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Soil nutrient mapping of the Lakhimpur district of Assam using geospatial technology

BIKRAM BORKOTOKI[1], DEBAJIT BHATTACHARYYA[2], KISHORE KUMAR SHARMA[3], PRABAL SAIKIA[4] PRIYANUZ GOSWAMI[5] AND BUDDHA BORA[6]

Assam Agricultural University- Zonal Research Station, North Lakhimpur -787032, Assam

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ABSTRACT

Soil Nutrient Mapping of Lakhimpur District of Assam comprises the status of soil reaction (pH), organic carbon (OC), available primary nutrients (N, P and K) , one secondary nutrient (S) and two important micronutrients (Zn and B) of surface soils (0-15cm) collected from geo-reference points at 2.5 km grids and neighbouring points within 1 km radius of the grid. The analytical database was fed to GIS platform (ArcGIS) to obtain the nutrient status map. The results reveal that strongly acid (5.1-5.5) and medium acid (5.6-6.0) soils were predominant in the district followed by very strongly acid (4.5-5) soil reactions covering 40.15, 22.00 and 21.33 per cent, respectively. Only 9.22, 3.46, 2.11, 1.25 and 0.48 per cent soils were under slightly acid (6.1-6.5), neutral (6.6-7.3), mildly alkaline (7.4-7.8), extremely acid (<4.5) and moderately alkaline (7.9-8.4) in soil reaction, respectively. Medium soil organic carbon (OC) was predominant in the district covering 37.18 per cent area followed by high (24.59 %), low (22.38 %), very high (10.18%) and very low (5.67%) status of organic carbon. Major portions of the soils in the district comprised of medium level of available nitrogen (64.46%) followed by low (25.26%), very low (9.22%) and high (1.06%) levels of the nutrient. Medium level of available phosphorus (P_2O_5) was predominant in the district covering 48.70 per cent samples followed by low (35.93%), very low (14.41%) and high (0.96%). Medium level of available potassium (K_2O) was also predominant in the soils of the district covering a 42.07 per cent area followed by low (26.8%), very low (11.14%), high (10.57%) and very high (9.41 %) status of available potassium. Medium level of available sulphur was also predominant in the district covering 45.44 per cent area followed by high (31.99%), very high (13.74%), low (8.45%) and very low (0.38%) levels of Sulphur in soil. DTPA extractable zinc (Zn) was found to be deficient in 25.36 per cent soil samples while 33.43 % samples were found to be deficient in available boron. Available nitrogen (N) ranged from 37.33 kg/ha to 687.76 kg/ha with an average of 280.94 kg/ha. Available P_2O_5 ranged from 2.47 kg/ha to 81.28 kg/ha with an average of 24.52 kg/ha. Available K_2O ranged from an extremely low value of 13.84 to 1211.14 kg/ha with an average of 234.1 kg/ha. Organic C ranged from 0.05 to 2.00 per cent with an average of 0.66 per cent. Calcium Chloride Dihydrate ($CaCl_2 2H_2O$) extractable available sulphur ranged from 4.51 mg/kg to 63.63 mg/kg with an average of 16.43 mg/kg . DTPA ($C_{14}H_{23}N_3O_{10}$) extractable Zn ranged from 0.10 to 3.98 mg/kg with an average of 0.89 mg/kg , while hot water-soluble B ranged from 0.03 mg/kg to 1.81 mg/kg with an average of 0.56 mg /kg.

Keywords: GPS, GIS, Soil nutrient mapping, Geospatial technology

INTRODUCTION

Green Revolution made our country self-sufficient in food grain production (Shikha and Subhash, 2020). However, it also brought the ailing effect of chemical intensive cropping on soil health (Eliazer Nelson *et al.*,2019), with hardly any attention paid to balanced fertilization, efficient utilization of organic manures and recycling of farm wastes. On the other hand, injudicious and imbalance fertilization even the blanket fertilizer recommendations, and the use of high-analysis fertilizers widen the variability amongst soil fertility and enhance soil degradation in terms of nutrient stock, depletion of soil organic carbon , decreased soil pH, elevate the level of GHG emission and caused soil and water pollution (John and Babu, 2021). Preparation of soil fertility maps helps both macro and micro level planning of soil health management in a scientific manner (Mishra *et al.*, 2013) The Geographic Information System (GIS) based soil fertility maps aren't just technical tools; they are game-changers for both big-picture planning and individual farms. At the broader level, they lay the groundwork for holistic soil health management strategies. On a smaller scale, these maps become a farmer's personalized guide for Site-Specific Nutrient Management (SSNM), helping them tailor

[1]AICRPDA, Biswanath College of Agriculture, AAU, Biswanath Chariali-784176, Assam (Corresponding author. Email: bikram.borkotoki@aau.ac.in), [2]Retired Professor, Dept. of soil Science, Assam Agricultural University, Jorhat-785013, [3]Assam, Professor, Dept of Genetics and Plant Breeding, AAU, Jorthat-785013, Assam, [4]Chief Scientist, AAU-ZRS North Lakhimpur-787032, Assam, India, [5]Project Scientist, OPIU, APART, AAU, Jorhat-13, Assam, [6]Dept. of Plant Pathology, Biswanath College of Agriculture, AAU, Biswanath Chariali-784176, Assam

fertilizer use to the unique needs of their land (Das, 2004). Using these maps as a compass for fertilizer application opens up exciting possibilities. It's not just about safeguarding soil health but also about squeezing the most efficiency out of our fertilizer use. Looking ahead, these maps are set to play a vital role in ongoing surveys. They become a touchstone for understanding the evolving fertility landscape at the local level in real-time—whether it's a block, village, or district. This foresight is invaluable, providing the insights needed to tweak and fine-tune soil health management strategies, ensuring sustainable and resilient farming practices (Mishra *et al.,*2016). In essence, this work embodies a forward-thinking approach to address the unintended consequences of our past practices, forging a path toward a more sustainable and resilient future in agriculture .Keeping all these in view a project was implemented by the Department of Soil Science, Assam Agricultural University Jorhat on "Mapping and soil testing of macro and micronutrients for precise fertilizer recommendation to the farmers of Assam" where the work under the Lakhimpur district of Assam was carried out by AAU-ZRS North Lakhimpur during 2017 and 2018 with the objective of preparing GIS based soil fertility map of the district. Utilizing these maps as a tool to guide fertilizer application in a site-specific manner might lead to new opportunities for managing soil health and attaining the maximum possible fertilizer usage efficiency. When the time comes for the next survey, these maps may be used as a reference to obtain a clear image of the evolving fertility scenario at the block, village, or district level on a real-time scale.

