P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating: 5.04
www.extensionjournal.com

Extension Journal

International Journal of Agriculture Extension and Social Development

Volume 7; SP-Issue 11; November 2024; Page No. 82-96

Received: 14-08-2024
Accepted: 18-09-2024

Indexed Journal
Peer Reviewed Journal

Soil fertility maps preparation using GPS and GIS for Narayanpur district, Chhattisgarh, India

D Das*, Saugata Sasmal, RR Korram* and MK Verma***

*Krishi Vigyan Kendra Narayanpur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

** Krishi Vigyan Kendra Raipur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

DOI: https://doi.org/10.33545/26180723.2024.v7.i11Sb.1326

Corresponding Author: D Das

Abstract

Soil fertility maps of Narayanpur district, Chhattisgarh were prepared by using Global Positioning System (GPS) and Geographical Information System (GIS). Soils of different villages for each Gram Panchayat of the district were collected by Garmin extra MAKE GPS instrument. These GPS based soil samples were processed and analyzed in laboratory for pH, Organic Carbon, available nitrogen, available phosphorus, available potassium, available sulphur, hot water-soluble boron, DTPA extractable Zinc, Copper, Iron and Manganese by using standard methods. All these soil characteristics were entered in attributed table and linked with the GIS software to develop a relational database. The analogue soil fertility maps on 1:250000 scale were geo-referenced and digitized by using ArcGIS software. Thematic layer were developed for block boundaries to prepare the base map. Superimposing polygons (Spatial coverage) of block units on the base map, soil fertility maps were prepared. These maps were integrated in GIS to generate a composite database of GPS based soil fertility maps of Narayanpur district. These maps were divided into 2 mapping units (2 blocks of Narayanur district i.e; Narayanpur and Orchha block). The soils of all blocks were neutral in soil reaction and organic carbon content ranged from medium to high. Mineral nitrogen content was medium whereas, available phosphorus and available potassium content was ranged from medium to high. On the other hand, available sulphur was high. Hot water soluble boron and micronutrients content remained above the critical limits in both the blocks.

Keywords: GPS, GIS, Soil Fertility Maps & Narayanpur district

Introduction

Soil, land and water are essential resources for the sustained quality of human life and the foundation of agricultural development (Das *et al.*, 2009) [3]. Efficient management of soil and water resources is a major challenge for the scientists, planners, administrators and farmers to ensure food, water and environmental security for the present and future generations (Kanwar 2000) [7]. Soil fertility is the ability of the soil to provide all the essential plant nutrients in available forms and in a suitable balance, to sustain plant growth and optimize crop yield. Earlier the land could support plant growth efficiently without addition of synthetic fertilizers, pesticides etc. which in long run prove to be detrimental to soil quality and soil health (Mistry *et al.*, 2022) [16]. The modern geospatial technologies such as Remote Sensing (RS), Geographical Information System (GIS), Global Positioning System (GPS) and Information Technology (IT) offer immense potential for soil and water resources development and management (Das, 2004) [5].

Geographical Information System (GIS) is a potential tool used for easy access, retrieval and manipulation of voluminous data of natural resources often difficult to handle manually. It facilitates manipulation of spatial and attributes data useful for handling multiple data of diverse origin (Mishra *et al.*, 2014 and Mandal and Sharma, 2010) [10, 9].

Geo-referenced soil samples collection and characterization of soils greatly helped in preparation of soil fertility maps prepared using GIS platform. This in turn helps in site specific nutrient/fertilizer recommendation, balanced application of nutrients for soil health management and sustaining crop productivity (Rathore *et al.*, 2023) [15]. Fifteen composite soil samples are collected from each gram panchayat by the helps of ‘Garmin etrax’ MAKE GPS instrument to know latitude and longitude of that particular place. It has got great significance in agriculture for future monitoring of soil nutrient status of different locations/villages. It also helps to know elevation, road map, nearest city/town(s) and speed of movement (Choudhari *et al.*, 2022).

The 26th state of India, Chhattisgarh was formed on November 1, 2000 which is located in the central of the Country. Its soil and vegetation is both rich and diverse. It is located between 80° 15' and 84° 20' East of Longitude and 17° 46' and 24° 5 North of Latitude. It encompasses a total area of 136 lakh hectares of total land, which consists of 58.81 lakh hectares of cultivable land area and 60.76 lakh hectares forest land area. The vegetation of Chhattisgarh comprises of numerous varieties of horticultural plants, trees, crops like paddy, maize, pulses and many more. Some of the main trees found in the forests of Chhattisgarh are Bija, Saja, Harra, Tendu, Teak, haura, Mahua etc.

Agriculture is the main occupation of the people of Chhattisgarh where nearly 80% of the population is engaged in cultivation. The major crop grown is paddy especially in the central plains of the state, popularly known as rice bowl of central India. Apart from paddy other crops grown here are oilseeds, wheat, coarse grains, groundnut, maize and pulses. The soil is suitable for the cultivation of horticultural plants guava, mango, banana etc. and a various types of vegetables.

Study area

The district Narayanpur is a part of Bastar plateau which covered by natural dense forest area is surrounded by Kanker district in the north, Bastar and Dantewada district in the west, Bijapur in the south and Maharastra state in the east. It was formed as district on 2007. The district of Narayanpur lies between $19^0 13'41''$ N to $19^0 56'46''$ N latitude and $80^0 39'51''$E to $81^0 30'57''$ E longitude and extends over an area of 6640 sq kms. It consists of 496 no of villages. For administrative convenience these villages are grouped into 2 development blocks namely Narayanpur and Orchha. The district is known for its forest produce and mineral wealth. The economy of the district is mainly dependent upon cultivation and 90% workers are engaged in agriculture sector. The normal annual rainfall is 1386.77 mm. The annual temperature varies from 10.6 °C in winter to 46 °C in summer. The relative humidity varies from 90% in rainy season to 30-40% during winter. The soils in the district are having wide variations. Most of the area is covered by red gravely, red sandy and loamy alfisols. As most of the area is covered by crystallines and metamorphic rocks and the soils derived by weathering are red soils. At some places Ultisols in the form of laterites are also present. The trap rocks in the district are occurring as hills rather than plateaus and consequently the trap slopes developed light soils rather than the deep black cotton soil (Soni, 2012).

Materials and Methods

Narayanpur district of Chhattisgarh was selected for carrying out the study to prepare GPS and GIS based thematic soil fertility maps. Latitude (Lat) and Longitude (Long) were recorded by Global Positioning System (GPS) instrument from soil sampling places. Fifteen composite GPS based soil samples have been collected from all gram panchayat of each block. The soils were collected from 5-6 spots for one composite soil sample and by quartering process the soil quantity was reduced upto 1 kg. Soil samples were brought to the laboratory and air dried under shade avoiding contamination with foreign materials and then crushed with a wooden pestle. The sample is then screened through a 2mm sieve and the pebbles, stones and roots are rejected. About 500 to 1000 gm of air dried crushed soil sample was put in the plastic sample bottle, lebelled and stacked for analysis. Total 1265 numbers of GPS based soil samples from the 2 blocks namely Narayanpur and Orchha were collected and analysed. The analysis of soil samples have been done by using standard methods. Piper's method (1967) 1:2.5 soil water suspension for pH using a glass electrode pH meter, soluble salt- bridge process as suggested by Black, 1965 was used to determine EC, organic carbon (OC) was determined using Walkley and Black's rapid titration process (1934). Procedure determined by Subbiah and Asija (1959) [18] was used to evaluate available nitrogen, method suggested by Olsen *et al.* 1954, 0.5M $NaHCO_3$ (pH-8.5) as extracting agent was used to measure available P in the soil, and P in the extract was measured in a spectrophotometer using the ascorbic acid process defined by Olsen and Watanabe (1965) [20]. The method suggested by Jackson, for available K, extracted with neutral normal ammonium acetate (Hanway and Heidal, 1952) [6]. Williams and Steinberg (1969) [21] identified a turbidimetric process for determining available S in soil. Lindsay and Norvell (1978) [8] defined a system for determining the micro-nutrients Zn, Cu, Fe, and Mn. Berger and Troug (1939) [1] identified a method for determining available B in soil. Using this method, hot water was used as the extracting agent. Base map of the Narayanpur district were digitized and geo-referenced. Polygons were superimposed on the geo-referred map. Then latitude, longitude and analysis data were entered into attributed table and linked to GIS software for making thematic soil fertility maps.

