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Morphological characteristics of tea growing areas in Kishanganj district, Bihar using remote sensing and GIS technologies

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Abstract
The present investigation was carried out "Morphological characteristics of tea growing areas in Kishanganj district, Bihar using remote sensing and GIS technologies. The results revealed that most of tea growing soils belong to Entisols order as 7th approximation of soil classification, and taxonomically classified as *Aeric fluvaquents, Typic ustipsamments, Typic ustifluvents and Aeric endoaquepts etc.* at sub-group level. Whereas, characterisation of soil series level, Harbhita, Khajuria, Khajuri and Soksanand series are major predominating soil series have been identified for tea growing soils in Kishanganj district. The soil reactions were varied from acidic to neutral in reactions. However, no effervescence with dil. HCl have been observed in all horizon, which indicated that there was nil of calcium carbonate content in tea growing soils. The soil colour varied from light Gray, olive colour, and pale-yellow colour have been observed which indicated that low organic carbon content has been observed in tea growing soils.

Keywords: Morphological characteristics, remote sensing, GIS technologies, Bihar

Introduction
Tea (Camellia Sinensis) is a major commercial crop, and its account for 28% of global production, and 13% of the global trade. Bihar, is the one of the leading states which is the significant contributor as tea producing state despite, the low to very high productivity potential because of various soil and climate related constraints like rainfall, specific humidity, microbial consortia etc. In recent decades, variations in temperature, rainfall, and the occurrence of extreme weather events such as drought and high-intensity rainfall have had a negative impact on tea output and production (de Costa *et al*. 2007, Wijeratne *et al*. 2007, Duncan *et al*. 2016) [1, 1, 3]. Thereby, with well management of the above constraint by adopting different conservation practices enhance the quality, as same time extend their potential areas up to 10,000 acres. Differences in soil parent material, climate, irrigation, and biological activity are the main causes of variance in soil qualities (including humans). The relative deficiency of soil nutrient content, substantial fertilisation management, and soil acidification concerns are more prevalent, which pose a serious threat to the environment. As the pH of the soil rises, so does the availability and concentration of macronutrients (Nath 2013) [5]. A well-drained, deep, and well-aerated soil with more than 2% organic matter is recommended for tea growth (de Silva 2007) [2]. As a result, this research to aid the details intensive information regarding morphological characteristics of tea growing soils in Kishanganj district, and this approach to offer the information regarding gneiss of a tea garden in order to provide scientific guidance on fertilisation balancing, which has significant practical implications for the long-term sustainability of regional gardens. In light of the foregoing, the current study was designated to "Morphological characteristics of tea growing areas in Kishanganj district, Bihar" and classified them based on the Soil Taxonomy (USDA).

Material and Method
In order to delineate the soil series characterisation of tea growing areas in Kishanganj district topographical and geographical setting (SRTM Data) were imposed the details characterisation after advocating the geospatial input using standard procedure (Soil survey staff, 1951, 1975) [6, 7]. Total 6 soil profile was excavated which were especially placed under tea growing soils. The geographical extension of Kishnaganj district were varied from 26° 18' 28.0548" N to 87°

46'34.8132" E having total area of 1884km^2, and it occupy the six C.D. blocks namely Thakurganj, Dighalbank, Kochadhamin, Bahadurganj, Pothia and Kishanganj (Soil Survey Staff, 1998, 1999) [8, 9]. The soil colour was determined through Munshell colour chart, and meanwhile soil pH was determined through Potentiometric method (Jackson, 1973) [4]. The beauty of soils belong to Kishanganj district is Mananda river passes from north east to south west which meets in the Ganges in Katihar district, which play pivotal role towards genesis of these types of soils. Similarly, the latitude, longitude along with altitude was also recorded from each sample point with the help of portable geo-positing system (Garmin's), and samples distribution was mainly confined to tea growing soils, and mapping work was done through licence version through ARC-GIS 9.2.

