Appraisal of available macro and micro nutrient in soils of Nisija, Kaimur by using G.P.S. and G.I.S. system

THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF

Master of Science (Agriculture)

in

Soil Science – Soil and Water Conservation

Supervisor
Prof. P.K. Sharma

Submitted by
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To,

The **Registrar**
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Dear Sir,

We have great pleasure in the forwarding of the thesis entitled **"Appraisal of available macro and micro nutrient in soils of Nisija, Kaimur by using G.P.S. and G.I.S. system"** submitted by **Mr. Chandan Kumar Upadhyay** in partial fulfilment of the requirements for the award of the degree of **Master of Science (Agriculture)** in **Soil Science -Soil and Water Conservation,** Institute of Agricultural Sciences, Banaras Hindu University, Rajiv Gandhi South Campus, Barkachha, Mirzapur.

It is certified that the entire scheme of investigation reported herein, was planned and carried out by the candidate under our guidance, to the best of my knowledge and belief.

Forwarded **Forwarded** **Yours faithfully**

Head **(Course Coordinator)** **(Prof. P.K. Sharma)**
Chairman of the Advisory Committee

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Date: ***(Chandan Kumar Upadhyay)***

Place: *Varanasi*

CONTENTS

LIST OF SYMBOLS AND ABBREVIATIONS

%	-	Per cent
°C	-	Degree Celsius
Agri.	-	Agriculture
Ca	-	Calcium
Cl	-	Chloride
cm.	-	Centimetre
Cmol $(P^+)kg^{-1}$	-	Centimol per Kilogram
CO_3	-	Carbonate
Dept.	-	Department
dS m^{-1}	-	Decisiemens per meter
DTPA	-	Diethylenetriaminepenta acetic acid
Dur_ Mon	-	During monsoon
EC	-	Electrical conductivity
EDTA	-	Ethelene di amine tetra acetic acid
et al.	-	*Et alia,* and others
Fig.	-	Figure
HCO_3	-	Bi-carbonate
i.e.	-	*Id est,* that is
IWQI	-	Irrigation Water Quality Index
J	-	Journal
K	-	Potassium
KR	-	Kellys Ratio
M ha	-	Million hectare
Max.	-	Maximum
meq L^{-1}	-	Milli equivalent per litre
Mg	-	Magnesium
mg L^{-1}	-	Milligram per litre
Min.	-	Minimum
mm.	-	Millimetre
Na	-	Sodium

No.	-	Number (s)
pH	-	Puissance de hydrogen
PI	-	Permeability Index
Post Mon	-	Post monsoon
Pre_Mon	-	Pre-monsoon
RSC	-	Residual Sodium Carbonate
S.N	-	Serial number
SAR	-	Sodium Adsorption Ratio
Sci.	-	Science
Soc.	-	Society
sq. km	-	Square Kilometer
SSP	-	Soluble Sodium Percentage
TDS	-	Total Dissolved Solid
Temp.	-	Temperature
Univ.	-	University
viz.	-	Vide licet, namely

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Chapter I

INTRODUCTION

The primary and most significant resources for meeting the country's increasing population's needs for food, fuel, fibre, and timber are soil and water. Soil is crucial for the survival of all living things on the planet. With the start of the green revolution, a period of modernization began, resulting in the mechanisation of farm operations, including the use of tractors, farm machinery, and excessive fertiliser use, among other things. This had an impact on the soil's physical, chemical, and biological qualities.

In today's environment, the long-term viability of any system has become a top priority. Assessments of soil fertility can be performed to identify regions that require special attention or a different management method (Bahareh Delsouz Khaki *et al*., 2017). One of most basic choice tool for implementing optimal nutrient management is to measure soil fertility (Brady and Weil, 2004). There are other methods for determining soil fertility, but soil testing is still the most common (Havlin *et al*., 2010). It gives data on nutrient availability in the soil, which is used to make fertiliser and nutrient recommendations for increasing crop yield and extending the field's fertility status. The process of determining the physical, chemical, and biological properties of soil is known as soil fertility evaluation. Texture, structure, colour, water holding capacity of the soil, bulk density, particle density, and other physical properties are among them.

Similarly, the Chemical parameter includes soil reaction (pH), organic carbon content, macro and micronutrient values, and so on. The physical and chemical study is carried out to determine the soil's capability to provide mineral nutrients to plants (Ganorkar & Chinchmalatpure, 2013). The macro and micronutrient concentrations, and so on. The purpose of the physical and chemical analysis is to determine the soil's capability of producing mineral nutrients to plants (Ganorkar &Chinchmalatpure, 2013).

As it is applied to soil as irrigation, it has an impact on the soil qualities. The ultimate goal of groundwater analysis is to examine the impact of water quality on soil and, consequently, plant development. In most cases, irrigation is used. Water, in addition to soil, is critical to life's survival. In addition, presence and abundance of macro and micronutrients, acidity, alkalinity, salts and salt-inducing substances, suspended particles, and total hardness are all considered when evaluating water quality (Ajayi and Ogunbayo, 1990).

Bihar is a state in East India bordering Nepal. It is divided by river Ganga which floods its fertile plains. Bihar has a total geographical area of about 93.60 lakh ha, out of which only 56.03 lakh ha is net cultivated area and gross cultivated area being 79.46 lakh ha. The percentage of population employed in agricultural production in Bihar is around 80%, which is much higher than the national average.