MATERIALS AND METHODS

Study area

The Lakhimpur district is situated in the North Bank Plan Zone (NBPZ) of Assam within a geographic extent from $26^0$48' N to $27^0$53'N latitude and $93^0$42'E to $94^0$20'E longitude. The district is bordered to the north by the districts of Siang and Papumpare in Arunachal Pradesh, and to the east by the Subansiri River and Dhemaji District of Assam. The Majuli District and the Brahmaputra River are situated on the southern side, and the Gohpur subdivision of the Biswanath District is on the West of it. The district has its headquarters at North Lakhimpur with four subdivisions *viz*. North Lakhimpur, Dhakuakhana, Bihpuria and Narayanpur. The district comprises seven (7) revenue circles and nine (9) developmental blocks *viz*. Bihpuria Boginadi Dhakuakhana, Ghilamora, Karunabari Lakhimpur, Naoboicha, Narayanpur and Telahi. Block wise agricultural land use pattern of Lakimpur district is presented Table1. Many factors may cause variations in nutrient status among soils in these blocks. Some more influential factors include parent material, climate-induced weathering, vegetation, topography, cropping and tillage practices, fertilization history etc. Lakhimpur district is having a total geographical area of 2,27,700 ha (2277 km^2). Winter Rice is the predominant crop in the district followed by rabi crops like toria and winter vegetables (Goswami *et al.,* 2022). Average rainfall of Lakhimpur is 2949 mm (Sarma *et al.,* 2013), humidity is about 89 per cent and range of temperature is 11.4-32^0C (Central Ground water Board, 2019). Soils of Lakhimpur district can be classified under two soil orders viz. Inceptisols and Entisols. Vadivelu *et al.* (2004) identified 4 different soil series in the district viz. Baungaon (15,650 ha), Jiyadhol (1, 91,540 ha). Kamalabari (22,970 ha) and Lahangaon (10,895 ha).

Base map preparation

Base maps are prepared at the pre-field level of data/soil sample collection and laboratory analysis. There are 14 nos. of SOI toposheets viz 83F/9, 83F/13, 83J/1, 83E/12, 83E/16, 83I/4, 83I/8, 83I/12, 83E/15, 83I/3, 83I/7, 83I/11, 83I/2 and 83I/6 having 1:50000 scale was used in the study. Survey of India topo-sheets are used to trace various permanent features such as roads, railways, reserved forest boundaries, locations of important places etc. using Geographic Information System (GIS). With the help of GIS tools raster toposheets were first Georeferenced, projected with datum WGS84 UTM zone 46N and then this was followed by several processing steps like masking, mosaicing etc. Finally various permanent features such as roads, railways, reserved forest boundaries, locations of important places were extracted from SOI Toposheet through digitization method.

Extracted features were again superimposed with the recent high resolution satellite imageries available in Google earth platform for further correction. The rivers as well as the riverine sandy areas are delineated from satellite imagery through visual interpretation and image analysis techniques. The data used for this study was Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) multispectral satellite imagery with 30-meter spatial resolution, 16 days revisit period, 11tiles covered the whole state of Assam. Out of which, the tiles having path no. 135, row 41 and image acquisition date 22-01-2018 was downloaded from USGS earth explorer https://earthexplorer.usgs.gov/ and used for this study.

Table 1: Block wise Agricultural Land Use Pattern in Lakhimpur District of Assam

Name of the Block	Area under Agriculture (ha)			
	Cropped Area	Net Sown	Area Sown more than once	Cropping Intensity (%)
Bihpuria	5555	5152	1625	107.82%
Boginadi	18004	16367	1698	110.00%
Dhakuakhana	214.32	148.16	67.3	144.66%
Ghilamora	5390	4320	1206	124.77%
Karunabari	11703	3510	175	333.42%
Lakhimpur	18456	13799	2073	133.75%
Nowboicha	20069	16745	5550	119.85%
Narayanpur	21770	17730	4040	122.79%
Telahi	17400	14400	10800	120.83%
Total	118561.32	92171.16	27234.30	129%

(Source: Central Ground water Board, 2019)

Fieldwork

Surface soil samples (0-15 cm) were collected at 2.5 km (aerial distance) grid with the help of scaled revenue maps (16"=1mile) for each revenue circles (total 7) using GPS and 3-4 numbers of neighbouring points of each grid were also collected with 1 km (aerial distance) radius of the grid point. The toposheet was used as a Base map for this field survey but we also needed the revenue circle boundaries for proper planning for the GPS based survey. We have prepared some grids in revenue maps and drawn some tentative points before going to the field survey. Ground truth verifications have also been made while collecting filed samples.

Soil analysis

Soil pH was determined in soil: water suspension of 1:2.25 using a pH meter. Lime Requirement was determined using the method given by Shoemaker *et al.* (1961). Mineralizable Nitrogen (Available Nitrogen) was estimated using the alkaline $KMnO_4$ method as described by Subbiah and Asija (1956). Available P was estimated following Bray's P-1 method (Bray and Kurtz, 1945) in acid soils and Olsen *et al.*, 1954 in alkaline soils. Available K was estimated in a flame photometer following the Amononium Acetate method of K extraction (Hanway and Heidel, 1952). Oxidisable organic carbon was determined using the Walkley and Black (1934) titration method. $CaCl_2$- extractable available S was determined following the procedure proposed by Williams and Steinberg (1969). Zn was determined using the DTPA extraction method (Lindsay and Norvell, 1978) in an Atomic Absorption Spectrophotometer. Available B was estimated spectrophotometrically following the hot water-soluble method (Gupta, 1967) using Azomethine-H (John *et al.*, 1975).

GIS work

Soil maps were prepared with the help of a Geographic Information System (ArcGIS 10.4) supported with GPS locations of the sample points described in terms of geographic coordinates of latitudes and longitudes. Based on various physical and chemical parameters of the samples, the soil maps were generated. The spatial interpolation technique employed in the study is described below.

Interpolation

The interpolation algorithm followed in this study is based on the Inverse Distance Weighing (IDW) method (Kravchenko and Bullock, 1999). The sample sites were digitized under a GIS environment and soil parameter attributes were assigned to each point. After that interpolation was carried out using GIS (ArcGIS 10.4) software. The interpolated image was reclassed and vectorized and finally, map composition was done to get the final output.

RESULTS AND DISCUSSION

Distribution of sampling points

The sampling points are presented in Fig 1. The figure reveals that soil sampling points were more or less evenly distributed covering all 9 blocks under Lakhimpur district. Rating chart of soil nutrients (Borkotoki *et al.,* 2018) is presented in Table 3.