Results and Discussion

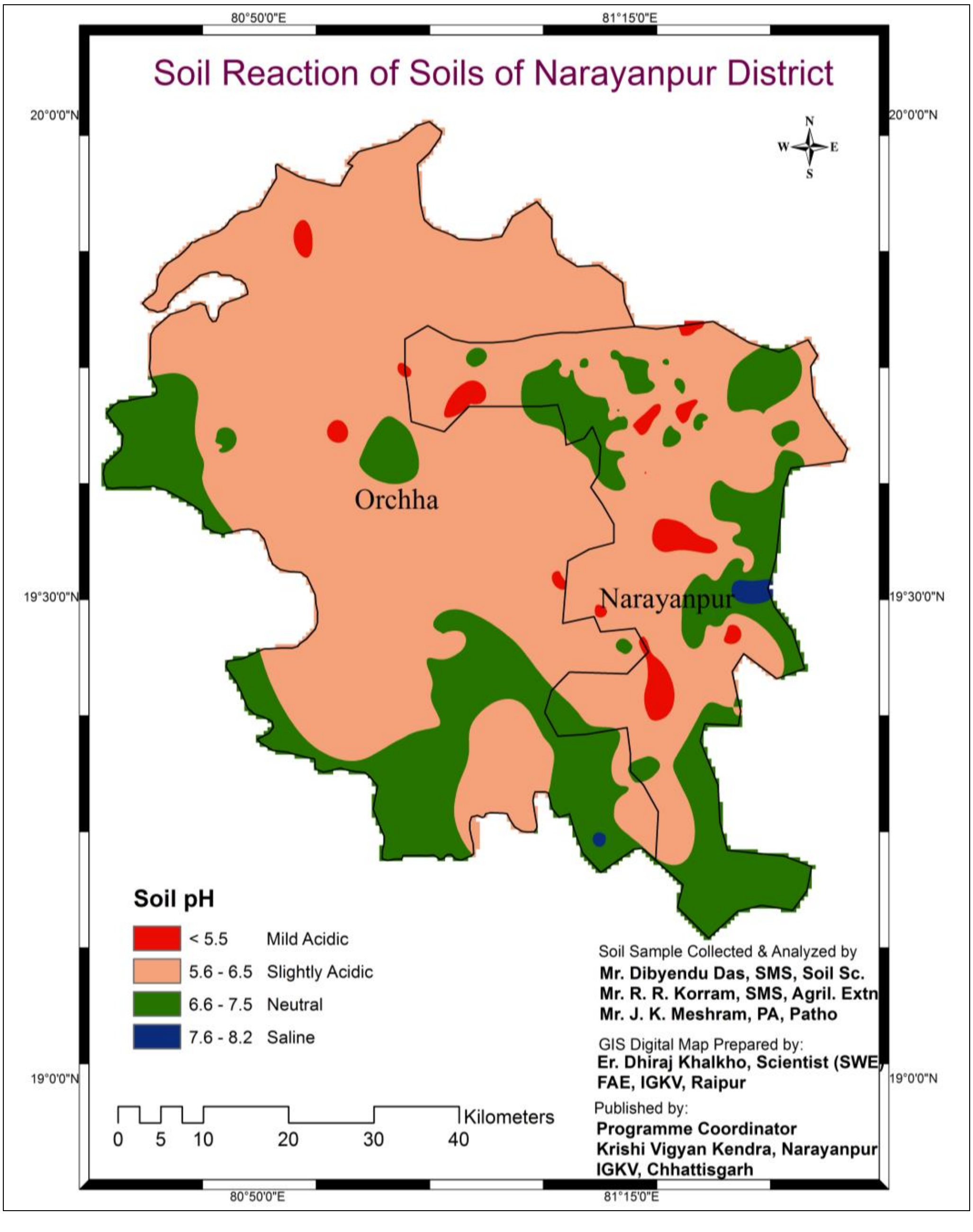
The soil fertility status of Narayanpur district presented in Table No.1. Soil reaction of the both the blocks of Narayanpur district maximum neutral which varied from 4.50-8.20 in Narayanpur and 4.90 – 7.50 in Orchha with their respective mean value of 6.26 and 6.17. The electrical conductivity of Narayanpur and Orchha blocks ranged from 0.02-0.56 and 0.08-0.40 dSm^{-1}, respectively (Fig.1). The data revealed that electrical conductivity is safe for crop production may be due to far way from the sea. The organic carbon content varies between 0.13-1.95% in Narayanpur and 0.11-1.55% in Orchha block with their respective mean value of 0.72 and 0.83% which are in medium range its mean organic carbon content is due to the dense forest area present in this district . Similar result also found by Mitra *et al.* (2002).

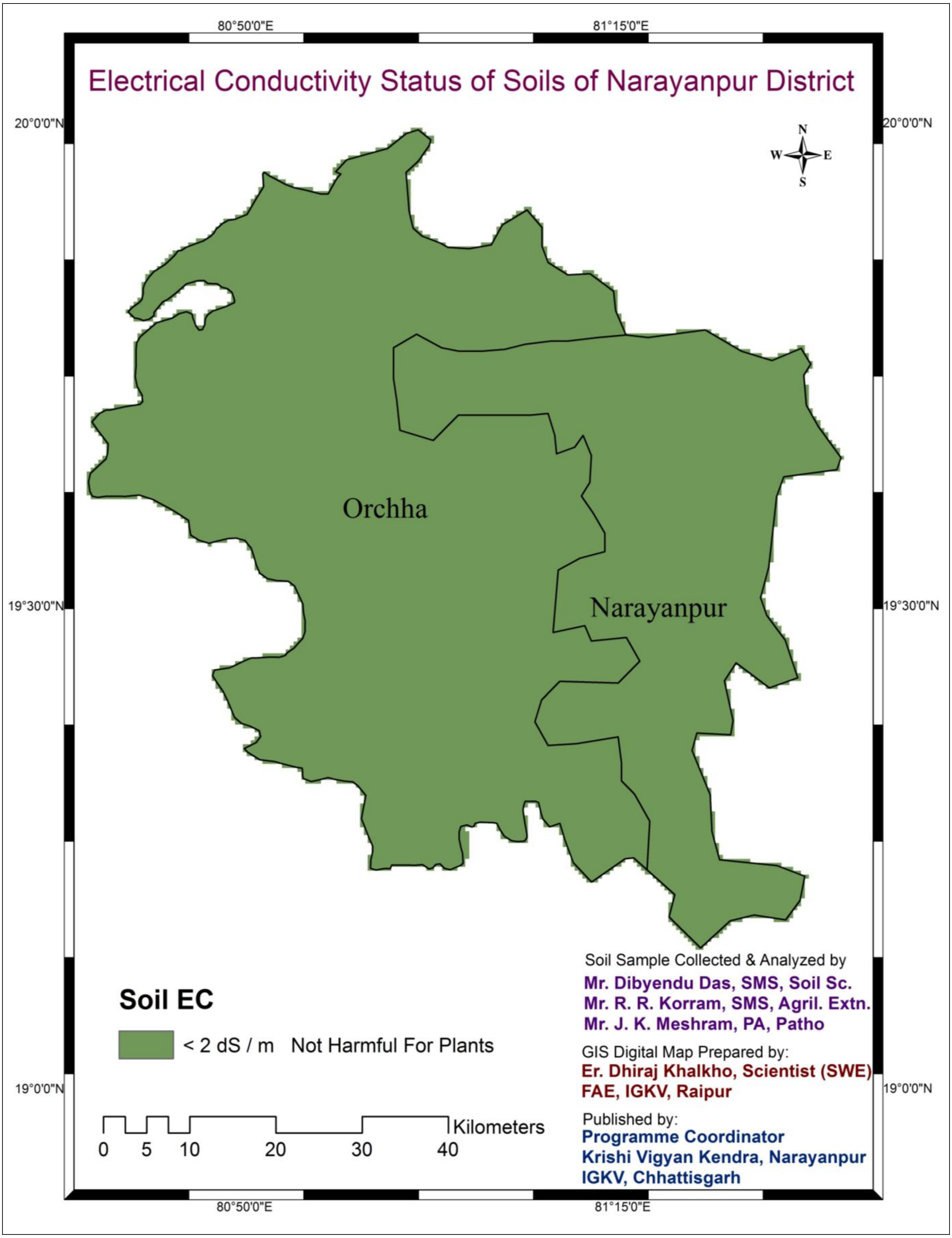
The primary nutrient status namely mineral nitrogen, available phosphorus and available potassium which are required in large quantity for crop production. Mineralizable nitrogen, available phosphorus and available potash of Narayanpur block are low to high which ranged from 60.41-536.25, 4.46-64.44 and 4.48-627.20 kg ha^{-1}, respectively with their respective mean value of 260.83, 24.64 and 156.89 kg ha^{-1}(Fig.2). Similar observation found in Orchha block which varied between 50.34-425.50, 11.07-56.50 and 4.48-894.10 kg ha^{-1}, respectively with their respective mean value of 284.72, 33.41 and 321.63 kg ha^{-1}. This is may be due to application of FYM, vermicompost and dense forest which also found by (Mishra *et al.*, 2013) [11].