Kaimur district is one of the districts of Bihar. Before 1991, it is a part of Rohtas district. The district headquarters are at Bhabua. Till 1764 the region was a part of Ghazipur district and was a part of Kamsaar raj and later it was a part of Chainpur Estate till 1837.Total area of this district is 3,362 km^2 and total population is 1,626,384 Geographically,the district can be divided into two part which is hilly and plain. The plain on the western side is flanked by the river Kramnasa and the Durgawati. Kaimur district has large forest cover of measuring roughly 106,300 ha which contain the Kaimur Sanctuary. The economy of district is mainly driven by agriculture and related industries like rice-polishing. Rice, wheat, sugar cane, oil-seed, pulses and maize are the main crops of this district. Kaimur is known as rice bowl of Bihar. Canal irrigation system is very prominent in this region. Kaimur town is the local trading center for food grains, agricultural products and agricultural equipment.

This district have net area under cultivation is 176736 ha. In which 71794 ha are irrigated. It falls under Agro-climatic zone –III (A).

Village Nisija is located in eastern part of Kaimur district of Bihar. This village is situated in Jalalpur Panchyat of Rampur Block. It is located at $24^0$57"North longitude And $83^0$51" east Latitude. This village is 30 KM North away from famous

Gupta Dham Cave which is famous for lord Shiva temple and 22 km West from Sasaram.The total area of this village is 279.45 ha. In north side Kudari village and in south, Son canal is situated. In eastern side river Durgauti whereas in west, village Rampur and Pali is Located. Major landforms in this village are upland. River Durgwati is the major source for irrigation. The direction of slope of village is west to east. The Economy of this village is farming- based economy. As we know soil has major role in Agriculture. Nisija has mainly 3 type of soil found that is clay, loam and alluvial.

In the view of fertility and productivity this is an important soil among all. The total area of the cultivated soil in village is 160 ha. In this soil mainly crops like rice and wheat are grown. In local language this soil is called as “BHATH” or “BHATAUR”. This soil is mainly found in the area belongs to river bank. The area of this soil is only 10 ha. Mainly pigeon pea and watermelon are cropped in this area. Other crops like Pea, Mustard, Chick pea, Arhar and vegetables like Tomato, Potato, Brinjal & cucumbers are also grown. This village is located in middle of the Ganga basin so the climate is mainly Monsoon type.

A few pioneer projects in various regions of the country have demonstrated the need of site-specific database management for farm planning, as well as the necessity of developing such a database at the village level for future farm development work in all states (Natarajan *et al.,* 2010). The integrated management of natural resources is the key to overcoming the current issues. As a result, understanding of land and soil resources in terms of their spatial distribution, potentials, restrictions, and appropriateness for alternative land uses aids in the development of strategies to increase production on a larger scale. Traditional approaches are expensive and time-consuming due to the large number of observations required. Computer and information technology improvements, on the other hand, have led to the development of new instruments, systems, tools, and methodologies. This necessitates a rapid and accurate inventory of natural resources using modern and scientific technologies such as geographic information systems (GIS) and remote sensing. Remote sensing techniques like these have shown to be quick, dependable, and cost-effective, and they deliver timely data. The repetitively of the satellites used in remote sensing range from daily to 24 days in multispectral, multi-temporal and multi spatial format from the space platform for the given area of interest has revolutionized in providing vital inputs in inventorying, mapping, management and monitoring of natural resources like soil, vegetation and water resources. No data regarding the soil fertility status of the village is available, therefore the present investigation has been undertaken to study **"Appraisal of available macro and micro nutrient in soil of Nisija Kaimur by using G.P.S. and G.I.S. system".** The objective of study are as follows:-

1. To assess the availability of macro and micronutrients status in soils of village Nisija of district Kaimur Bihar

2. To find the relationship between macro and micronutrients and various soil properties.

3. To create spatial variability maps of macro and micronutrients of the area.

Chapter II

REVIEW OF LITERATURE

Soil is an important component for the active functions for all the organism. It is a complex matter which constitute of organic matter, mineral, water and air. Its physic-chemical properties play an important role in the sustainability of its ecology and productivity too. The review of literatures pertaining to this study are discussed under the following heads:

2.1 Physical and Chemical properties of soils

2.2 Status of primary macronutrients

2.3 Status of secondary nutrient

2.4 Status of micronutrients

2.1 Physical and chemical properties of soils

Choudhary *et al*. (1981) reported that dose of 30 and 60 kg P_2O_5, 30 kg K_2O and 15 tones FYM ha^{-1} for 9years did not affect EC of soil.

Bhriguvanshi (1988) reported that the long- term affect of high dose of FYM on soil and revealed that in clay loam soils use of FYM tends to increase the EC in surface soil. Electrical conductivity increased from 0.18 to 0.36 dSm-1 in sandy loam and from 0.20 to 0.40 dSm-1 in clay loam soils.

Ridder de and Keulen Van (1990) reported that application of organic material such as green manures, crop residues, compost or animal manure can counteract the negative effects of mineral fertilizers in soils.

Raghuwanshi *et al*. (1992) collected two brown and one black soil of Jabalpur and conducted a study on various physical and chemical properties and reported that brown soil were slightly acidic (pH 5.6-6.6) while the black soil was neutral (pH 7).

Felter *et al.* (1992) described that soil organic carbon get increase with the clay and silt contents but there was a poor relationship with the amount of rainfall.

Tembhare *et al.* (1998) revealed that even after continuum cropping and fertilizer application to Typic Haplustert for 24 years periods the soil pH and the salt concentrations (EC) remained unaffected.

Aggrawal and Nayyar (1998) collected the soil samples from varying depths from 22 fields of Punjab agriculture University Ludhiana to analysis of the trend of EC. In 6 profiles, they observed that EC varied from 0.15 to 0.29 dSm^{-1}. They also reported that there was depth wise decline in EC.