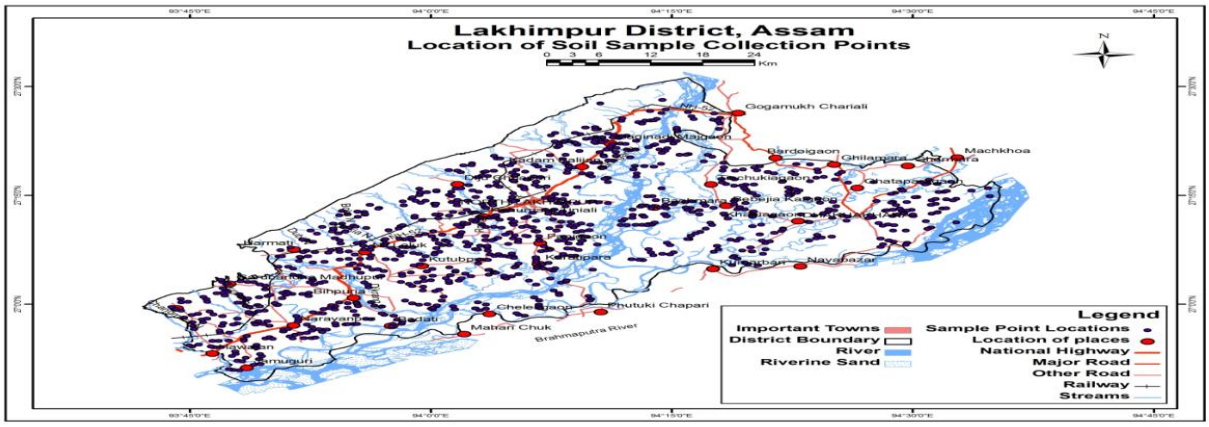

Fig 1: Distribution of soil sampling points in Lakhimpur district

Soil Reaction (pH) and lime requirement

The pH of the soils in the district ranged from 4.1 to 8.13 with an average of 5.58. The status of soil reaction in Lakhimpur district is illustrated in Fig 2. The Lime Requirement (LR) of the soil samples were measured by using Shoemaker-McLean-Pratt (SMP) method developed by Shoemaker *et al.* (1961) for the soils having a pH less than 5.5. The LR in tones ha^{-1} of pure $CaCO_3$ was calculated for achieving pH target 6.4 and 1/10 of the same had been recommended accordingly for application as a fertilizer not as an amendment in furrows with 50 per cent recommended dose of chemical fertilizers and FYM@ 2 t/ha for Rabi vegetables and pulses as per package of practices of rabi crops of Assam. The block-wise average lime requirement is presented in Table 2.

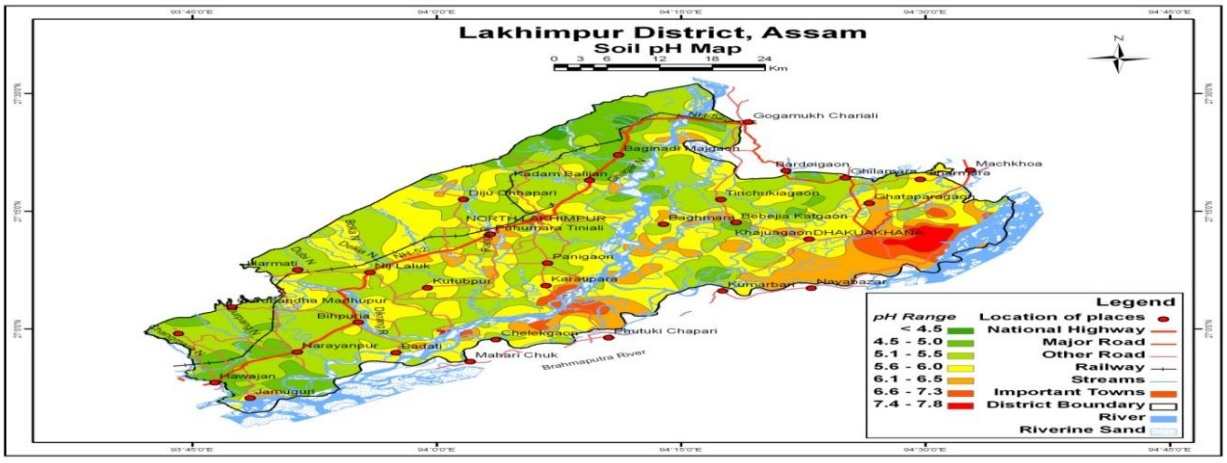

Fig 2: Status of soil reaction (pH) in Lakhimpur district

Table 2: Block wise lime requirement and cost of liming materials for Lakhimpur district

Sl No	Block	Number of soil samples collected and analyzed	% samples need liming (pH<5.5)	Average 1/10 of lime requirement kg/ha
1	Bihpuria	45	48.88	416.23
2	Boginadi	140	80.71	1011.43
3	Dhakuwakhana	101	15.84	528.00
4	Ghilamora	104	49.53	1006.09
5	Karunabari	106	59.43	516.23
6	Lakhimpur	146	54.29	762.88
7	Naoboicha	129	44.96	777.48
8	Narayanpur	158	76.58	741.93
9	Telahi	112	35.71	906.97
	District Average	1041	51.77	740.8044

In Bihpuria Block, 13.33 per cent of soils were found to be very strongly acid, 46.67 per cent of soils were strongly acid, 22.22 per cent were medium acid, 4.44 per cent were slightly acid and neutral each and 8.89 per cent mildly alkaline in soil reaction. The pH ranged from 4.58 to 7.85 with an average value of 5.69. In Boginadi block, 6.43 per cent of soils were extremely acid, 45 per cent soils were very strongly acid, 31.43 per cent soils were strongly acid, 10 per cent soils were medium acid, 5 per cent of soils were slightly acid, 1.43 per cent soils were neutral and 0.71 per cent soils were mildly alkaline in reaction. The pH ranged from 4.1 to 7.69 with an average value of 5.17. In Dhakuakhana block, 2.97 per cent soils were very strongly acid, 19.8 percent soils are strongly acid, 30.69 per cent soils were medium acid, 21.78 per cent slightly acid,7.92per cent soils are neutral, 11.88 per cent soils were mildly alkaline, 4.95 per cent soils were moderately alkaline. The pH ranged from 4.87 to 8.13 with an average value of 6.24. In Ghilamora block, 0.96 per cent soils ere extremely acid, 19.23 per cent soils were very strongly acid, 42.31 per cent soils were strongly acid, 25 per cent soils were medium acid, 8.65 per cent soils were slightly acid, 1.92 per cent soils were neutral and 1.92 per cent soils were mildly alkaline in reaction. pH ranged from 4.28 to 7.66 with an average value of 5.53. In Karunabari block, 13.21 per cent soils were very strongly acid, 63.21 per cent soils were strongly acid, 17.92 per cent soils were medium acid, 3.77 per cent soils were slightly acid and 1.89 per cent soils were neutral in reaction.

Table 3: Rating of nutrients and soil reaction

Rating of soil mutrients					
Parameters	Ratings				
	Very low	Low	Medium	High	Very High
Soil Org, C (%)	<0.25	0.25-0.49	0.50-0.75	0.76-1.0	>1.0
N (kg/ha)	<136	136-271	272-544	545-816	>816
P_2O_5 (kg/ha)	<11.0	11.0-22.4	22.5-56	56.1-84	>84
K_2O	<68	68-135	136-337.5	338-506	>506
S (mg/kg)	<5	5-9	10-15	16.22.5	>22.5
Zn (mg/kg)	<0.6	Deficient	>0.6	Suffcient	
B (mg/kg)	<0.5	Deficient	>0.5	Suffcient	
Rating os soil reaction					
Parameters	Rating				
pH	Extremely acid (< 4.5), Very strongly acid (4.5-5.0), Strongly acid (5.1-5.5), Medium acid (5.6-6.0), Slightly acid (6.1-6.5), Neutral (6.6-7.3), Mildly Alkaline (7.4-7.8), Moderately alkaline (7.9-8.4)				

The pH ranged from 4.86 to 7.03 with an average value of 5.45. In Lakhimpur block, 17.12 per cent soils were very strongly acid, 43.84 per cent soils were strongly acid, 23.29 per cent soils were medium acid, 11.64 per cent soils were slightly acid, 3.42 per cent soils were neutral and 0.68 % soils were mildly alkaline in reaction. pH ranged from 4.6 to 7.53 with an

average value of 5.55. In Naoboicha block, 12.4 per cent soils were very strongly acid, 41.09 percent soils were strongly acid, 28.68 per cent soils were medium acid, 14.73 per cent soils were slightly acid and 3.1 % soils were neutral in reaction. pH ranged from 4.64 to 7.02 with an average value of 5.60. In Narayanpur bock, 1.9 per cent soils were extremely acid, 41.14 per cent soils were very strongly acid, 39.24 per cent soils were strongly acid, 13.29 per cent soils were medium acid and 4.43 % soils are slightly acid in reaction. pH ranged from 4.17 to 6.58 with an average value of 5.22. In Telahi block, 8.89 per cent soils were very strongly acid, 38.39 per cent soils were strongly acid, 33.04 per cent soils were medium acid, 8.04 per cent soils were slightly acid, 9.82 per cent soils were neutral and 1.79 per cent soils were mildly alkaline in reaction. pH ranged from 4.63 to 7.56 with an average value of 5.74.