The status of available sulphur, hot water soluble boron and DTPA extractable micronutrients content of both the blocks remains above critical limits are presented in Table 1. Mean available sulphur (0.15% $CaCl_2$ extractable) content of Narayanpur and orchha block ranged from 5.34-36.95 and 9.27-36.47 ppm respectively with their respective mean value of 21.55 and 25.29ppm. Similar result found in case of hot water soluble boron content which varied between 0.35-1.49 and 0.37-1.48 ppm respectively with their respective mean value of 1.02 and 1.12 ppm (Fig.3). The micronutrients like DTPA extractable zinc, iron, manganese and copper ranged from 0.35-0.89, 1.03-163.01, 3.10-8.95 and 0.15-1.59ppm respectively in Narayanpur block with their respective mean value 0.65, 26.74, 5.91 and 1.13 ppm. Similarly in Orchha block DTPA extractable zinc, iron, manganese and copper ranged from 0.43-0.89, 1.26-158.01, 4.20-8.47 and 0.27-1.58ppm respectively with their respective mean value 0.67, 34.54, 6.04 and 1.01 ppm (Fig.4).

Table 1: Soil fertility status of both blocks of Narayanpur district

Sl. No.	Parameters	Narayanpur		Orchha	
		Range	Mean	Range	Mean
1	pH	4.50-8.20	6.26	4.90-7.50	6.17
2	EC (dS m^{-1})	0.02-0.56	0.15	0.08-0.40	0.17
3	OC (%)	0.13-1.95	0.72	0.11-1.55	0.83
4	Avl. N (kg ha^{-1})	60.41-536.25	260.83	50.34-425.50	284.72
5	Avl. P (kg ha^{-1})	4.46-64.44	24.64	11.07-56.50	33.41
6	Avl. K (kg ha^{-1})	4.48-627.20	156.89	4.48-894.10	321.63
7	Sulpher (ppm)	5.34-36.95	21.55	9.27-36.47	25.29
8	Hot water-soluble Boron (ppm)	0.35-1.49	1.02	0.37-1.48	1.12
9	DTPA extractable Zinc (ppm)	0.35-0.89	0.65	0.43-0.89	0.67
10	DTPA extractable Iron (ppm)	1.03-163.01	26.74	1.26-158.01	34.54
11	DTPA extractable Manganese (ppm)	3.10-8.95	5.91	4.20-8.47	6.04
12	DTPA extractable Copper (ppm)	0.15-1.59	1.13	0.27-1.58	1.01




80°50'0"E
81°15'0"E
Electrical Conductivity Status of Soils of Narayanpur District
20°0'0"N
19°30'0"N
19°0'0"N
N
W
E
S
Orchha
Narayanpur
Soil EC
< 2 dS / m Not Harmful For Plants
0 5 10 20 30 40
Kilometers
Soil Sample Collected & Analyzed by
Mr. Dibyendu Das, SMS, Soil Sc.
Mr. R. R. Korram, SMS, Agril. Extn.
Mr. J. K. Meshram, PA, Patho
GIS Digital Map Prepared by:
Er. Dhiraj Khalkho, Scientist (SWE)
FAE, IGKV, Raipur
Published by:
Programme Coordinator
Krishi Vigyan Kendra, Narayanpur
IGKV, Chhattisgarh