Sharma and Khan (2000) conducted the research on soil of Pali, Balotra and Jodhpur district of western Rajasthan and reported that physical and chemical properties of soils had declined significantly, leading to an adveffectffect on nutrient availability. The degraded soils acq red compaction; reduced filtration rate, unfavorable prismatic and cloddy struc,ture and surface sealed crusting resulting in an unsuitable environment for soil microorganisms and reduced nutrient availability. Agriculturally these lands have become either not suitable for cultivation or the production potential has been reduced to a larger extent because of high soluble salts content, harmful to plant due to moisture stress and toxicity of some of the ions.

Tamgadge *et al*. (2002) reported that organic carbon varied from 0.5-0.8 to 0.4-1.9% in Vertisols and from 0.3-0.6 to 0.4-0.9% in Inceptisols of different government research farms of Chhattisgarh state. The role of soil organic matter in maintaining soil fertility and productivity has been well recognized from time to time and it’s maintenance in the soil is of outmost concern under modern intensive farming.

Kakralya and Singh (2003) collected soil samples from nine location in the districts of Sriganganagar, Churu and Nagaur in Rajasthan and conducted a research on organic carbon content, pH, electrical conductivity (EC) and water holding capacity of soil samples. The soil pH varied between 8.41 and 8.88 and EC as high as 340.45 micro mhos/cm.

Mathur and Yadav (2006) collected50 surface soil samples of North west plain soils of Rajasthan. They concluded that soil was slight alkaline in reaction. The pH of the soils ranged from 7.2 to 8.60. Electrical conductivity varied between 0.20 to 2.60 dSm-1 and numbers of the irrigated soils in North west plain zone were defecient in organic carbon and the moderate level of calcium carbonate and CEC values.

Sharma (2010) collected soil samples randomly from 35 different places at a depth of 0- 23cm from the state of Uttar Pradesh. In this evaluation, The result described that the pH value and E.C. of soil samples ranged from6.3 from 8.9 and 0.03 to 1.30 $dSm^{-1,}$ respectively, whereas the organic carbon content varied from 0.03 to 0.95 %.

Sharma *et al.* (2010) randomly collect samples from 35 locations(0-23 cm) representing different locations of Uttar Pradesh and described that the pH value, EC and organic carbon varied between 6.3 to 8.9; 0.03 to 1.30 dSm-1 and 0.03 to 0.95%, respectively.

Kumar and Babel (2011) evaluated surface soil samples of district Jhunjhunu of Rajasthan. The soil samples were collected from wheat-growing areas at a depth of 0-30 cm. The result revealed that the pH and E.C. of soil samples varies between 8.10 to 9.20 and 0.20 to 2.14 dSm^{-1} stated that soils were medium alkaline and non-saline.

Jayaprakash *et al.* (2012) collected100 soil samples from areca nut gardens of different talukas at a depth of 0-20 cm, evaluated the status of macronutrients. The result described that the pH of the soil samples varied from neutral to alkaline, and electrical conductivity was less due to the leaching of soluble salts by irrigation water and high rainfall.

Bhuyan *et al.* (2013) conducted a research at East Siang district in Arunachal Pradesh on Soil nutrients level in prominent agro-ecosystems. They describe that the soil samples collected were acidic and ranged between 4.75 to 6.23, and the organic carbon content of soil ranged between 0.59% and 2.38%.

Ram *et al.* (2013) reported that the pH of the soil samples varied between 8.45 and 8.38, electrical conductivity from 0.26 and 0.24 dSm^{-1} and organic carbon content varied between 0.43 and 0.41%.

Mandal *et al.* (2013) collected 80 composite samples of soil from two village group of Vikasnagar community development block in district Dehradun of Uttarakhand. After analysis, it was found that the pH of the soil samples varied from 6.1 to 6.7 and organic carbon (O.C.) content varied from 7.1 to 23.1 g/kg.

Arun Kumar *et al.* (2016) collected soil samples at a depth of 0-20cmfrom Thirunavalur village of Villupuram district, Tamil Nadu and conducted a research by mapping available nutrient status by using G.I.S. In this eevaluation soil samples, and G.P.S put down exact locations of soil samples. Map 76CSx instrument. The result stated that the pH of the soil samples varies from 7.01 to 9.56, indicating that pH was neutral to strongly alkaline in reaction, whereas the E.C. ranged from 0.17 to 1.65 dSm^{-1}. The O.C. content of the soil samples varies from 2.6 to 7 g kg^{-1}.

Singh *et al.* (2016) collected 38 surface soil samples at a depth of 0-15cm of Arajiline Block, Varanasi district, U.P. and evaluated them for various physio-chemical properties. The result stated that the bulk density of soil samples varied between 1.35 to 1.42 Mg $m^{-3,}$ whereas particle density and porosity of soil samples varied between 2.24 to 2.39 Mg m^{-3} and 36.1 to 54.0%, respectively.

Dutta *et al.* (2017) studied on the alluvium-derived soils of the Jorhat district of Assam for the characterization of the soil affected by different land uses. Four representative soil profiles collected from a different field, i.e. rice, tea plantation, vegetable growing area and natural forest. They evaluated that the texture varied from sandy loam to clayey. The result showed that soils were acidic in reaction (pH 4.5 to 5.5). The surface horizons of all soils were hold with a higher amount of organic carbon, i.e. 7.6 to 20.6 g kg^{-1} and shown a regular decreasing pattern with depth.

Kumar *et al.* (2017) collected soil samples from 100 different location from Gapattinam district, Tamil Nadu. The result revealed that the pH of soils was neutral to alkaline in a reaction as it varied between 6.78 -7.95 with the mean value of 7.59. The organic carbon (O.C.) and electrical conductivity (E.C.) of the soil ranged from 0.20-7.54% and 0.07- 0.62 dSm^{-1} with a mean value of 1.077% and 0.344 dSm^{-1}respectively. The organic carbon content was found very low (< 0.50%) in 64 % of the soil samples, medium in 21%, high in 15% of the soil sample.