Organic carbon (OC)

Organic C ranged from 0.05 to 2.00 % with an average of 0.66 %. Medium soil organic carbon was predominant in the district covering 37.18% area followed by high (24.59 %), low (22.38 %), very high (10.18%) and very low (5.67%) status of organic carbon. Status of soil organic C in Lakhimpur district is illustrated in Fig 3.

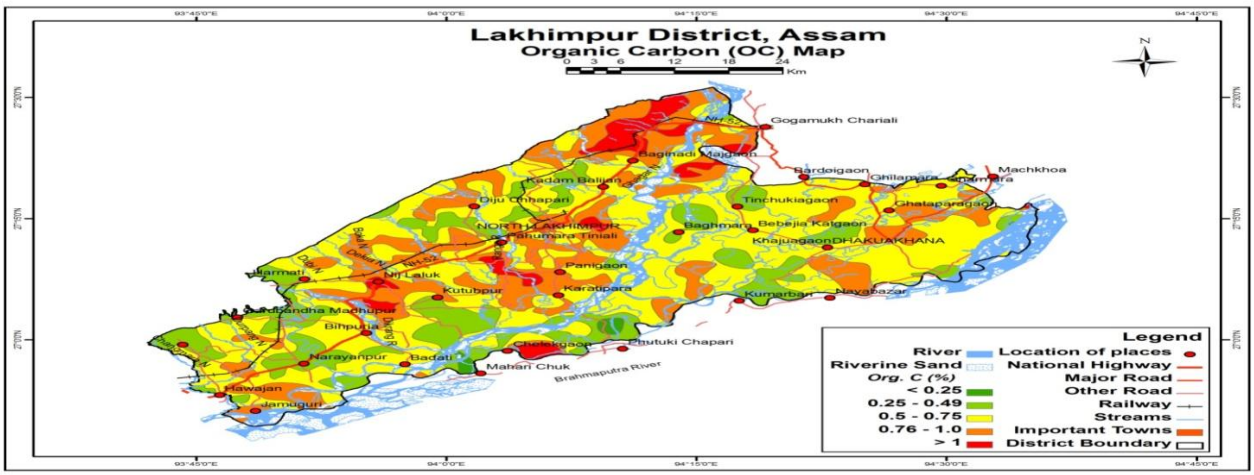

Fig 3: Status of soil organic carbon in Lakhimpur district

In Bihpuria block, soil organic C ranged from 0.18 to 1.04 % with an average of 0.52 per cent. Very low, low, medium, high and very high content of organic carbon was recorded to be 6.67, 37.78, 51.11, 2.22 and 2.22 per cent soils, respectively. Organic C in Boginadia Block ranged from 0.21 % to 1.93 % with an average of 0.78 per cent. Very low, low, medium, high and very high content of organic carbon was recorded to be 1.43, 14.29, 37.86, 26.43 and 20.0 per cent soils, respectively. Organic C in Dhakuakhana block ranged from 0.12 to 1.59 % with an average of 0.67 per cent organic C. Very low, low, medium, high and very high content of organic carbon was recorded to be 4.95, 17.82, 47.52, 20.79 and 8.91 per cent soils, respectively. In Lakhimpur block soil organic C ranged from 0.16 %to 1.62 % with an average value of 0.6 per cent. Very low, low, medium, high and very high content of organic carbon was recorded to be 6.85, 23.29, 34.93, 24.66 and 10.27 per cent soils, respectively. In Naoboicha block soil organic C ranged from 0.07 to 1.69 % with an average of 0.69 per cent. Very low, low, medium, high and very high content of organic carbon was recorded to be 8.53, 20.16, 27.91, 29.46 and 13.95 per cent soils, respectively. In Telahi block soil organic C ranged from 0.05 % to 1.97% with an average of 0.71 per cent. Very low, low, medium, high and very high content of organic carbon was recorded to be 6.25, 16.07, 34.82, 34.82 and 8.04 per cent soils, respectively. In Ghilamora block, soil organic C ranged from 0.19 to 1.47%, with an average of 0.61 per cent. Very low, low, medium, high and very high content of organic carbon was recorded to be 4.81, 22.12, 50.96, 19.23 and 2.88 per cent soils, respectively. In Karunabari Block, soil organic C ranged from 0.18 % to 1.49 % with an average of 0.70 per

cent. Very low, low, medium, high and very high content of organic carbon was recorded to be 1.87, 27.36, 27.36, 30.20 and 13.21 per cent soils, respectively. In Narayanpur Block, soil organic C ranged from 0.14 to 2% with an average of 0.59 per cent. Very low, low, medium, high and very high content of organic carbon was recorded to be 8.86, 30.38, 34.81, 20.25 and 5.70 per cent soils, respectively.

Available Nitrogen (N)

In Lakhimpur district, available N ranged from 37.33 kg/ha to 687.76 kg/ha with an average of 280.94 kg/ha. Major parts of the soils in the district contained medium levels of available nitrogen (64.46%) followed by low (25.26%), very low (9.22%) and high (1.06%). The status of available Nitrogen in soils of the Lakhimpur district is illustrated in Fig 4.