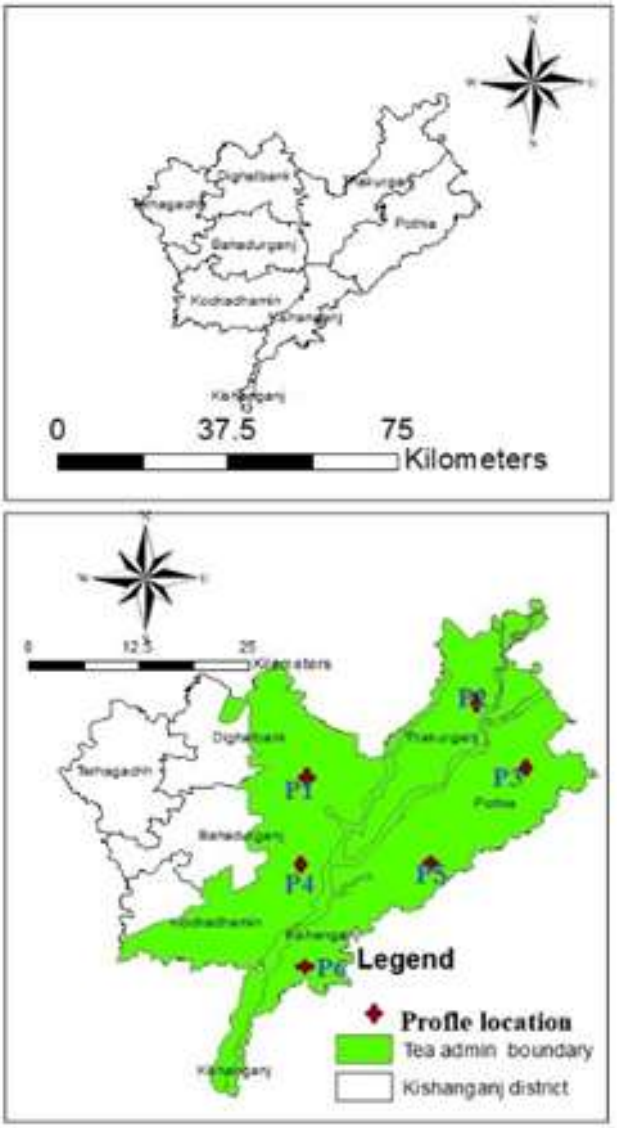

Fig 1: Location map of Tea growing soils in Kishanganj district

Results and discussion

Pedon1 (P_1)

Soil colour of harbhita soil series was varied from 5Y6/2 to 5Y7/2 with abrupt and smooth boundary, and pH value varied from 5.3 to 6.3 with increasing trends**,** and colour of the soil varies from deep black to grey black, and due to the various factors, soils belong to these areas acidic in nature with poor in base status and available plant nutrients and taxonomically classified *Aeric Fluvaquents.*

Pedon2 (P_2)

P_2 have also been placed under Harbitha soil series. However, soil colour varied from D5Y/2 to D5Y6/2 with gradual and smooth boundary except Ap layer (clear and smooth boundary), and minor variation of soil pH have also been observed which was found in increasing trends (6.8 to 7.2) towards downward the soil profile, and taxonomically classified as *Aeric Fluvaquent* like P_1.

Pedon3 (P_3).

In P_3, soil colour was varied from 10Y8/1 to 10YR8/2 with clear and smooth boundary have been observed in Ap and C2, and rest of the horizon were observed in gradual and smooth boundary. Some pea size ferruginous concretions were observed, and finally classified under Khajuri series with *Typic Udipsamments* as per 7th approximation of USDA classification. Meanwhile, pH was value was varied from 7.4 to 7.2 towards downward the soil profile. Soil texture also maintains sandy and loamy features which make its plains suitable for the agricultural activities. It has also been found that the soil is also deficient in nutrients because of variations in biology, climate and terrain features which enable to brought significant impact on soil chemical markers (Yan, 2008) [12]. These soils are coarse to finer in texture, deep to very deep and greyish in colour and mostly neutral in reaction. The erratic distribution of sand and silt have also been observed by Vadivelu *et al*. (2003) [10] because of frequent seasonal floods and alter the mode of stratification within the alluvial profiles in Brahmaputra plains.

Pedon4 (P_4)

The soil colour varied from 5Y7/1 to 8/2 with smooth and clear boundary, and soil pH was observed in decreasing trends which was varied from 7.6 to 6.1, and due to lithological discontinuity of such types of soils placed under Nathpur series, and taxonomically classified as *Aquic udifluvents*.