Rajakumar *et al.* (2017) conducted a research at Belgaum district of Karnataka on soil fertility mapping by using G.I.S. in three agro-climatic zones. The soil samples were delineated at 300 m grid intervals from three micro-watersheds, and maps were developed using Arc G.I.S. v 10.0. The result describe that the soils of zone-3 were alkaline in reaction (pH> 8.5), soils of zone-8 were slightly alkaline (7.0-8.5), and soil of zone-9 was slightly acidic (5.5-6.5), whereas organic carbon content in soils of both the zone-3 and 8 were high (6.9 g kg-1).

Chandrakala *et al.* (2018) studied on soil fertility evaluation under different land-use systems in the humid tropical regions of Kerala. The results exhibit that the pH of soils in Elamdesam block varied from 4.06 to 6.48. Out of total soil samples, 57.42% soil samples were very strongly acidic, followed by extremely acidic 18.06% and strongly acidic 18.06%.

Shanmuganthani and Rajendran (2018) collected surface soil samples from fifteen different locations& conducted a research at the Thiruvarur district of Tamil Nadu., one sample from each location using a spade. They reported that the bulk density of soil samples varies from 1.13-1.30 g cm^{-3}. The pH of soil samples varies from 6.3 – 8.3, which disclose that they were a little acidic to moderately alkaline, whereas the water holding capacity of soil samples varies from 42.34 to 52.18 %.

Priyanaka *et al.* (2018) conducted a research by assembling sixty soil samples from 30 villages, two samples from per village, and evaluate various physio-chemical properties. Analysed that nutrient content of soil under Inceptisols from Washitahsil of Osmanabad district, Maharashtra. The result revealed that the bulk and particle density of soil samples varies from 1.13 to 1.86 Mg m^{-3} and 2.03 to 2.96 Mg $m^{-3,}$ respectively, whereas the pore % of soil samples varies between 20 to 56%.

Kharal *et al.* (2018) collected soil samples from five different land-use systems: Grassland, forest land, upland, lowland, and vegetable field at a depth of 0-15 cm. and studied on soil fertility evaluation under different land-use systems in the Dhading district of Nepal reported that the highest (3.55%) amount of soil organic matter was found in forest soil and the lowest (1.26%) in the upland field soil. The lowland and upland field had a less quantity of soil O.M. (1.61%), while vegetable field and grazing land had a medium soil organic matter content, i.e. 2.49% and 2.61%, apart.

Malla *et al.* (2020) randomly collected131 geo-referenced combined soil samples from a depth of 0-20 conducted a research on soil fertility mapping and assessing the spatial distribution of Sarlahi district, Nepal. The conclusion described that the pH of soil samples varies between 3.9 to 7.5 with a mean of 5.the organic matter content varies between0.48 to 5.7%

2.2 Primary Macro-nutrients in soil

Ghosh and Hasan (1980) revealed that acidic red and lateritic soils are found in the content of low organic carbon and available nitrogen and expect Kerala and some pockets of Bihar, Orissa, and Karnataka where available nitrogen status of entire North Eastern region is high in status as compared to other states in the country.

Sharma (1992) analyzed the subsoil layers in FYM and crop residues treated plots. And founded their helpful effects on soil physicochemical and microbiological properties.

Sharma and Gupta (1993) reported that the maximum content of available N was founded in surface layer after harvest of soybean with incorporation of FYM in combination with inorganic fertilizers as contrast to control plots in after five successive year of experiment.

Padmaja *et al*. (1993) studied on soils of Nalgonda and Mahaboobnagar district in the Telangana region of Andhra Pradesh and observed that the available nitrogen content of these soil varied from 21 to 178 kg ha-1. Highest available N content was observed in surface horizons and lowest in lower horizons, thus available N content decreased with increasing depth.

Moslehuddin *et al*. (1997) reported that almost all uplands soils were low in organic matter and deficient in N. Availability of P to the crops was a problem mostly in calcareous soils of ganges floods plain and acidic soils of terrace and hilly regions. Status of K was not a great problem in floods plain areas, but terrace soils were not capable of supplying enough K to the crop.

Walia *et al*. (1998) founded that the available N of the soil accounted for 12 to 42 percent of the total Nitrogen in the range of 95 to 159 mg N kg -1 sol in the surface and 51 to 159 mg N kg-1 soil in subsurface horizons.

Akbari *et al.* (2003) collected107 red loam soil samples (84 and 23 from Udaipur and Chittorgarh district, respectively) of Mewar region of Rajasthan conducted a research and revealed that medium to high in available phosphorus (13.44 to 132.96 kg P2O5/ha) and moderate to high in available potassium content (104.08 to 953.68 kg K2O/ha).

Shankaraiah *et al.* (2006) evaluated the status and distribution of sulphur in black soils of Karimnagar district, Andhra Pradesh.They observed that the available nitrogen content was low and ranged from 137.98 to 217.2 kg ha^{-1}, the phosphorus avaiblity of soils was medium to high ranged from 4.6 to 60.0 kg ha^{-1} and potassium content ranged between 185.2 to 360.0 kg ha−1. The total sulphur accounts of black soils (Vertisols) varied between 117.0 to 406.0 ppm.

Meena *et al*. (2010) reported that the available nitrogen was highest in soils of ERU followed by PB and MP and it might be partly due to management Practices also. The available nitrogen was high in the surface and decreased with depth. This could be attributed to organic carbon which has a high correlation with available nitrogen. Available P was the highest in soils of ERU followed by MP and PB. Available P was highest in surface and it decreased with depth.