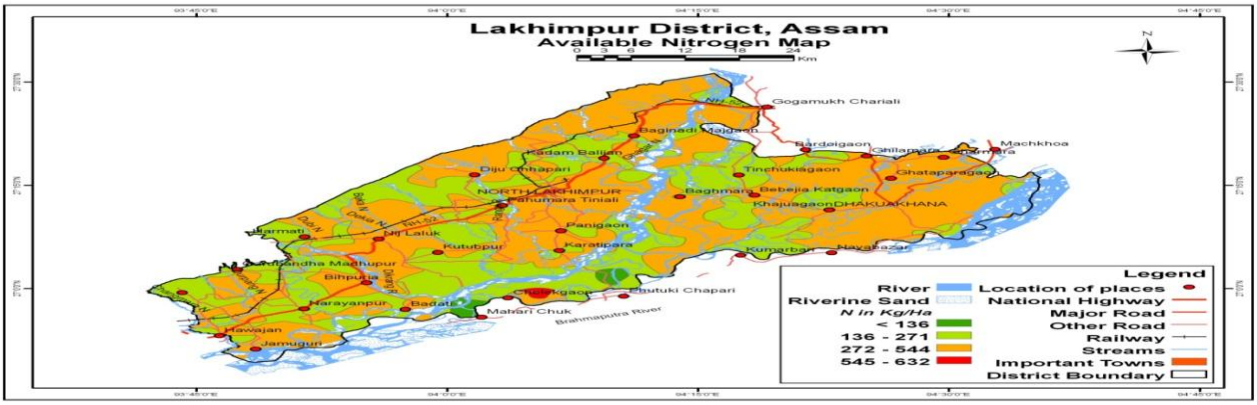

Fig 4: Status of available nitrogen in soils of Lakhimpur district

Available N in Bihpuria block ranged from 86.75 kg/ha to 433.60 kg/ha with an average of 233.5 kg/ha. Category of Very low, low, and medium status of soil available N was recorded to be 11.11, 31.11 and 57.78 per cent, respectively. Available N in Boginadi block ranged from 101.94 to 581.23 kg/ha with an average of 306.49 kg/ha. Category of Very low, low, medium and high status of soil available N was recorded to be 7.14, 32.14, 58.57 and 2.14 per cent, respectively. Available N in Dhakuwakhana block ranged from 98.1 to 467.1 kg/ha with an average of 322.91 kg/ha. Category of Very low, low and medium status of soil available N was recorded to be 4.95, 17.82 and 77.23 per cent, respectively. Available N in Lakhimpur block ranged from 86.42 to 501.3 kg/ha with an average of 313 kg/ha. Category of very low, low and medium status of soil available N was recorded to be 7.53, 8.90, 83.56 per cent, respectively. Available N in Naoboicha block ranged from 38.4 to 523.68 kg/ha with an average of 254.6 kg/ha. Category of Very low, low and medium status of soil available N was recorded to be 12.40, 39.53, 48.06 per cent, respectively. Available N in Telahi block ranged from 37.33 to 687.76 kg/ha with an average of 277.64 kg/ha. Category of Very low, low, medium, and high status of soil available N was recorded to be 8.04, 32.14, 57.14, 2.68 per cent, respectively. Available N in Ghilamora block ranged from 89.88 to 569.55 kg/ha with an average of 266.70 kg/ha. Category of Very low, low and medium and high status of soil available N was recorded to be 6.73, 22.11, 69.23 and 1.92%, respectively. Available N in Karunabari block ranged from 80.57 to 558.02 kg/ha with an average of 286.76 kg/ha. Category of Very low, low and medium and high status of soil available N was recorded to be 10.38, 20.75, 67.92 and 0.94 per cent, respectively. Available N in Narayanpur block ranged from 70.79 to 576.68 kg/ha with an average of 266.86 kg/ha,. Category of Very low, low and medium and high status of soil available N was recorded to be 13.92, 25.94, 58.86 and 1.27 per cent, respectively.

Available Phosphorus (P_2O_5)

Available P_2O_5 in the district ranged from 2.87 kg/ha to 81.28 kg/ha with an average of 24.52 kg/h. Most of the soils (48.7%) were medium in available phosphorus followed by low (35.93%), very low (14.41%) and high (0.96) status in available phosphorus. Staus of available phosphorus in soils of Lakhimpur district is illustrated in Fig 5.

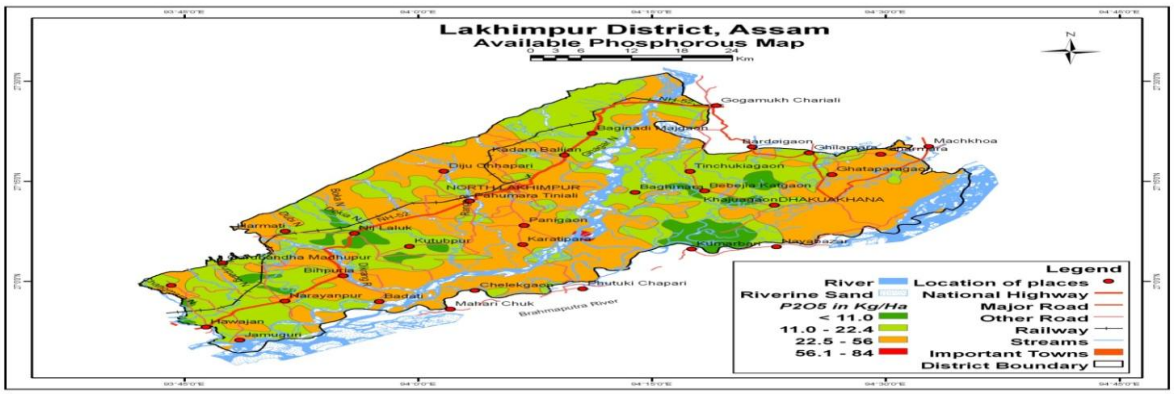

Fig 5: Status of available phosphorus (P_2O_5) in soils of Lakhimpur district

Available P_2O_5 in Bihpuria block ranged from 6.06 to 58.27 kg/ha with an average of 34.27 kg/ha. Category of very low, low and medium status of soil available P_2O_5 was recorded to be 2.22, 13.33 and 84.44 per cent, respectively. Available P_2O_5 in Boginadi block ranged from 9.32 to 32.9 kg/ha with an average of 21.45 kg/ha. Category of very low, low and medium status of soil available P_2O_5 was recorded to be 3.57, 65.00 and 31.43 per cent, respectively. Available P_2O_5 in Dhakuwakhana block ranged from 8.79 to 65.24 kg/ha with an average of 33.52 kg/ha. Category of very low, low, medium and high status of soil available P_2O_5 was recorded to be 1.98, 21.78, 69.30, and 6.93 per cent, respectively. Available P_2O_5 in Lakhimpur block ranged from 5.62 to 55.58 kg/ha with an average of 27.47 kg/ha. Category of very low, low and medium of soil available P_2O_5 was recorded to be 8.22, 23.29 and 68.49 per cent, respectively. Available P_2O_5 in Naoboicha block ranged from 5.02 to 55.00 kg/ha with an average of 25.03 kg/ha,. Category of very low, low and medium of soil available P_2O_5 was recorded to be 8.53, 22.00 and 68.99 per cent, respectively. Available P_2O_5 in Telahi block ranged from 6.38 to 81.28 kg/ha with an average of 30.18 kg/ha. Category of very low, low, medium and high status of soil available P_2O_5 was recorded to be 4.46, 29.46, 63.39 and 2.68 per cent, respectively. Available P_2O_5 in Ghilamora block ranged from 3.37 to 40.10 kg/ha with an average of 14.66 kg/ha,. Category of very low, low and medium status of soil available P_2O_5 was recorded to be 42.31, 38.46 and 19.23 per cent, respectively. Available P_2O_5 in Ghilamora block ranged from 2.47 to 35.81 kg/ha with an average of 15.52 kg/ha. Category of very low, low and medium status of soil available P_2O_5 was recorded to be 29.25, 51.89 and 18.87 per cent, respectively. Available P_2O_5 in Narayanpur block ranged from 3.71 to 49.11 kg/ha with an average of 18.54 kg/ha, Category of very low, low and medium status of soil available P_2O_5 was recorded to be 24.68, 40.5 and 34.81 per cent, respectively.