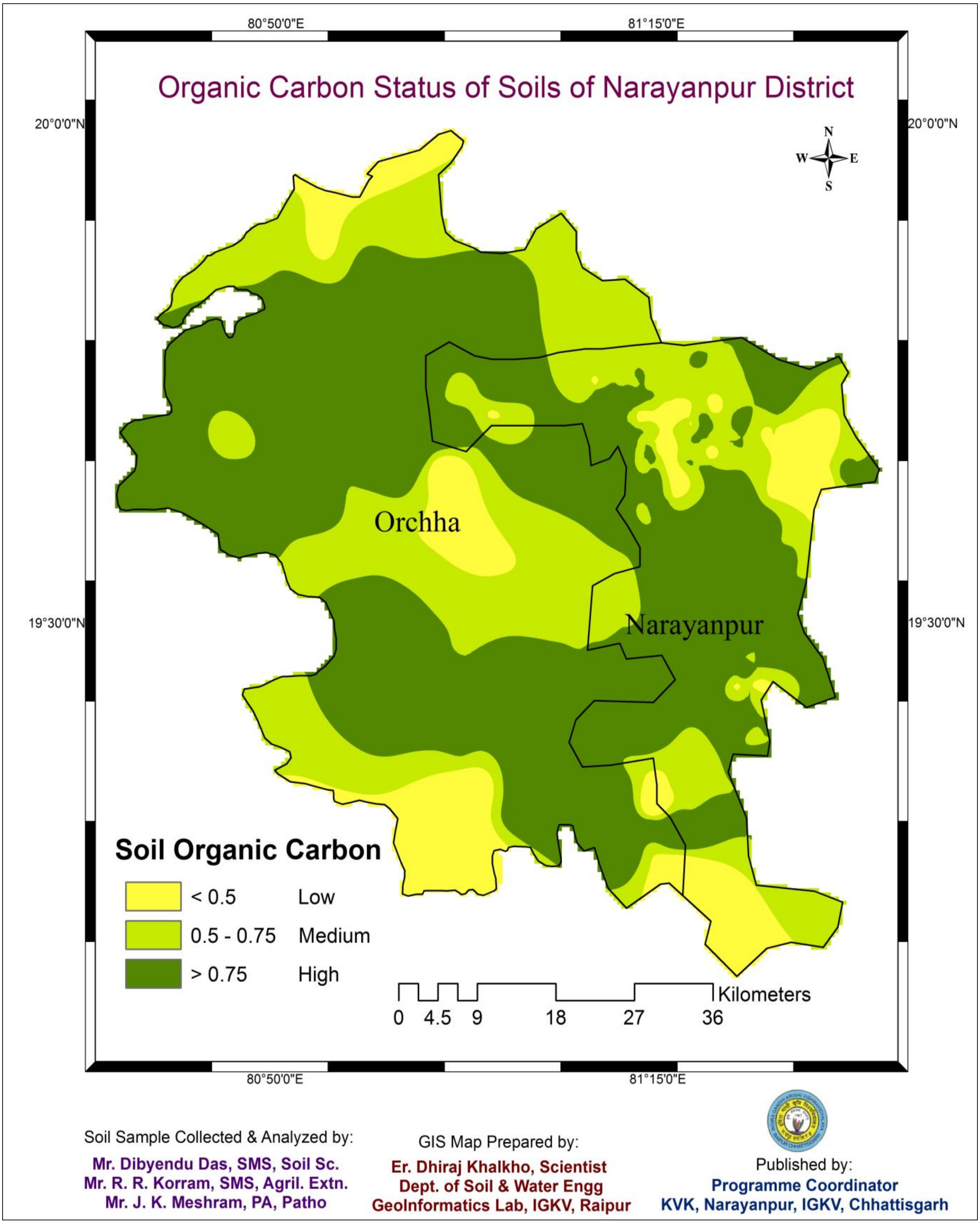
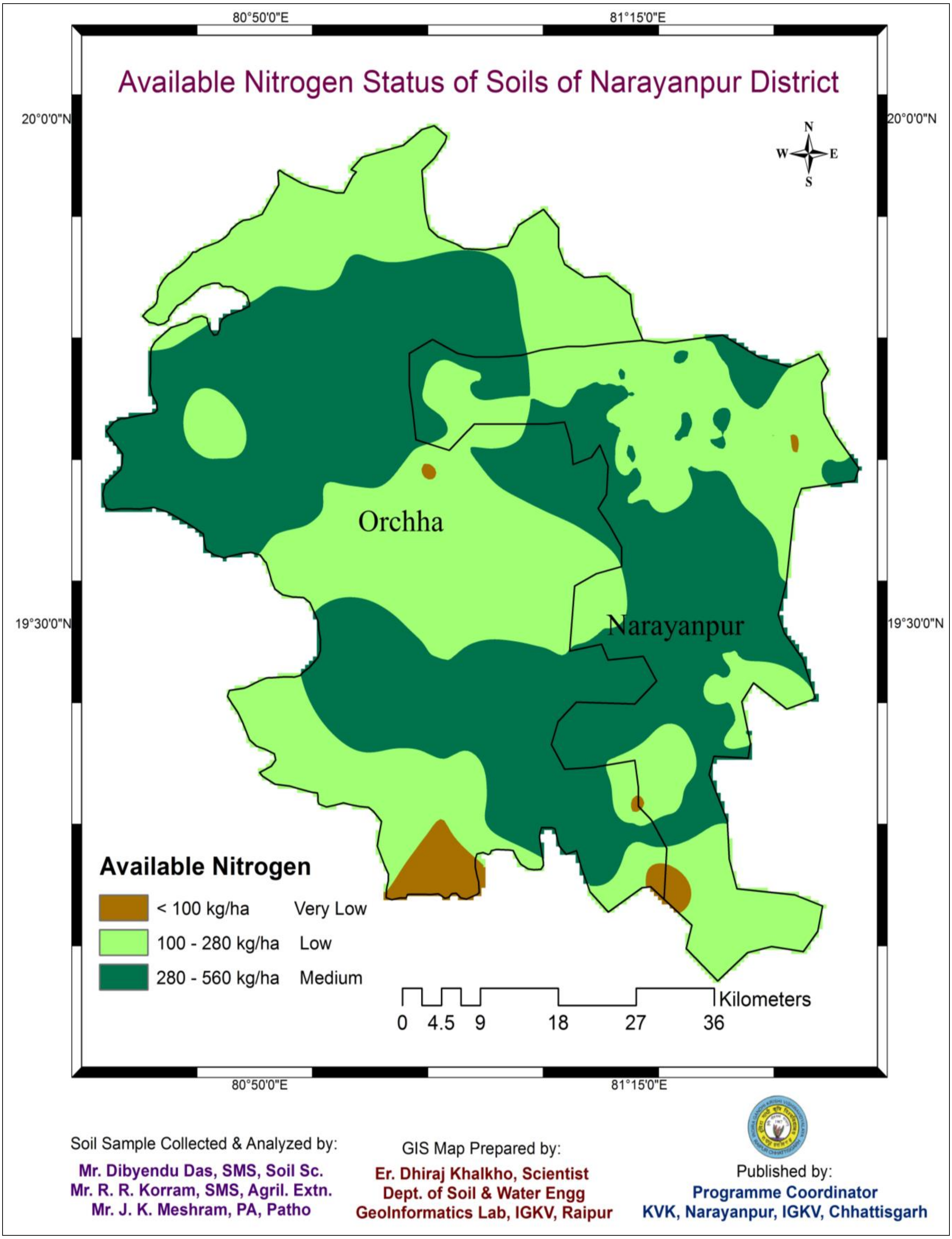
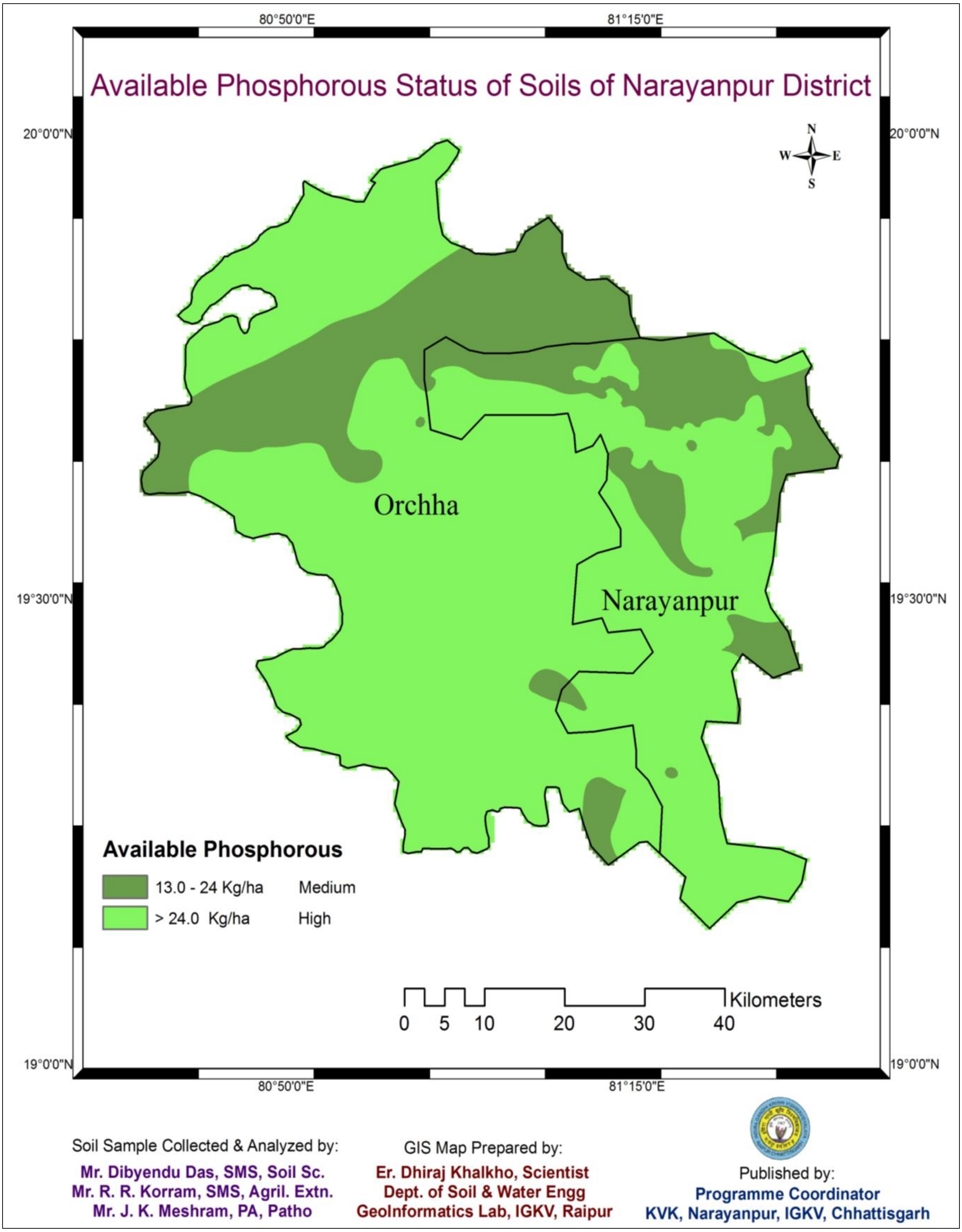


Fig 1: GPS and GIS based Soil pH, EC and OC map of Narayanpur district


Available Nitrogen Status of Soils of Narayanpur District
80°50'0"E
81°15'0"E
20°0'0"N
19°30'0"N
N
W
E
S
Orchha
Narayanpur
Available Nitrogen
< 100 kg/ha Very Low
100 - 280 kg/ha Low
280 - 560 kg/ha Medium
0 4.5 9 18 27 36
Kilometers
Soil Sample Collected & Analyzed by:
Mr. Dibyendu Das, SMS, Soil Sc.
Mr. R. R. Korram, SMS, Agril. Extn.
Mr. J. K. Meshram, PA, Patho
GIS Map Prepared by:
Er. Dhiraj Khalkho, Scientist
Dept. of Soil & Water Engg
GeoInformatics Lab, IGKV, Raipur
Published by:
Programme Coordinator
KVK, Narayanpur, IGKV, Chhattisgarh


Available Phosphorous Status of Soils of Narayanpur District
80°50'0"E
81°15'0"E
20°0'0"N
19°30'0"N
19°0'0"N
N
S
E
W
Orchha
Narayanpur
Available Phosphorous
13.0 - 24 Kg/ha Medium
> 24.0 Kg/ha High
0 5 10 20 30 40 Kilometers
Soil Sample Collected & Analyzed by:
Mr. Dibyendu Das, SMS, Soil Sc.
Mr. R. R. Korram, SMS, Agril. Extn.
Mr. J. K. Meshram, PA, Patho
GIS Map Prepared by:
Er. Dhiraj Khalkho, Scientist
Dept. of Soil & Water Engg
GeoInformatics Lab, IGKV, Raipur
Published by:
Programme Coordinator
KVK, Narayanpur, IGKV, Chhattisgarh