Sharma *et al*. (2010) observed that available nitrogen ranges from 78.0 to 472.5 kg ha-1 with a mean value of 208.0 kg ha-1. Thus, the most of the soils were observed low in available nitrogen. The soils of the central and eastern part of Uttar Pradesh was deficient in available phosphorus, while medium in the western part of Uttar Pradesh, and thus varied between 2.18 to 77.77 kg ha-1. The most of the soils were although moderate in available potash.

Ganorkar and Chinchmalatpure (2013) collected five soil samples randomly from five field at 0 to 15 cm and 15 to 30 cm depths and studied physico-chemical properties of soils of Warud Tahsil of District Amravati, Maharashtra.. The result reveled that available nitrogen content varied between 219- 298 kg ha^{-1}. Sample PGC-2 was high in nitrogen content compared to PGC-1, PGC-3, PGC-4, PGC-5, PGC-6. The phosphorous content in the samples varied between 18.5- 25 kg/hectare. PGC-4 and PGC-6 samples were having low phosphorous content in contrast to sample PGC-2, PGC-3 and PGC-5.

Kumar *et al.* (20013) conducted the reserch on soil fertility status of th**e** Faridkot district of Punjab and observed that 48%, 30%, 18% and 4% samples ranged from low, medium, high and very high in available P content. Most of the villages were low in O.C., low to medium in terms of available P and high in the available K**.**

Kumar *et al.* (2017) collected soil sample from 84 villages at a depth of 0-15 cm depth from rice-chickpea growing areas comprising Bodala, Kawardha, Pandariya and Sahaspur LoharaTaluka of the Chhattisgarh plain regions. The result revealed that the available nitrogen content in soil samples varied between 76 to 322 kg ha^{-1}, phosphorus content ranges between 2.1 to 44.5 kg $ha^{-1,}$ and the potassium content ranged between 120 to 821 kg $ha^{-1.}$

Chandrakala *et al.* (2018) revealed that phosphorus content in soil samples varied between 0.54 to 226.6 mg kg-1. Among the soil samples collected, 27.74% of soils fall under less, 23.23% was medium in class, and only 15% samples were found high in available P. Potassium content in soil samples 11.35 to 494.28 kg ha^{-1}. Among the samples studied, 33.55% were under medium, and 30.32 were in the very low and low category in potassium content.

Lohiya *et al.* (2018) collected soils of Golpura village in district Dhar, Madhya Pradesh. They described that the soils were low in available nitrogen content, ranges between 145 to 263 kg ha^{-1}, low to medium in available phosphorus (7.6 to 28.95 kg ha^{-1}), and medium to high potassium(215 to 391 kg ha^{-1}).

Dameshwar *et al.* (2018) collected the soil samples from arid, irrigated and rainfed areas at a depth of 15-20 cm across a Kasdol block in Matya village, Chattisgarh and observed that the available nitrogen in soil ranged from 99.47- 281.4 kg ha^{-1}, phosphorus content ranged between 4.75 – 18.5 kg ha$^{-1,}$ and potassium content in soil samples varied between 145.0-585.5 kg ha^{-1}.

2.3 Status of Secondary macro-nutrients in soil

Kumar *et al.* (2011) collected soil sample from 126 villages at a depth of 0-15 cm from Janjgir-Champa district in Chhattisgarh and conducted a Correlation studies on available sulphur and soil effects in soils of Dabhra block under. It is concluded that the sulphur content in soil samples varied from 7.28 to 89.6 kg ha^{-1} with an average of 35.02 kg ha^{-1}. The correlation study between available S and the soil effects found a significant negative correlation with the pH and a significant positive correlation with organic carbon.

Patil *et al.* (2016) collected sixty soil samples from 30 villages research on thenutrient content of soil under Inceptisols from Washitahsil of Osmanabad district,Maharashtra. The result revealed that exchangeable Ca++ and exchangeable Mg++ content ranged from 17 to 58 cmol (P+) kg^{-1} and 2 to 28 cmol (P+) kg$^{-1,}$ respectively, and available S varied between 3.95 to 50.70 mg kg^{-1}

Singh *et al.* (2017) examined physico-chemical properties of the soil of Lahar block in Bhind district, Madhya Pradesh. The results concluded that the calcium availablity in the soil samples varied between 4.50-9.05 mg/kg, magnesium content varied between 2.73-6.99 mg/kg, whereas sulphur content of the soil samples ranged between16.58-26.68 mg/kg.

Priyadarshini *et al.* (2017) collected the soil samples from the three particular villages, namely, Banahara, Pikola and Barada, at a depth of 0-15cm of Salepur block of Cuttack district and results reveled that the pH of soil samples varied between 5.13 and 6.63, and the sulphur content in soil samples varied from 1.74 to 8.61 mg kg^{-1}.

Gothwal and Kumar (2019) collected soil sample at a depth of 15-20cm from three different zones - mountainous, populated and deserted zone.evaluated Nakki Lake in Mount Abu, Rajasthan on physico-Chemical study of Soil during Summer months in Lentic Fresh Water Ecosystem. The result revealed that the magnesium content of the soil sample from the populated zone was 158 mg L^{-1}, from the mountainous zone was 150 mg L^{-1}.