Available Potassium (K_2O)

Available K_2O raged from extremely low value 13.84 to 1211.14 kg/ha with an average of 234.1 kg/ha in the district. Out of 1041 samples tested, 11.14 % samples were very low, 26.80 % samples were low, 42.07 % samples were medium, 10.57% samples were high and 9.41 % samples were very high in available potassium. Status of soil available potassium in soils of Lakhimpur district is illustrated in Fig 6.

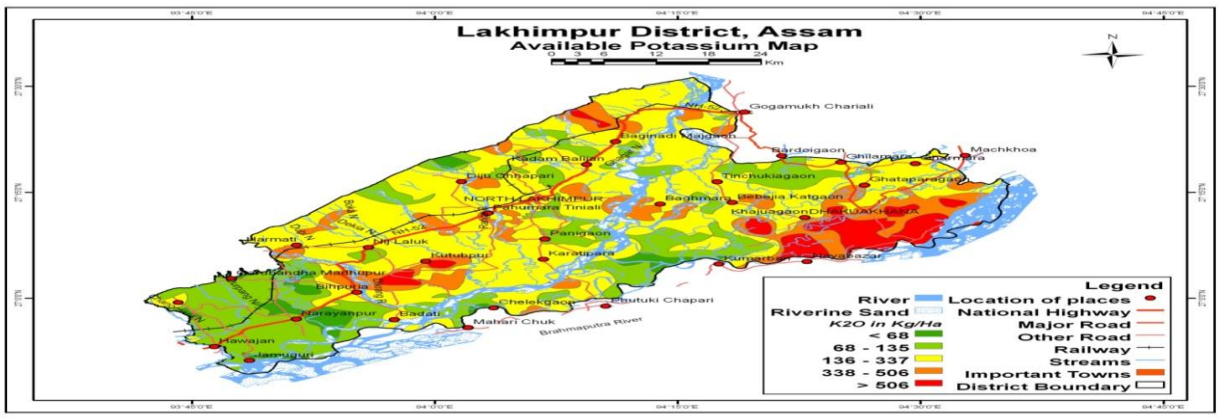

Fig 6: Status of available potassium (K_2O) in soils of Lakhimpur district

Available K_2O in Bihpuria block ranged from to 27.69 to 877.21 kg/ha with an average of 172.85 kg/ha. Category of very low, low, medium, high and very high status of soil available K_2O was recorded to be 11.11, 28.89, 53.33, 4.44 and 2.22 per cent, respectively. Available K_2O in Boginadi block ranged from 29.70 to 620.93 kg/ha with an average of 207.43 kg/ha. Category of very low, low, medium, high and very high status of soil available K_2O was recorded to be 8.57, 24.29, 54.29, 8.57, and 4.29 per cent, respectively. Available K_2O in Dhakuwakhana block ranged from 82.83 to 987.9 kg/ha with an average of 451.82 kg/ha, Category of low, medium, high and very high status of soil available K_2O was recorded to be, 9.90, 30.69,18.81 and 40.59 per cent , respectively. Available K_2O Lakhimpur block ranged from 28.0 to 920.34 kg/ha with an average of 271.27 kg/ha. Category of very low, low, medium, high and very high status of soil available K_2O was recorded to be 12.33, 26.03, 29.45, 15.75 and 16.44 per cent, respectively. Available K_2O Naoboicha block ranged from 45.10 to 553.06 kg/ha with an average of 249.43 kg/ha. Category of very low, low, medium, high and very high status of soil available K_2O was recorded to be 3.10, 13.95, 62.79, 17.83 and 2.33 per cent, respectively. Available K_2O in Telahi block ranged from 35.63 to 1211.14 kg/ha with an average of 205.19 kg/ha. Category of very low, low, medium and high status of soil available K_2O was recorded to be 8.93, 33.93,45.54,2.68 and 8.93 per cent, respectively Available K_2O in Ghilamora block ranged from 41.66 to 900.18 kg/ha with an average of 181.05 kg/ha. Category of very low, low, medium, high and very high status of soil available K_2O was recorded to be 9.62, 34.62, 43.27, 9.62 and 2.88 per cent, respectively. Available K_2O in Karunabari block ranged from 37.13 to 1067.06 kg/ha with an average of 272.56 kg/ha, Category of very low, low, medium, high and very high status of soil available K_2O was recorded to be 4.72, 19.81, 49.06, 16.98 and 9.43 per cent, respectively Available K_2O in Narayanpur block ranged from 13.84 to 270.14 kg/ha with an average of 95.26 kg/ha,. Category of very low, low and medium status of soil available K_2O was recorded to be 32.91, 44.93 and 22.15 per cent, respectively

Available Sulphur

Available S ranged from 4.51 mg/kg to 63.33 mg/kg with an average of 16.43 mg/kg. In Lakhimpur district, out of 1041 numbers of samples tested, 0.38 % samples were very low, 8.45 % samples were low, 45.44 % samples were medium, 31.99 % samples were high and 13.74% samples were very high in available S. Status of soil available S in soils of Lakhimpur district is illustrated in Fig 7.

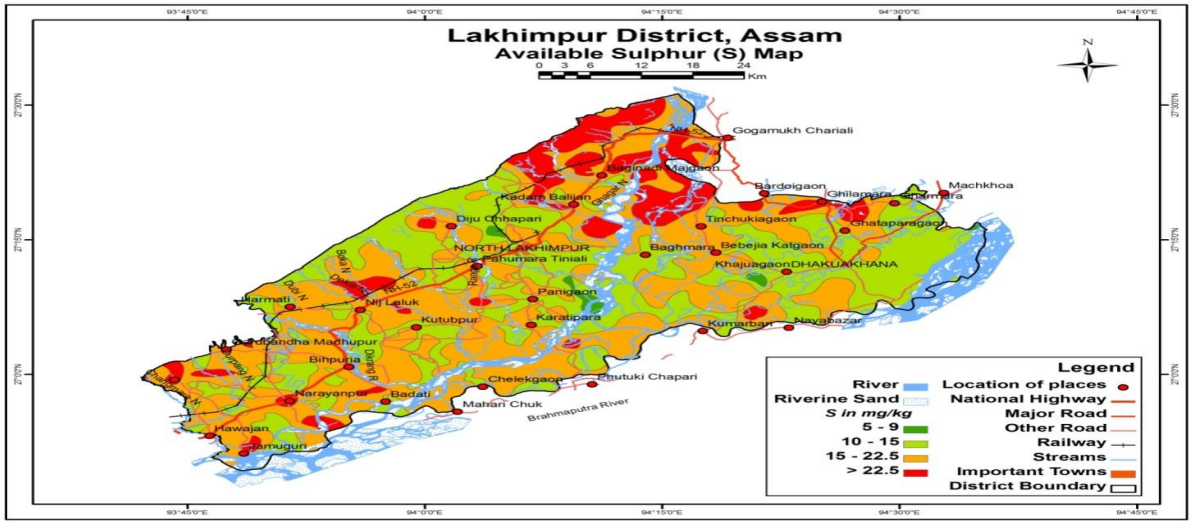

Fig 7: Status of available sulphur (S) in soils of Lakhimpur district

Available Sulphur in Bihpuria block ranged from 10.48 to 30.65 mg/kg with an average of 17.71 mg/kg S. Most of the soil samples were found to be medium (44.44%) in $CaCl_22H_2O$ extractable available sulphur. Among the rest of the samples, 33.33 per cent were high