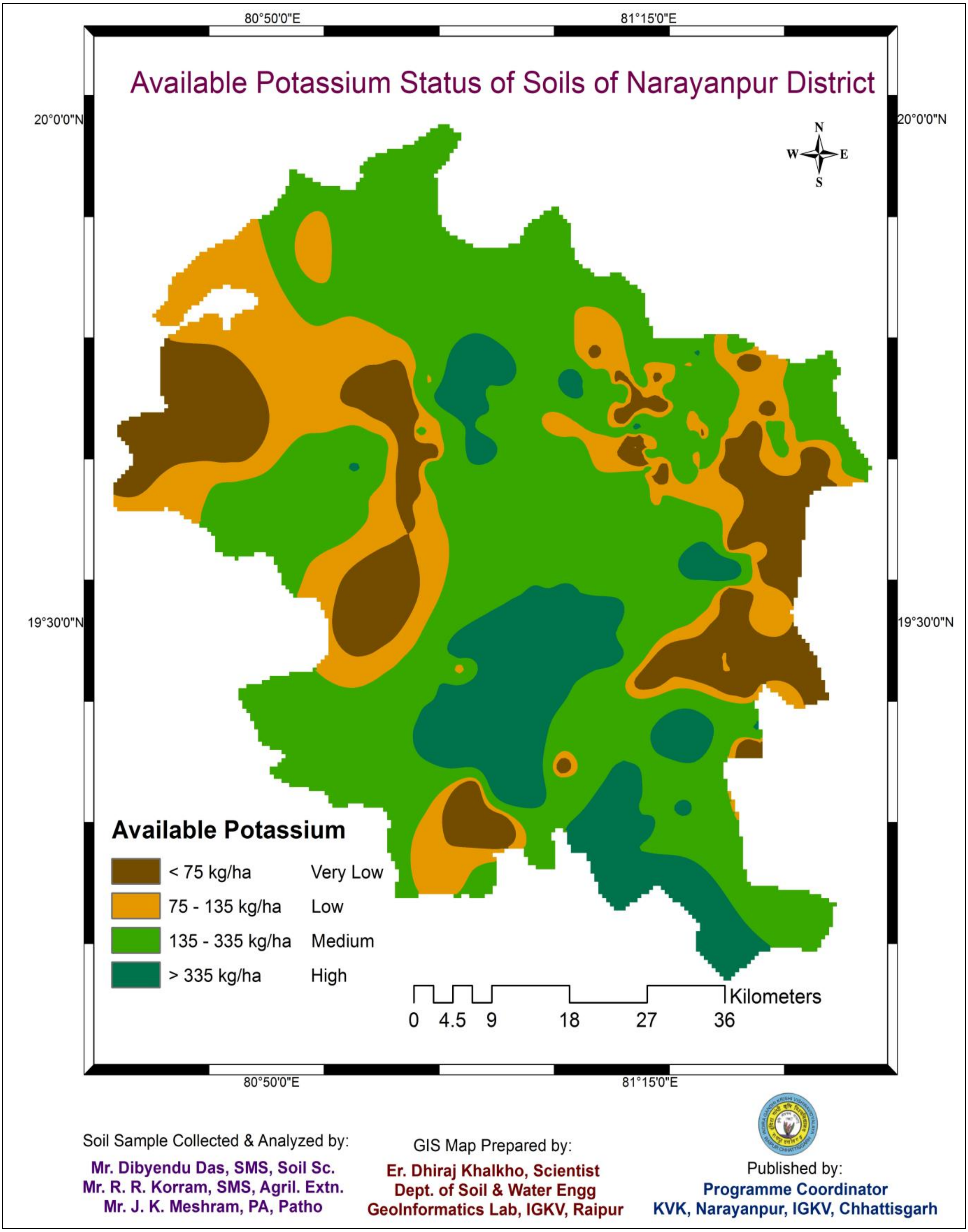
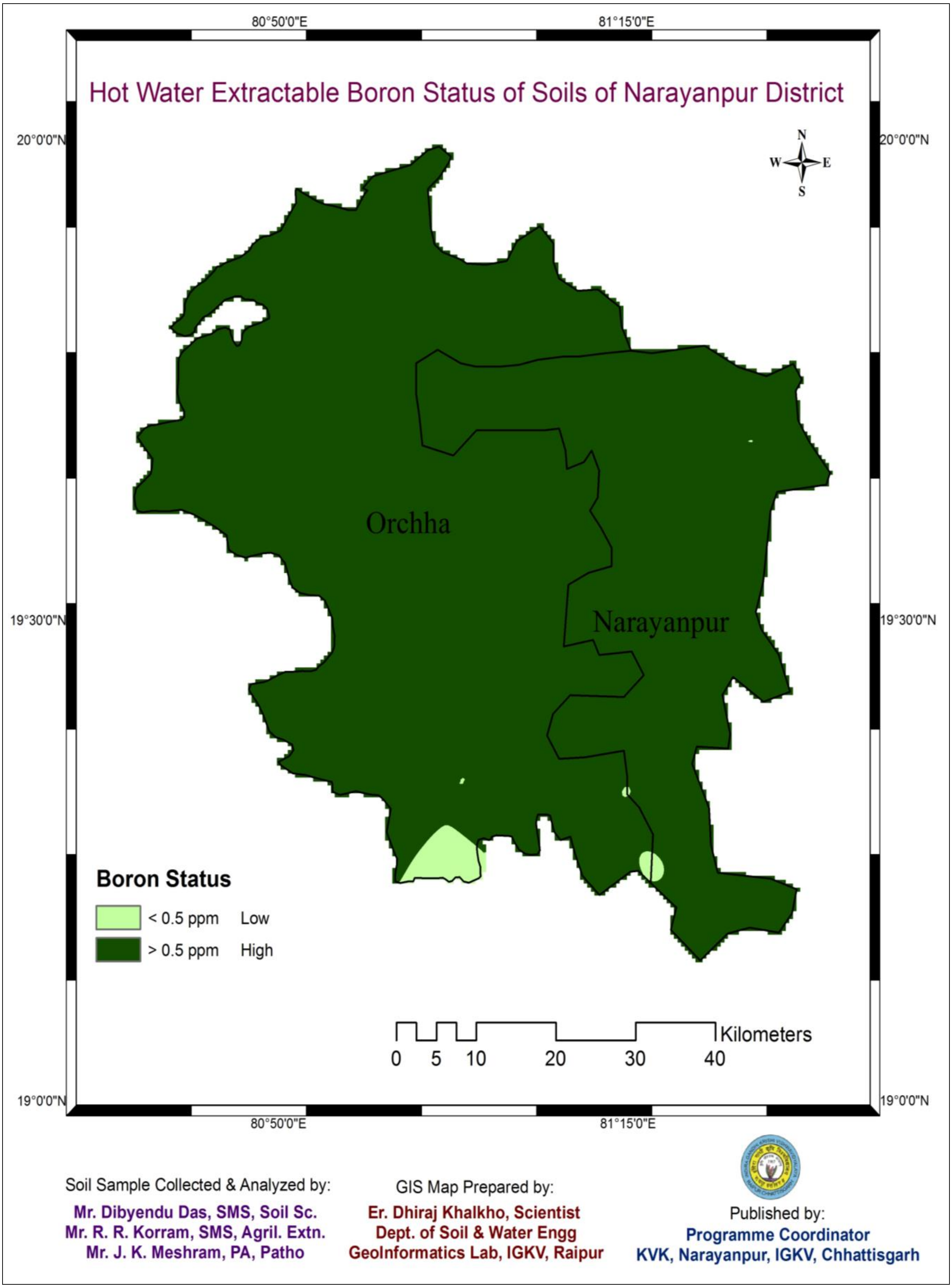
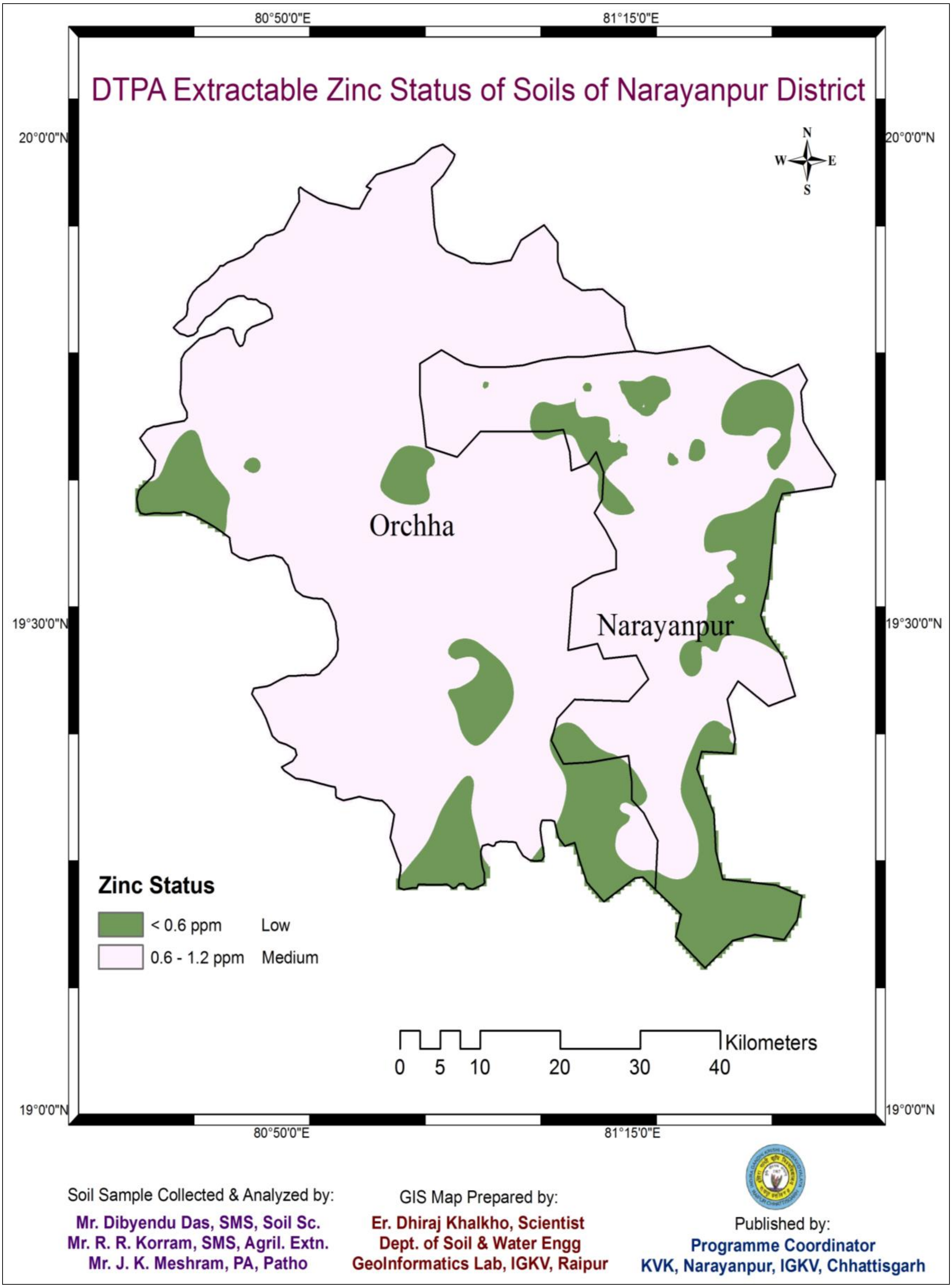