Pedon5 (P_5)

In P5, the soil colour varied from 5Y5/3 to 5Y5/4, and clear and smooth boundary (Ap and C3), and gradual and abrupt bound, respectively. However, irregular pH distribution was observed in all horizon. Such types of soils placed under Sokshanand series, and taxonomically classified as Aquic udifluvents.

Pedon6 (P_6)

In P6, the soil colour was varied from 5Y7/2 to 8/3, and clear and smooth boundary have been observed in C_1 and C_{21} horizon, and irregular pH was observed like P_5 horizon, and minor variation of pH have been observed which was varied from 7.2 to 7.3. However, no effervescence have been observed in all horizon. Thereby, the taxonomically classified of above character full fill the criteria of P_5 horizon.

Table 1: Morphological characteristics of 0. Growing soils in Kishanganj district

Depth (cm)	Horizons	Pedon1: Harbhita (Aeric Fluvaquents)
0-15	Ap	Light grey (5 Y 7/2) silt loam, weak blocky structure, slightly sticky and slightly plastic when wet, few fine distinct yellow mottles, no effervescence with dilute HCl, pH 5.3, abrupt and smooth lower boundary.
15-35	2C1	Light grey (5 Y 7/2) coarse sand, single grained structure, non-sticky and non-plastic when wet, no effervescence with dil HCl. pH 6.4, abrupt and smooth lower boundary.
35-50	3C2	Olive grey (5 Y 5/2) silt loam, platy structure, sticky and plastic when wet, common medium yellow mottles, no effervescence with dil HCl, pH 6.1, abrupt and smooth lower boundary.
50-100	3C3	Pale yellow (5Y 7/3) sandy loam, single grained, structure, non-sticky and non-plastic when wet, common coarse distinct brown mottles, no effervescence with dil HCl, pH 6.2, abrupt and smooth lower boundary.
100-150	2C4	Light olive grey (5Y 6/2) silt loam, medium moderate blocky structure, sticky and plastic when wet, no effervescence with dil HCl, pH 6.4, abrupt and smooth lower boundary.
Depth (cm)	**Horizons**	**Pedon2: Harbhita (Aeric Fluvaquents)**
00-20	Ap	Olive grey (D 5Y 5/2) sandy loam, ploughed slightly hard when dry, slightly plastic and slightly sticky when wet, no effervescence with dilute hydrochloric acid, no concretion, common medium faint (10YR 6/8) olive yellow mottles, brick bats, pH 6.8 and clear and smooth boundary.
20-55	C1	Pale olive (D 5Y 6/3) sandy silt, single grained, loose when dry non-plastic and slightly sticky when wet, no effervescence with dilute hydrochloric acid, common medium friable iron concretion, common, medium distinct (10YR 5/6) yellowish brown mottles, pH 7.0 and with gradual and smooth boundary.
55-110	C2	Pale olive (D 5Y 6/4) sandy silt, single grained, loose when dry, slightly sticky and non-plastic when wet, no effervescence with dilute hydrochloric acid, common medium coarse and distinct (10YR 5/6) yellowish brown mottles. pH 7.0 and with gradual and smooth boundary.
110--160	C3	Pale olive (M 5Y 6/2) medium sand, structure less, loose when moist, non-plastic and non-Sticky when wet, strong effervescence with dilute hydrochloric acid, no concretion, common, Medium and distinct (10YR 5/6) yellow mottles and pH 7.2.
Depth (cm)	**Horizons**	**Pedon3: Khajuri series: Typic Udipsamments**
00-15	Ap	White (10 YR 8/1) loamy sand, single grained, slightly sticky and non-plastic, no effervescence with dil HCl, slight reaction, with H2O2, pH 7.4; clear and smooth lower boundary.
15-47	C1	White (10 Y R 8/2) fine sand, sticky grained structure, slightly sticky and non-plastic, few soft mustard and pea sized ferruginous concretions, no effervescence with dil HCL, slight reaction with H_2O_2, pH 7.2; gradual and smooth lower boundary.
47-75	C2	White (10 YR 8/1) sandy loam; medium moderate, blocky structure, sticky and slightly plastic when wet, some soft mustered and pea sized ferruginous concretions; many brown mottles, no effervescence with dil, HCl, no reaction with H_2O_2, pH 7.1; clear and smooth lower boundary.