and 22.22 per cent were found to be very high in available sulphur. Available Sulphur in Boginodi block ranged from 6.65 to 63.63 mg/kg with an average of 21.23 mg/kg S. Most of the soil samples were found to be very high (35%) in $CaCl_2 2H_2O$ extractable available sulphur. Among the rest of the samples 33.57 per cent were high, 28.57 per cent were medium and 2.86 per cent were low in available sulphur. Available Sulphur in Dhakuwakhana block ranged from 4.93 to 20.10 mg/kg with an average of 12.7 mg/kg S. Most of the soil samples were found to be medium (53.47%) in $CaCl_2 2H_2O$ extractable available sulphur. Among the rest of the samples 24.75 per cent were low, 20.79 per cent were high and 0.99 per cent was very low in available sulphur. Available Sulphur in Lakhimpur block ranged from 5.60 to 33.2 mg/kg with an average of 13.77 mg/kg S. Most of the soil samples were found to be medium (58.23%) in $CaCl_2 2H_2O$ extractable available sulphur. Among the rest of the samples, 21.92 per cent were high, 17.80 per cent were low and 2.05 per cent were very high in available sulphur. Available Sulphur in Naoboicha block ranged from 4.51 to 35.2 mg/kg with an average of 16.88 mg/kg S. Most of the soil samples were found to be medium (41.86%) in $CaCl_2 2H_2O$ extractable available sulphur. Among the rest of the samples 34.88 per cent were high, 16.27 per cent were very high, 4.65 per cent were low and 2.33 per cent were very low in available sulphur. Available Sulphur in Telahi block ranged from 6.92 to 30.44 mg/kg with an average of 15.06 mg/kg S. Most of the soil samples were found to be medium (40.75%) in $CaCl_2 2H_2O$ extractable available sulphur. Among the rest of the samples, 37.5 per cent were high, 15.18 per cent were low and 3.57 per cent were very high in available sulphur. Available Sulphur Ghilamora block ranged from 9.69 to 33.82 mg/kg with an average of 16.83 mg/kg S. Most of the soil samples were found to be medium (49.04%) in $CaCl_2 2H_2O$ extractable available sulphur. Among the rest of the samples, 36.54 per cent were high, 13.46 per cent were very high and 0.96 per cent samples were low in available sulphur. Available Sulphur Karunabari block ranged from 6.88 to 31.45 mg/kg with an average of 16.78 mg/kg S. Most of the soil samples were found to be medium (50.94 %) in $CaCl_2 2H_2O$ extractable available sulphur. Among the rest of the samples, 33.02 per cent were high, 15.09 per cent were very high and 0.94 per cent samples were low in available sulphur. Available Sulphur Narayanpur block ranged from 8.67 to 31.05 mg/kg with an average of 16.91 mg/kg S. Most of the soil samples were found to be medium (41.77 %) in $CaCl_2 2H_2O$ extractable available sulphur. Among the rest of the samples 36.71 per cent were high, 16.46 per cent were very high and 5.06 per cent samples were low in available.

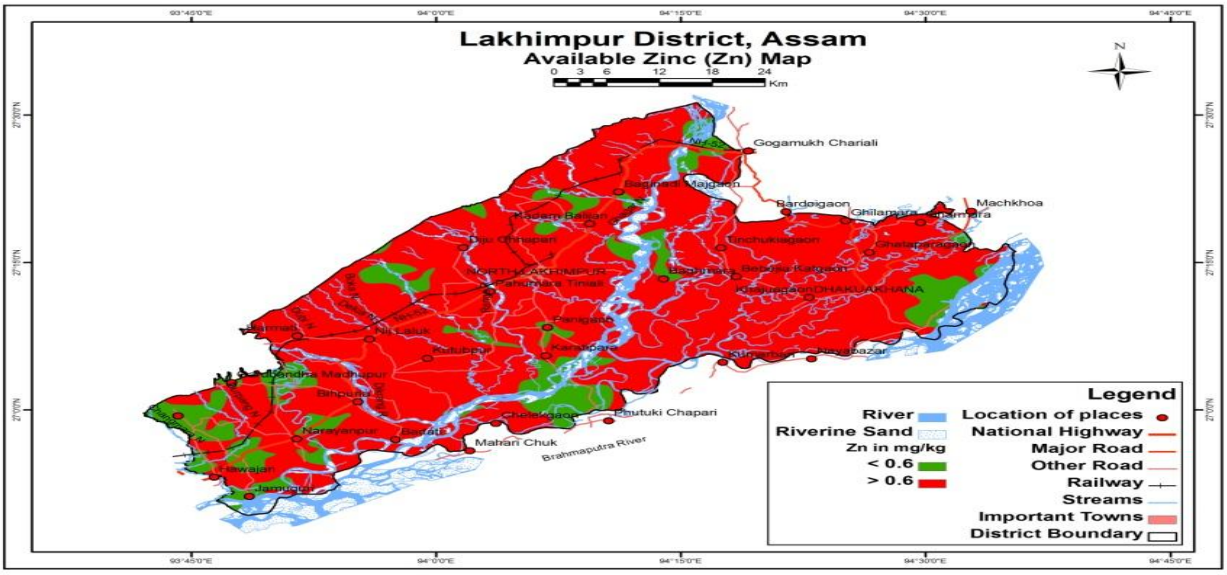

Fig 8 a: Deficient and sufficient areas of available zinc in soils of Lakhimpur district

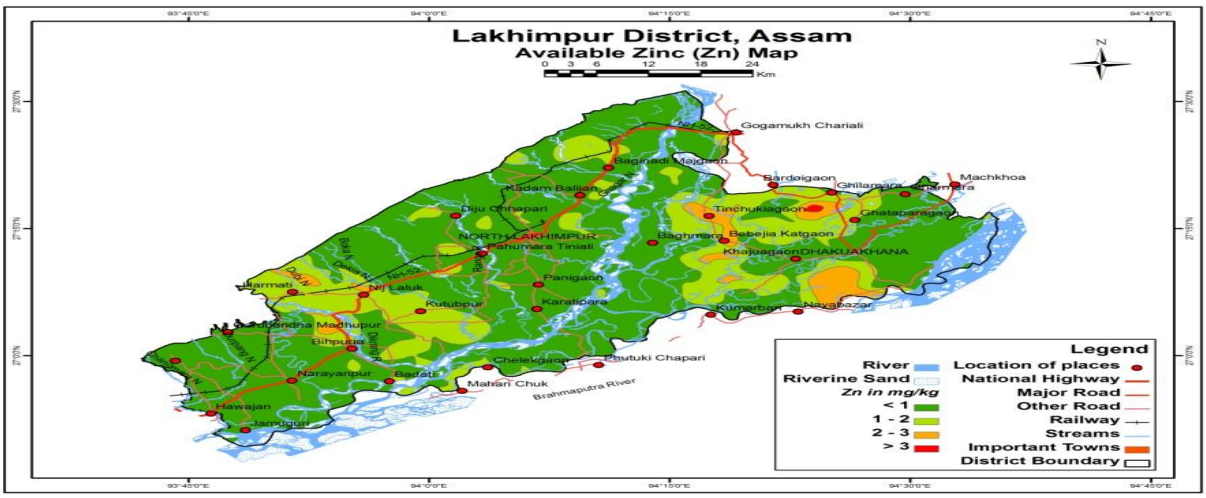

Fig 8 b: Status of available zinc in soils of Lakhimpur district

Available Zinc (Zn)

DTPA extractable available Zn ranged from 0.10 to 3.98 mg/kg with an average of 0.89 mg/kg. In Lakhimpur district out of 1041 numbers of tested samples 25.36% samples were found to be deficit in Lakhimpur district. Deficient and sufficient areas of available Zn in soils of Lakhimpur district is illustrated in Fig 8a. Status of available Zn in soils of Lakhimpur district is illustrated in Fig 8b.