Fig 2: GPS and GIS based Soil primary nutrients content map of Narayanpur district


Hot Water Extractable Boron Status of Soils of Narayanpur District
80°50'0"E
81°15'0"E
20°0'0"N
19°30'0"N
19°0'0"N
N
W
E
S
Orchha
Narayanpur
Boron Status
< 0.5 ppm Low
> 0.5 ppm High
0 5 10 20 30 40 Kilometers
Soil Sample Collected & Analyzed by:
Mr. Dibyendu Das, SMS, Soil Sc.
Mr. R. R. Korram, SMS, Agril. Extn.
Mr. J. K. Meshram, PA, Patho
GIS Map Prepared by:
Er. Dhiraj Khalkho, Scientist
Dept. of Soil & Water Engg
GeoInformatics Lab, IGKV, Raipur
Published by:
Programme Coordinator
KVK, Narayanpur, IGKV, Chhattisgarh


DTPA Extractable Zinc Status of Soils of Narayanpur District
80°50'0"E
81°15'0"E
20°0'0"N
19°30'0"N
19°0'0"N
N
W
E
S
Orchha
Narayanpur
Zinc Status
< 0.6 ppm Low
0.6 - 1.2 ppm Medium
0 5 10 20 30 40 Kilometers
Soil Sample Collected & Analyzed by:
Mr. Dibyendu Das, SMS, Soil Sc.
Mr. R. R. Korram, SMS, Agril. Extn.
Mr. J. K. Meshram, PA, Patho
GIS Map Prepared by:
Er. Dhiraj Khalkho, Scientist
Dept. of Soil & Water Engg
GeoInformatics Lab, IGKV, Raipur
Published by:
Programme Coordinator
KVK, Narayanpur, IGKV, Chhattisgarh