Subbaiah and Rajasri (2020) collected 105 soil samples (0-25 cm depth) from different mandals of District Krishna in Andhra Pradeshand edvaluted for various chemical properties. The result revealed that the available Sulphur in soil samples ranged between 33.45 to 64.75 mg kg^{-1}

2.4 Status of Micronutrients

Sidhu and Sharma (2010) reported that in Trans Gangetic plains, Zn varied between 0.11to 5.08, Cu lies between 0.22 to 4.72, Mn varied from 2.9 to 101.2, and Fe varied from 1.05 to 97.9 mg kg^{-1}. In the Upper Gangetic Plains, the DTPA extractable Zn varied between 0.04to 2.53 Cu lies from 0.06 to 4.32, Mn varied from 11.1 to 421.0, and Fe lies between 3.48 to 90.2 mg

Satish and Kumar (2013) collected 90 soil samples from the cultivator's plot. Conducted a research on the fertility levels in Bt cotton-growing soil of district Kurnool, Andhra Pradesh. Results derscribed that the average values of DTPA extractable Fe, Mn, Zn, Cu, in Bt cotton Inceptisols were 6.79, 5.27, 1.35 and 0.72 mg kg-1, apart, while grown in Alfisols were 7.11, 6.79, 1.42 and 0.78 mg kg-1, and in the Vertisolswere 6.98, 5.37, 1.43 and 0.69 mg kg-1, respectively. It was found that all micronutrients were in their specific limit.

Prabhavati *et al.* (2015) collected soil samples from three micro-watersheds constitute the northern dry zone (zone-3), The result revealed that DTPA extractable Fe and Zn was deficient, and Cu and Mn were appropriate in soils of zone-3 and zone-8. However, In zone-9 contained S and Zn were found barely sufficient, whereas mn, Fe and cu were clearly in adequate quantity.

Patil *et al.* (2016) reported that Fe, Mn, Zn and Cu in soils of tehsil Panhala varied between 12.6 to 89.0, 2.2 to 104, 0.2 to 6.2 and 4.4 to 25.8 mg kg^{-1}, respectively. The majority of soils were abundent in available Fe, Mn and Cu, and most of them were deficient in available Zn.

Bulta *et al.* (2016) reported that the extracted Fe ranged from 50.04 to 209.72 mg/kg, 46.84 to 412.23 mg/kg and 60.08 to 240 mg/kg in Kedida Gamela, Damboya and Kecha Bira districts soils, subsquently. In comprision, Zn varied between 1.3 to 28 mg/kg, 1.0 to 39 mg/kg and 0.9 to 47 mg/kg for Kedida Gamela, Damboya and Kecha Bira districts, consequently

Kumar *et al.* (2017) collected soil samples from 100 different locations of the talukasat Sirkalitaluka, Nagapattinam district, Tamilnadu. The result revealed that the DTPA extractable Cu contents in the soil samples varied between 0.32- 1.52 mg kg^{-1}.

Lohiya *et al.* (2018) evaluated that the soils of Golpura village in district Dhar in Madhya Pradesh. Founded that the soils are high level in DTPA-extractable Cu, medium level in Fe content whereas, Zn and Mn were found low.

Malla *et al.* (2020) collected geo-referenced combined soil samples from a depth of 0-20 cm from the 25 Village Development Committees (VDC).analyzedsoil fertility and spatial distribution of Sarlahi district, Nepal.The result showed that Zn content in soil samples varied between 0.09 to 0.27 mg/kg with a mean value of 0.15 mg/kg.

Chapter III

MATERIAL AND METHODS

This chapter deals with the materials used and methods employed during the investigation to evaluate the ***"Appraisal of available macro and micro nutrient in soil Of Nisija Kaimur by using G.P.S. and G.I.S. system"***. The experimental area's field survey, collection of samples, analysis, and technique followed during research are presented in the following sections and sub-sections.

Description of Site

3.1 Location & Geography

Nisija is a village located in eastern pKumarf Kaimur district of Bihar India. This village is in the eastern part of Jalalpur Panchayat of Rampur development block. It is located at 240 57 ° North and 850 51 East longitude. This village is 30 km north from famous Guptadham cave and 22 km west from Sasaram.

Fig. 3.1: Spatial map of village Nisija

The total area of this village is 279.45 hectares. In the north of this village there is Kudari village and in the south there is Son high level canal. In the east Durgavati river originating from the zenith of Kaimur, which flows north and in the west are the villages of Rampur and Pali.It'slocation is tropical to sub-tropical i.e. 22 degrees north to 27 degrees latitude.

3.1.2 Climate and Weather

In Kaimur, the climate is warm and humid. There is significant rainfall throughout the year in Kaimur. Even the driest month still has a lot of rainfall. The Köppen-Geiger climate classification is Cfa. In kaimur, the average annual temperature is 25.6 °C | 78.2 °F. The annual rainfall is 1125 mm.

3.1.3 Soils and Agriculture

State Bihar is situated on the world's fertile alluvial plain of Gangetic Valley which extends from the foothills of the Himalayas in the north to a few miles south of the river Ganges as it flows through the State from the west to the east. Variation in relief, precipitation, vegetation, and parent rocks have resulted in various soil varieties due to the region relief features. The foothills of Kaimur consist of alluvial soil and are naturally fertile. But the soil becomes harder as one proceeds southwards. As one moves up the foothills, the soil becomes stony and poor in fertility. The Kaimur plateau is an undulating tableland having thin shrub jungles and the land is not very fertile. The soils of kaimur is **Balthar** and have properties of Sandy, calcareous, yellow. This type of soil is found between North Ganga plain and Southern plateau and it formed due to the alluvium deposited by **Sone, Punpun, and Falgu Rivers.** It is found in **Kaimur plateau to Rajmahal hills.**

Balthar Soil is less fertile and has less water absorption capacity. **maize, jowar, bajra, and gram** are chief crops in past days. But now a days with the good Irrigation facility, modern techniques and various Integrated methods are increasing the crop choices among the farmers of this District as well as the farmers of this village. In recent days farmers are easily following the various pattern like that wheat-rice, rice-moong, rice-mustard, rice- chickpea etc.