75-125+	C3	White (10 YR 8/1) fine sand, single grained structure non sticky, non-plastic, few mottles, some soft mustered to pea sized ferruginous concretions, no effervescence with dil HCl, slight reaction with H_2O_2, pH 7.2; abrupt and smooth lower boundary.
Depth (cm)	**Horizons**	**Pedon4: Nathpur series (Aquic Udifluvents)**
0-14	Ap	Light grey (5 Y 7/1) silt loam, fine weak angular blocky structure, hard when dry, sticky and slightly plastic when wet, strong reaction with dil HCl, pH 7.6; clear and smooth boundary.
14-34	C1	Light grey (5 Y 7/2) silt loam, fine weak angular blocky structure, sticky and plastic when wet, faint brown mottles, no reaction with dil HCl, pH 7.1; clear and smooth lower boundary.
34-90	C12	Pale yellow (5 Y 7/3) loam, non-sticky and non-plastic when wet, few brown mottles, no reaction with dil, HCl, pH 6.6, abrupt and smooth lower boundary.
90-125	C2	White (5 Y 8/2) sand, single grained structure, non-sticky and non-plastic when wet, no reaction with dil, HCl, pH 6.1.
Depth (cm)	**Horizons**	**Pedon5: Soksanand series (Typic Ustifluvents)**
0-40	Ap	Olive (5 Y 5/3) loam, blocky structure, sticky and plastic when wet, brown root mottles, vertical cracks, no effervescence with dil HCl, pH 7.3; clear and smooth lower boundary.
40-57	C1	Olive (5Y 5/4) silt loam, weak blocky structure, sticky and plastic when wet, pH 6.9, gradual and smooth lower boundary.
57-70	C2	Olive (5 Y 5/4) sandy loam, weak blocky structure, slightly sticky and non-plastic when wet, pH6.7, abrupt and smooth lower boundary
70-145	C3	Olive (5 Y 5/4) silty clay, angular blocky structure, very sticky and very plastic when wet, few faint yellow and brown mottles, pH 7.3, diffused and smooth lower boundary.
Depth (cm)	**Horizons**	**Pedon6: Soksanand series (Typic Ustifluvents)**
0-32	Ap	Light grey (5 Y 7/2) sandy loam, sub angular blocky structure, slightly sticky and non-plastic when wet, few fine faint yellow mottles, vertical cracks, no effervescence with dil HCl, pH 7.3; clear and smooth lower boundary.
32-67	C1	Light grey (5 Y 7/2) sand, single grained structure, non-sticky and non-plastic when wet, no effervescence with dil HCl, pH 7.3; clear and smooth lower boundary.
67-97	C21	Pale yellow (5 Y 7/3) loamy sand, granular structure, slightly sticky and non-plastic when wet, brown mottles, no effervescence with dil. HCl, pH 7.2, clear and smooth lower boundary.
97-160	C22	Pale yellow (5Y 8/3) sand, single grained, structure, non-sticky and non-plastic when wet, no effervescence with dil. HCl, pH 7.3.

Conclusion

From ongoing discussion, we can conclude that tea growing soils of Kishanganj district belongs to *Entisols* order as per 7th approximation of USDA classification, and taxonomically classified as *Aeric fluvaquents, Typic ustipsamments, Typic ustifluvents and Aeric endoaquepts etc.* at sub-group level. Whereas, characterisation of soil series level, Harbhita, Khajuria, Khajuri and Soksanand series are major predominating soil series have been identified for tea growing soils in Kishanganj district. The soil reactions were varied

from acidic to neutral in reactions with no effervescence with dil. HCl have been observed in all horizon which enable to refers the good potential for tea growing soils. The soil colour varied from light Gray, olive colour, and pale-yellow colour have been observed with low organic carbon content has been observed in tea growing soils. Thereby, we recommended that tea grower farmers apply judicious use of fertilizer after advocating the organic matter and inorganic fertilizer, and ultimately improve the soil health and soil quality, and improved the socio-economic conditions of farmers.

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