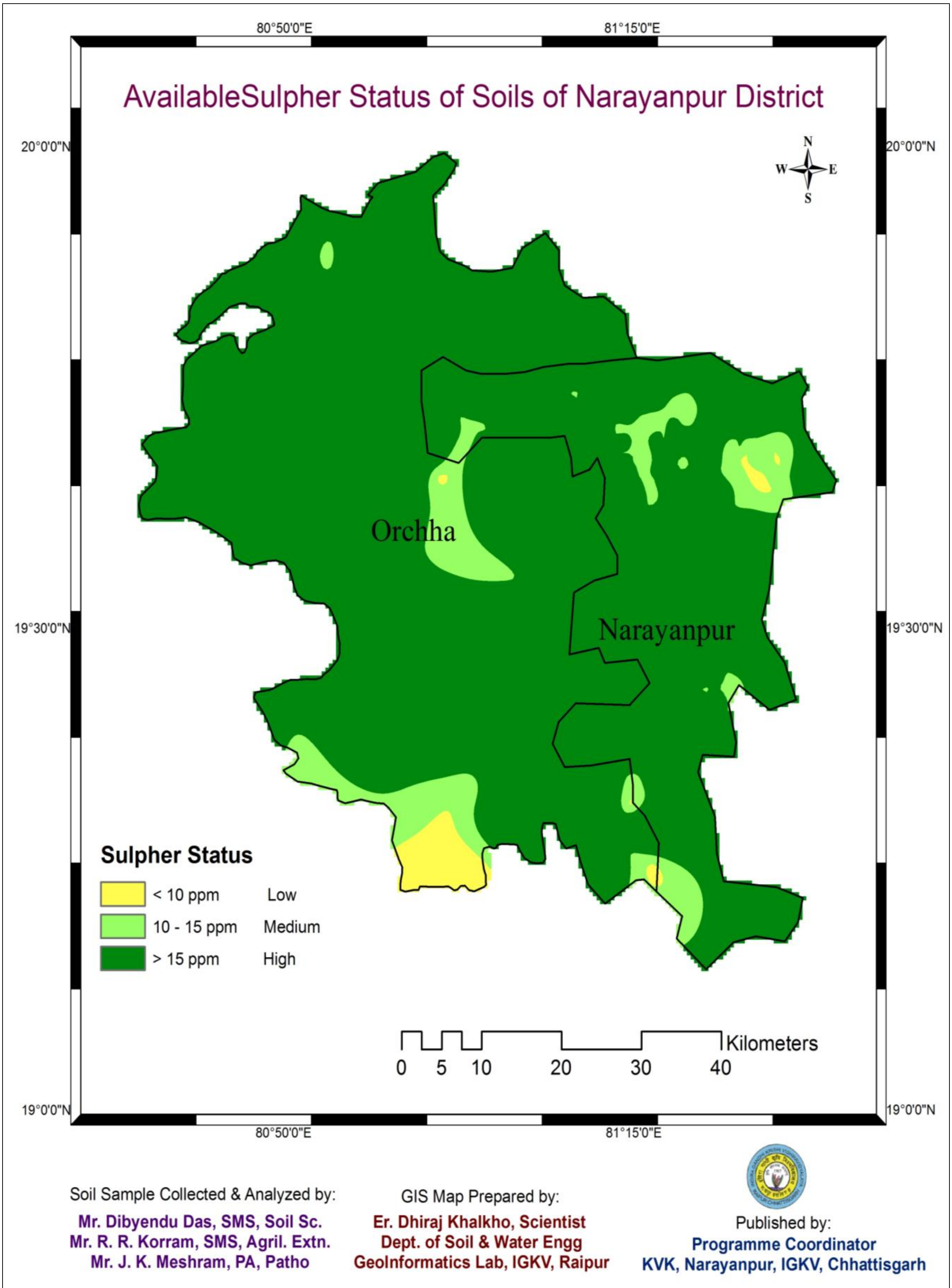
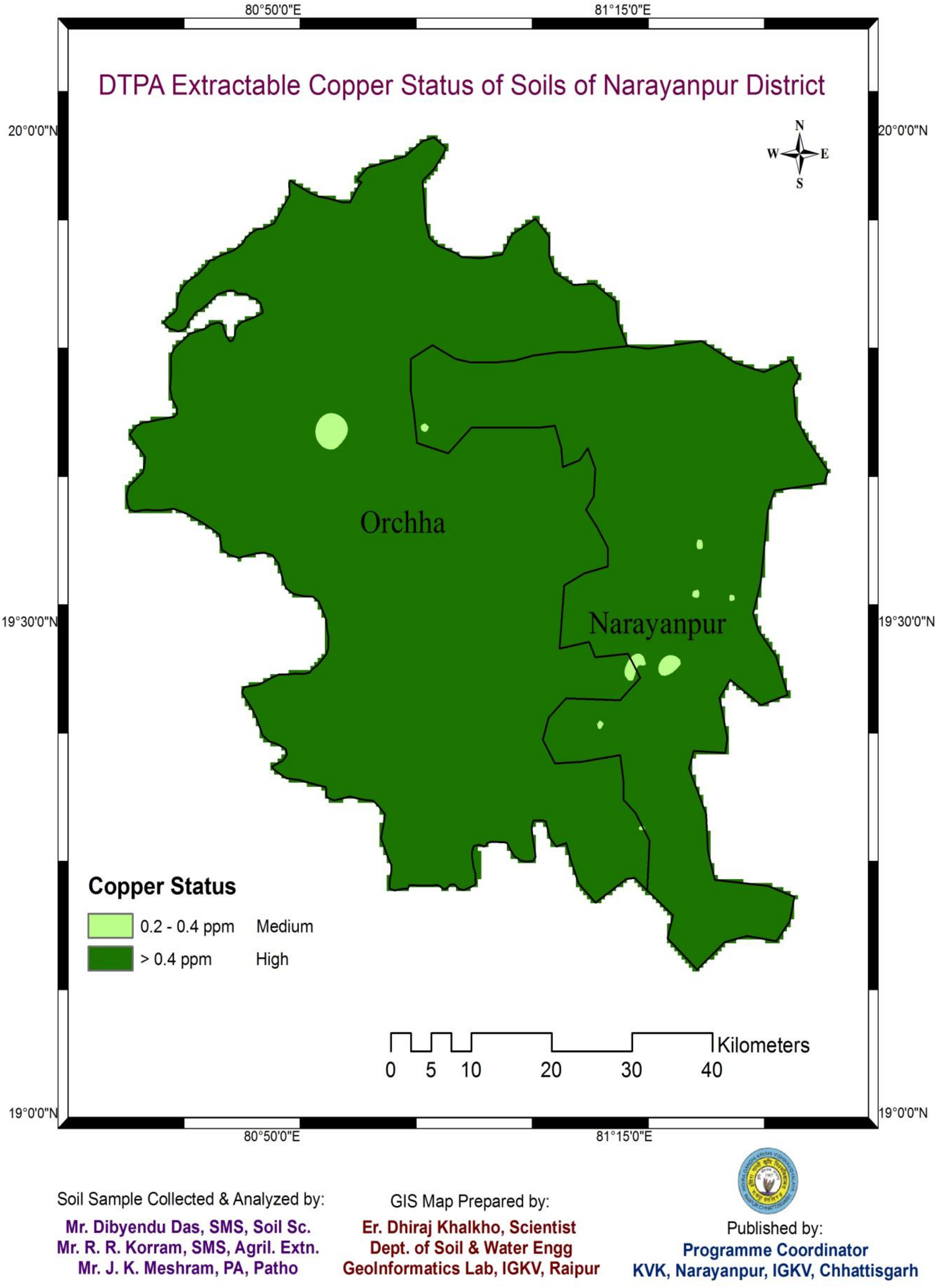
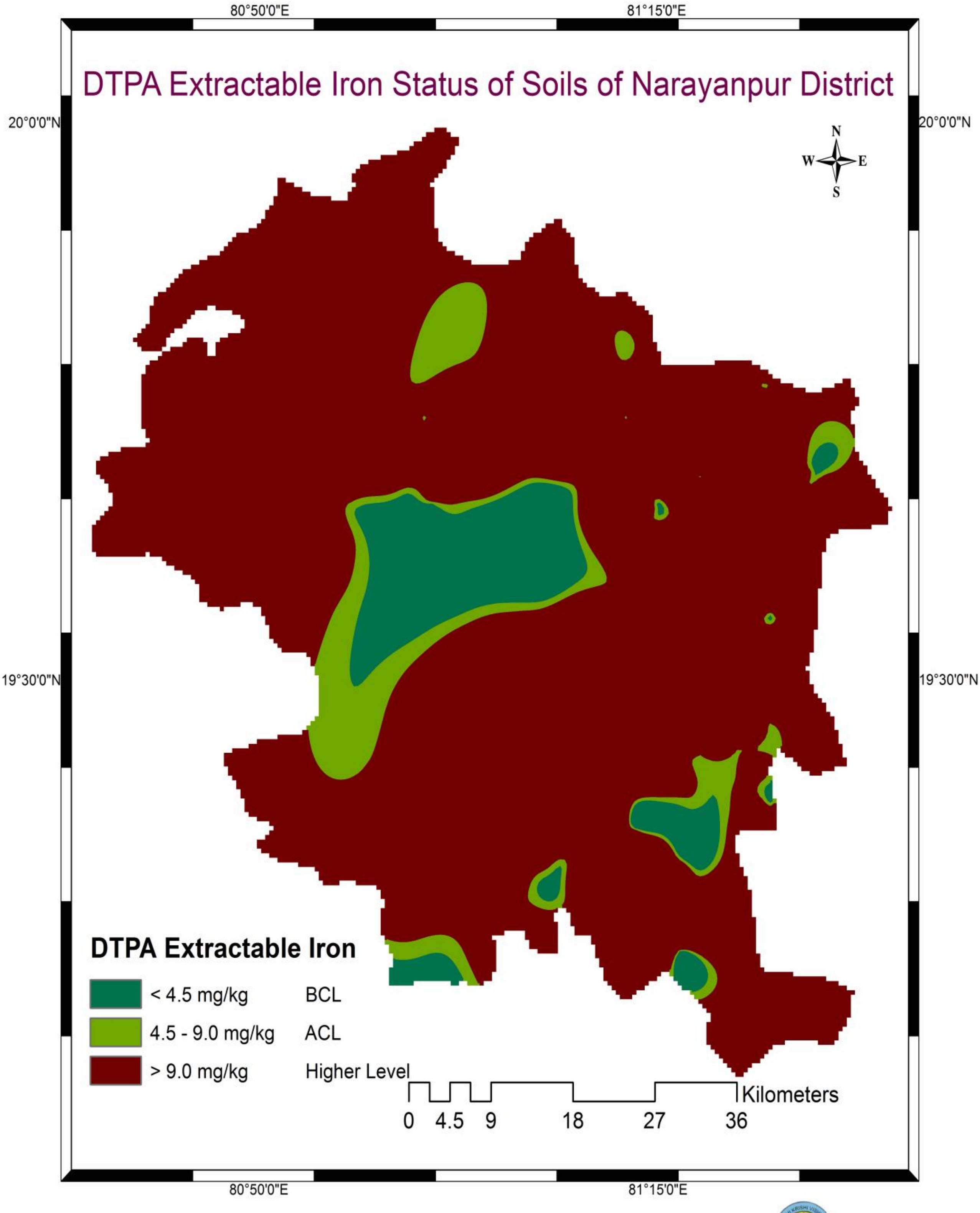


Fig 3: GPS and GIS based Soil available sulphur and micronutrients content map of Narayanpur district


80°50'0"E
81°15'0"E
DTPA Extractable Copper Status of Soils of Narayanpur District
20°0'0"N
19°30'0"N
19°0'0"N
N
W
E
S
Orchha
Narayanpur
Copper Status
0.2 - 0.4 ppm Medium
> 0.4 ppm High
0 5 10 20 30 40 Kilometers
Soil Sample Collected & Analyzed by:
Mr. Dibyendu Das, SMS, Soil Sc.
Mr. R. R. Korram, SMS, Agril. Extn.
Mr. J. K. Meshram, PA, Patho
GIS Map Prepared by:
Er. Dhiraj Khalkho, Scientist
Dept. of Soil & Water Engg
GeoInformatics Lab, IGKV, Raipur
Published by:
Programme Coordinator
KVK, Narayanpur, IGKV, Chhattisgarh



