil depth (Figure 5). The AvK and AvCa were found to be highly variable both at 0 to 9 cm and 9 to 18 cm soil depths. Most of the area had AvK in the range of 101 to 150 ppm (yellow color) followed by soil 51 to 100 ppm (orange color). On the other hand, the majority of the subsoil had AvK with the range of 51 to 100 ppm, which was displayed as orange color followed by 101 to 150 ppm which was displayed as yellow color (Figure 6). Figure 7 clearly shows that the majority of OTG had AvCa between 91 ppm and 180 ppm (orange color). The scenario was the same for both topsoil and subsoil. Although a small area had AvCa with 0 to 90 ppm at 0 to 9 cm, the area with that concentration was considerably higher at 9 to 18 cm of soil.

The maps of different parameters revealed distinct spatial variations between the topsoil and subsoil of the area. In previous studies, the IDW interpolation technique was found to be a valuable mapping tool that aided in predicting soil parameters at un-sampled places by comparing geographic coordinates with real analytical data (Roy et al., 2021; Rash et al., 2024). Chen et al. (2022) also used IDW interpolation as a tool for the suitability evaluation of a tea plantation area in Guangdong, China. The spatial differences in soil properties of the study area could be due to soil heterogeneity and some complex interrelated factors. Several researchers stated that the properties of soil highly vary spatially in a small land area due to various factors such as soil management practices, indigenous fertility status, nature of standing crops, and topography (Islam and Sanaullah, 2011; Kingsley et al., 2019; Khadka et al., 2020).

Nutrient potential map of soils for tea plants

The suitability of the area concerning soil nutrient potential is shown in Figure 8. Based on the suitability, the area was grouped into 5 categories. The total area covered by the 5.99 km^2

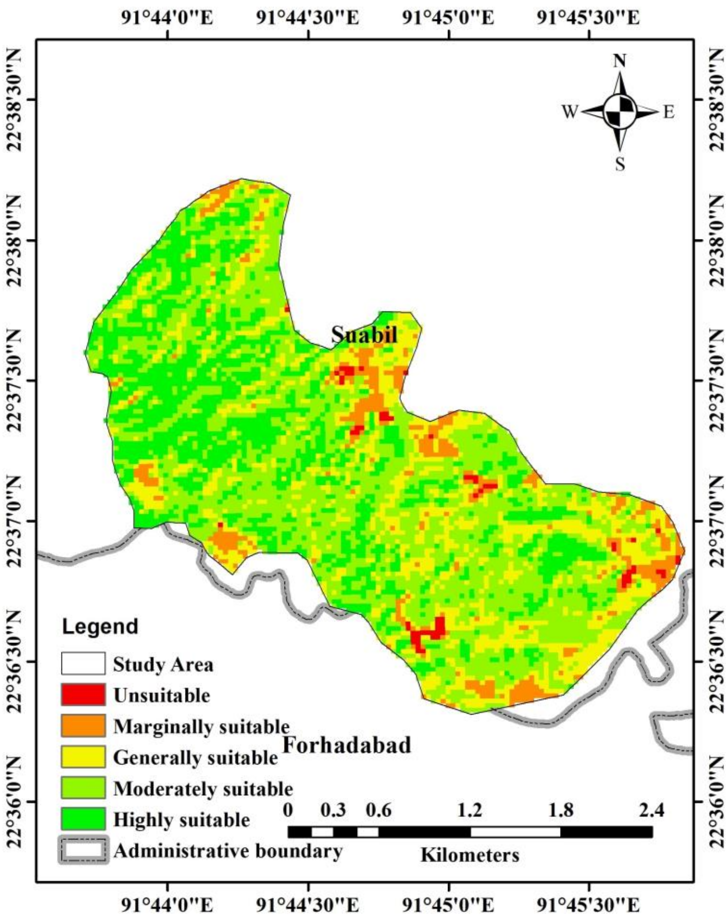

Figure 8. Suitability classes of soil nutrient potential for tea plants

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tea garden. The analysis revealed that 26.03% of the area is classified as highly suitable, 44.15% as moderately suitable, 21.67% as generally suitable, 7.06% as marginally suitable, and 1.08% as unsuitable. Several such approaches as random forest (RF), logistic regression (LR), and geographically weighted regression (GWR) models are practiced for the evaluation of land suitability through integrated mapping (Xing et al., 2022; Sahu et al., 2023; Sengupta and Thangavel, 2023). The applicability of AHP for land suitability evaluation and sustainable management has been supported by several studies (Chiranjit and Swain, 2016; Chen et al., 2022).

CONCLUSIONS

The soil nutrient potential for tea plantations was evaluated based on different soil variables such as pH, OM, TN, AvP, AvK, and AvCa. In the initial phase, soil samples were collected for physico-chemical assay in the laboratory. The maps of different soil attributes based on analytical data were developed by the ArcGIS geoprocessing tool using the IDW technique. At the final stage, an integration map was created to assess the suitability of nutrient potential for tea plants. The nutrient potential of the study area was predominantly categorized as moderately suitable, with a notable portion classified as highly suitable. Less than 2% of the total area was deemed unsuitable. This study of nutrient potential mapping of tea soils would profoundly benefit the stakeholders in managing soil nutrients for sustainable land use and tea production. The findings suggest that, for large-scale tea plantations in Bangladesh, it is essential to consider additional factors such as terrain, soil characteristics, precipitation, rainfall, and vegetation indexes when assessing land suitability maps.

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