In Bihpuria Block, DTPA extractable Zn ranged from 0.42 to 1.43 mg/kg with an average of 0.89 mg/kg and 35.56 per cent soils are found to be deficient in available Zn. In Boginadi Block, DTPA extractable Zn ranged from 0.22 to 2.10 mg/kg with an average of 0.83 mg/kg and 24.29 per cent soils are found to be deficient in available Zn. In Dhakuwakha Block, DTPA extractable Zn ranged from 0.10 to 2.90 mg/kg with an average of 0.80 mg/kg and 29.70 per cent soils are found to be deficient in available Zn. In Lakhimpur block, DTPA extractable Zn ranged from 0.46 to 1.2 mg/kg with an average of 0.80 mg/kg and 13.01 per cent soils are found to be deficient in available Zn. In Naoboicha block, DTPA extractable Zn ranged from 0.12 to 1.55 mg/kg with an average of 0.69 mg/kg and 31.78 per cent soils are found to be deficient in available Zn. In Telahi block, DTPA extractable Zn ranged from 0.21 to 2.06 mg/kg with an average of 0.68 mg/kg and 33.93 per cent soils are found to be deficient in available Zn.In Ghilamora block, DTPA extractable Zn ranged from 0.21 to 3.98 mg/kg with an average of 1.36 mg/kg and 11.54 per cent soils are found to be deficient in available Zn. In Karunabari block, DTPA extractable Zn ranged from 0.56 to 2.78 mg/kg with an average of 1.35 mg/kg and 1.89 per cent soils are found to be deficient in available Zn. In Narayanpur block, DTPA extractable Zn ranged from 0.30 to 1.87 mg/kg with an average of 0.64 mg/kg and 45.57 per cent soils are found to be deficient in available Zn

Available Boron (B)

Hot water-soluble available B ranged from 0.03 to 1.81 mg/kg with an average of 0.56 mg/kg. 33.43 % soils were found to deficient in boron. Status of available boron in soils of Lakhimpur district is illustrated in Fig 9. In Bihpuria block, hot water-soluble B ranged from 0.3 to 0.98 mg/kg with an average of 0.57 mg/kg B. 22.22 per cent soils were found to be boron deficient. In Boginadi Block, hot water-soluble B ranged from 0.29 to 0.82 mg/kg with an average of 0.54 mg/kg B. 31.43 per cent soils were found to be boron deficient. In Dhakuakhana block, hot water-soluble B ranged from 0.05 to 0.97 mg/kg with an average of 0.60 mg/kg B. 33.66 per cent soils were found to be boron deficient. In Lakhimpur block, hot water-soluble B ranged from 0.07 to 0.74 mg/kg with an average of 0.50 mg/kg B. 37.67 per cent soils were found to be boron deficient. In Naoboicha block, hot water-soluble B ranged from 0.03 to 0.97 mg/kg with an average of 0.57 mg/kg B. 20.93 per cent soils were found to be boron deficient.

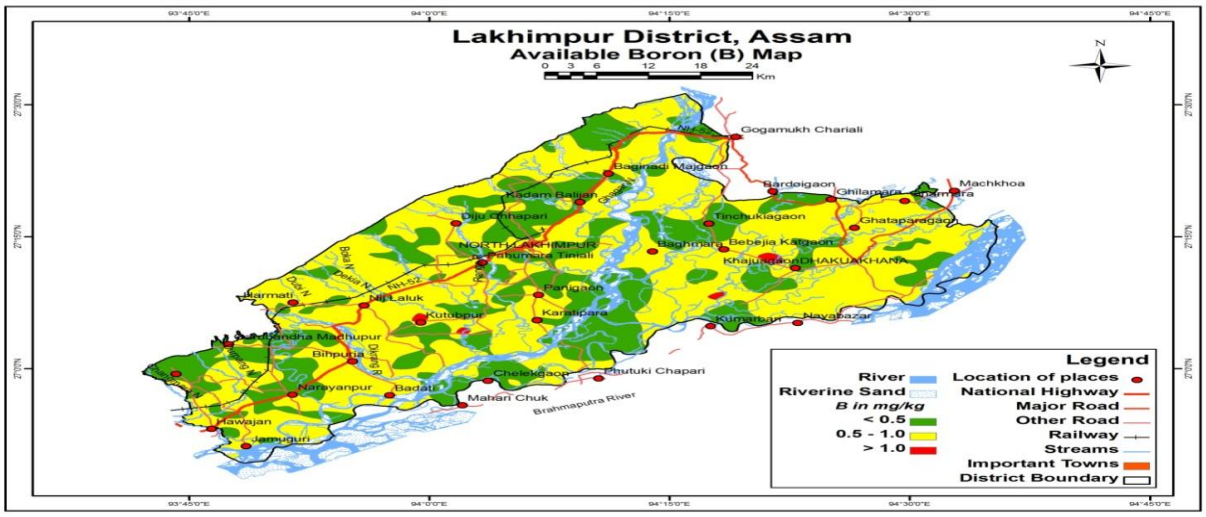

Fig 9: Status of available boron in soils of Lakhimpur district

In Telahai block, hot water-soluble B ranged from 0.12 to 0.96 mg/kg with an average of 0.51 mg/kg B. 42.85 per cent soils were found to be boron deficient. In Ghilamora block, hot water-soluble B ranged from 0.21 to 1.81 mg/kg with an average of 0.59 mg/kg B. 33.65 per cent soils were found to be boron deficient. In Karunabari block, hot water-soluble B ranged from 0.2 to 1.65 mg/kg with an average of 0.62 mg/kg B 29.25 % soils were found to be boron deficient. In Narayanpur block , hot water soluble B ranged from 0.15 to 0.94 mg/kg with an average of 0.54 mg/kg B. 40.51 per cent soils were found to be boron deficient.

CONCLUSION

The soil nutrient mapping of Lakhimpur District provides crucial information for sustainable agriculture practices. The prevalence of acidic soils and the varying levels of essential nutrients emphasize the need for a targeted soil nutrient management approach. Farmers and policymakers can utilize this information to implement customized fertilization strategies, enhancing crop productivity and ensuring the long-term fertility and sustainability of agricultural lands in the region.

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