Soil Sample Collected & Analyzed by:
Mr. Dibyendu Das, SMS, Soil Sc.
Mr. R. R. Korram, SMS, Agril. Extn.
Mr. J. K. Meshram, PA, Patho

GIS Map Prepared by:
Er. Dhiraj Khalkho, Scientist
Dept. of Soil & Water Engg
GeoInformatics Lab, IGKV, Raipur

Published by:
Programme Coordinator
KVK, Narayanpur, IGKV, Chhattisgarh

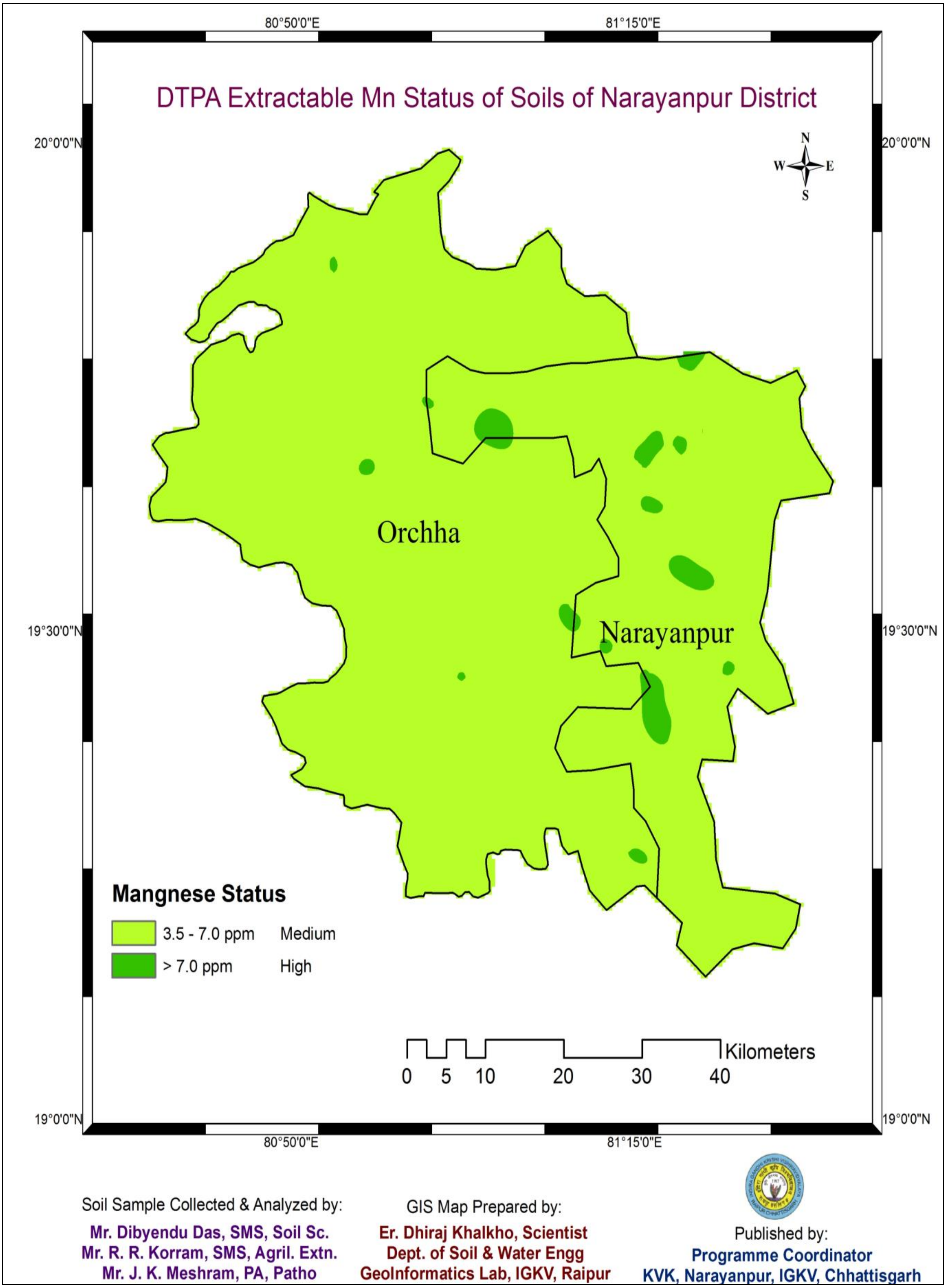


Fig 4: GPS and GIS based Soil micronutrients content map of Narayanpur district

Conclusions

It can be concluded that GPS and GIS based soil fertility maps helps in soil test based fertilizer recommendation for intensive cropping system to scientists, planners and farmers. It also helps in site specific nutrient management and monitoring the soil health for present and future agriculture. The soils of all study blocks were neutral in soil reaction and organic carbon content ranged from medium to high. Mineral nitrogen content was medium, available phosphorus content was ranged from medium to high whereas, available potassium content was high. On the other hand, available sulphur, Hot water soluble boron and DTPA extractable micronutrients content remained above the critical limits in both the blocks.

References

1. Berger KC, Troug K. Boron determination in soil and plants. Ind. Eng. Chem. Anal. 1939;2:540-545.
2. Chaudhari B, Patil VN, Patil J. GPS-GIS-Based Soil Fertility Maps of Shahada Tahsil of Nandurbar District (M.S.). Biol. Life Sci. Forum; c2022 .p. 16 -19.
3. Das D K, Bandyopadhyay S, Chakraborty D, Srivastava Rajeev. Application of Modern Techniques in Characterization and Management of Soil and Water Resources, Journal of the Indian Society of Soil Science. 2009;57(4):445-460.
4. Das D K. Remote sensing application in management of agricultural resources. Research Highlights. Indian Agricultural Research Institute, New Delhi; c1998 .p. 1-103.
5. Das D K. Role of geoinformatics in sustainable agriculture: Research, extension and service to the farmers. Chairman's address. In: Proceedings of the symposium Geoinformatics Applications for Sustainable Development, Indian Society of Agrophysics, IARI, New Delhi; c2004 .p. 1-11
6. Hanway JJ, Heidal H. Soil analysis, as used in Lowa State. College of Soil Testing Laboratory, lowa. Agriculture. 1952;57:1-31.
7. Kanwar J S. Soil and Water resources management for sustainable agriculture-imperatives from India. In: Development and Conservation. Int. Conf. Agricultural Production in 21st Century. Feb.14-18, New Delhi; c2000 .p. 17-37.
8. Lindsay, Norvell WA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of American Journal. 1978;42:421-428.
9. Mandal AK, Sharma RC. Computerized Database of Salt-affected Soils in Peninsular India using Geographic Information System. Journal of the Indian Society of Soil Science. 2010; 58(1):105-116.
10. Mishra A, Pattnaik T, Das D, Das M. Soil fertility maps preparation using GPS and GIS in Dhenkanal District, Odisha, India. International Journal of Plant & Soil Science. 2014;3(8):986-994.
11. Mishra Antaryami, Das D, Saren S. Preparation of GPS and GIS based soil fertility maps for Khurda district, Odisha. Indian Agriculturist. 2013; **57**(1):11-20.
12. Olsen SR, Cole CV, Watabebe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. of Agric. Cire; c1954. p. 939.
13. Olsen SR, Cole CV, Watanabe PS, Dean LA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America. 1954;42:421-428.
14. Piper CS. Soil and plant analysis. Hans's publishers, Mumbai; c1950. p. 368.
15. Rathore A S, Sharma, Y M, Tagore G S, Nagwanshi, A, Jayaraman, S. Soil Fertility Mapping Using GPS and GIS in Jhabua District, Madhya Pradesh, India. Journal of the Indian Society of Soil Science. 2023;71(3):276-286.
16. Mistry S, Sahu KK, Sengar AS, Dadsena R. GIS and GPS based soil fertility mapping of village Dhodha, district Balodabazar, Chhattisgarh The Pharma Innovation Journal. 2022; SP-11(12):432-438
17. Sony K B N. Ground Water Brochure of Narayanpur District, Chhattisgarh; c2012-13 .p. 1-13.
18. Subbiah BV, Asija GL. A rapid procedure for estimation of available Nitrogen in soil. Current Science. 1959;25:256-260.
19. Walkley A, Black IA. Rapid titration method of organic carbon of soils. Soil Science. 1934;37:29-33.
20. Olsen SR, Watanabe FS. Test of an ascorbic acid method for determining phosphorus in water and NaHCO3 extracts from soil. Soil Science Society of America Journal. 1965;29(6):677-8.
21. Williams CH, Steinberg A. Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. Australian Journal of Agricultural Research. 1969;10:340-352.