Table 3.1: Climate data of Kaimur district

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	16.2 °C (61.1) °F	20.1 °C (68.1) °F	25.8 °C (78.4) °F	31.4 °C (88.6) °F	33.5 °C (92.3) °F	32.3 °C (90.1) °F	28.7 °C (83.6) °F	28 °C (82.5) °F	27.4 °C (81.3) °F	25.3 °C (77.5) °F	21.6 °C (71) °F	17.5 °C (63.5) °F
Min. Temperature °C (°F)	10.2 °C (50.3) °F	13.5 °C (56.2) °F	18.2 °C (64.8) °F	23.5 °C (74.3) °F	26.7 °C (80) °F	27.8 °C (82.1) °F	26.2 °C (79.1) °F	25.6 °C (78.1) °F	24.7 °C (76.4) °F	20.7 °C (69.3) °F	15.8 °C (60.4) °F	11.5 °C (52.7) °F
Max. Temperature °C (°F)	22.3 °C (72.2) °F	26.6 °C (79.9) °F	32.9 °C (91.2) °F	38.6 °C (101.5) °F	39.7 °C (103.5) °F	36.9 °C (98.5) °F	31.8 °C (89.3) °F	31.3 °C (88.3) °F	30.8 °C (87.5) °F	30 °C (86.1) °F	27.5 °C (81.5) °F	23.7 °C (74.6) °F
Precipitation/ Rainfall mm (in)	18 (0.7)	25 (1)	12 (0.5)	8 (0.3)	15 (0.6)	158 (6.2)	337 (13.3)	276 (10.9)	209 (8.2)	50 (2)	8 (0.3)	9 (0.4)
Humidity (%)	63%	55%	38%	27%	37%	54%	79%	83%	83%	72%	60%	62%
Rainy days (d)	2	2	2	2	3	10	19	19	15	4	1	1

3.1.4 Experimental sites

50 representative surface soil samples collected from the farmer's field from Nisija village of the district: Kaimur of Bihar state.

3.2 Method of sampling and processing

3.2.1 Collection of soil samples

The soil samples were collected randomly from different sites of village to a depth of 0-15 cm by making a V-shape notch with khurpi. Collected samples were mixed thoroughly, and about 500 gram of composite samples were drawn from each site. The village geographical area is 279.45 ha., and the cultivated area is about 175 ha. The geographical locations of sampling sites are given in Appendix – 1.

3.2.2 Processing of soil samples

Collected surface soil samples were air-dried in the shade at room temperature and later brought to the laboratory. The air-dried samples were crushed and grounded with a wooden roller and sieved using a 2.0 mm sieve. Finally, processed samples were kept in a labelled polythene bag and analysed in the laboratory for further analysis.

3.3 Chemical analysis of soil samples

The collected soil samples were analysed for various chemical parameters in the laboratory.

3.3.1 Electrical conductivity

The soluble salt concentration was measured by using a conductivity meter illustrated by Jackson 1973. Soil water suspension in the ratio of 1:2.5 was prepared by taking 10g soil and 25ml distilled water in a 50 ml beaker, and the reading was taken by using a conductivity meter.

3.3.2 Organic Carbon

Organic carbon was estimated by Walkey and Black (1934) method of wet oxidation. 1 gram of soil sample was taken in a 500 ml conical flask, and 10ml of potassium dichromate solution was added, followed by 20ml of concentrated sulphuric acid. The content was swirled for one minute and kept for 30 minutes for completion of the redox reaction. Then 200 ml distilled water was added with 0.2g of sodium fluoride and 1ml of diphenylamine indicator. The solution was then titrated against ferrous ammonium sulphate until the colour changes from violet to green.

$$\%\text{Organic carbon } = \frac{\text{B} - \text{T} \times 0.003 \times 100}{2 \times \text{wt of soil}}$$

% organic matter = organic carbon × 1.724 (Van Bemmelen factor)

Where, B = Volume of 0.5N FAS solution used for blank titration

T = Volume of 0.5N FAS solution used for sample titration

3.3.3 Available Nitrogen

Available Nitrogen in the soil samples was determined by the method described by Subbiah and Asija (1956) of alkaline potassium permanganate. 5 g of soil with 5 ml distilled water together transferred in a distillation tube. 25 ml of 0.32% KMnO4 was added to the distillation tube, and a semi-auto analyzer instrument was set up. 20 ml of 2% boric acid containing mixed indicator was taken in a 250 ml conical flask and placed under the receiver tube, and the tube was dipped in boric acid. Tap water was run through the condenser. 25 ml of 2.5% NaOH solution was added and sucked into the distillation tube. The distillation process was set up for 15 minutes. During this process, the liberated ammonia is condensed and absorbed in boric acid, which produces green colour and then it was titrated against 0.02 N H_2SO_4 until pink colour appeared.

$$\text{Available N (kg ha}^{-1}) = \frac{(\text{S} - \text{B}) \times 0.02 \times 14 \times 2.24 \times 106}{1000 \times 5}$$

Where, S = Sample titration reading

B = Blank titration reading

3.3.4 Available Phosphorus

The available Phosphorus in soil samples was determined by Olsen's method for neutral and alkaline soil using 0.5M $NaHCO^3$ (pH 8.5). Firstly, reagent A and reagent B were prepared. In 150 ml of a conical flask, 2g of soil was taken, and a half spatula of Darco G-60 and 40 ml of Olsen's reagent were added. Then on a mechanical shaker, it was shaken for 30 minutes and then filtered by Whatman No. 1 filter paper. 10 ml of filtrate was taken in 25 ml of the volumetric flask, and 2-3 drops of p-Nitro phenol indicator were added; after that, 5N H2SO4 was added dropwise the yellow colour disappeared. 8ml of the ascorbic acid solution was added to the flask, making up 25 ml with distilled water. After 10 minutes, the blue colour appeared, and the reading was observed in a spectrophotometer at 730 nm. A blank was also carried out. The standard curve was also prepared using a standard solution of 0, 1, 2, 3, 4 and 5 ppm.

$$\text{Available Phosphorus (kg ha}^{-1}\text{)} = \frac{\text{R} \times \text{Volume of extract} \times 2.24 \times 10^{6}}{\text{The volume of aliquot} \times \text{wt. (g) of soil}}$$

Where, R = µg P in the aliquot (obtained from the standard curve)

3.3.5 Available Potassium

Available potassium in soil samples was measured on a Flame photometer (Schollenberger and Simon, 1945), and the soil samples were extracted using neutral normal ammonium acetate. A 100 ml conical flask 5g soil sample and 25 ml of 1N neutral ammonium acetate was shaken on a mechanical shaker for 5 minutes. The suspension was then filtered immediately by using Whatman No. 1 filter paper. The concentration of potassium in the filtrate was measured on a flame photometer. A Standard of 0, 20 and 40 ppm were prepared from 1000ppm of KCl solution. First, the standard reading was taken, followed by a sample reading.

Dilution factor = 25/5 = 5 times

Reading of the flame photometer for the test sample = C

Available Potassium (kg ha^{-1}) = C × 5 × 2.24

3.3.6 Exchangeable Calcium

Exchangeable calcium in soil samples was done by Jackson's 1973 method of neutral ammonium acetate. 5g of soil along with 25ml extractant was taken in a 100 ml conical flask and shaken on a mechanical shaker for 5 minutes. The content was then filtered immediately with the help of filter paper. 5ml of the filtrate was taken in a 150ml conical flask. Then 5 drops of 4N sodium hydroxide buffer solution and a pinch of muroxide indicator was added to the sample and titrated against 0.01N EDTA solution. The colour changed from orange to red to purple, and the reading of the burette was noted down.

$$\text{Amount of Ca (Meq L}^{-1}) = \frac{\text{R} \times \text{Normality of EDTA} \times 100}{\text{Aliquot (ml)taken}}$$

$$\text{Amount of Ca (Meq/100g)} = \frac{100}{\text{Soil weight (g)}} \times \frac{\text{Extract volume(ml)}}{100} \times \text{Ca (Meq L}^{-1})$$

Where, R = Volume (ml) of standard EDTA used in titration

3.3.8 Exchangeable (calcium + Magnesium)

Exchangeable Calcium + Magnesium of soil samples was done by neutral normal ammonium acetate solution described by Jackson (1973). A 5g soil sample was taken in a 100ml conical flask, and 25 ml of extractant was added. The content was shaken for 5 minutes in a mechanical shaker and filtered with Whatman No.1 filter paper immediately. Then 5 ml of aliquot was pipetted out in a 150ml conical flask and diluted with 25 ml of distilled water.0.5 ml of ammonium chloride-ammonium hydroxide with 4 drops of Eriochrome Black T indicator was added to the sample. The sample was then titrated against 0.01N EDTA till the colour changed from wine red to blue.Exchangeable calcium and Magnesium was calculated by using the following:-

$$\text{Amount of Ca} + \text{Mg (Meq L}^{-1}) = \frac{\text{R} \times \text{Normality of EDTA} \times 1000}{\text{Aliquot (ml) taken}}$$

$$\text{Amount of Ca + Mg (Meq/100g)} = \frac{100}{soil\ weight(g)} \times \frac{extract\ volume(ml)}{100} \times \text{Ca in Meq L}^{-1}$$

$$\text{Amount of Mg (Meq L}^{-1}) = \text{Ca + Mg (Meq L}^{-1}) - \text{Ca (Meq L}^{-1})$$

Where, R = Volume (ml) of standard EDTA used in titration

3.3.9 Available Sulphur

For extraction of sulphur, 0.15% calcium chloride solution was used. The aliquot was prepared from the extract, and barium chloride and gum acacia solution were added. Turbidity produced by barium sulphate was measured on a spectrophotometer at 340 nm, and the readings were noted. Standards of 0.25, 0.5, 1.0, 2.5 and 5.0 were also prepared from 100ppm A.R. grade K2SO4.

Available sulphur (kg ha-1) = A × B × C × 2.24 ÷ D × E

Where, A = S (mg L^{-1}) in aliquot

B = Final volume of turbid solution (mL)

C = Volume of soil extractant used for extraction (mL)

E = Air dry soil weight (g)

3.3.10 Available micronutrient

Cationic micronutrient zinc, iron, copper and manganese and heavy metals like cadmium, chromium, nickel and lead in the soil samples were measured on atomic absorption spectrophotometer. Extractant used were 0.005 M DTPA

(Diethylene Triamine Penta Acetic Acid), 0.01M calcium chloride dehydrate, and 0.1M triethanolamine buffered pH 7.3 (Lindsay and Norvell, 1978). Ina 100 ml conical flask, 10 g of soil sample was taken and added to that 20 ml DTPA solution. The contents were shaken on a mechanical shaker for 2 hours and filtered through Whatman no. 42 filter paper. The concentration of micronutrients and heavy metals were then analyzed on A.A.S.

3.4 Physical analysis of soil sample

3.4.1 Bulk density

The soil sample's Bulk density was measured using a pycnometer measured by the Black method (1965). The clean and dry pycnometer was taken and weighed over a weighing balance. The soil sample was filled with the help of a spatula up to the brim of the pycnometer. The pycnometer and soil weight were recorded, and after that, the soil from the pycnometer was decanted. Then the empty pycnometer was then filled with water (dropwise) with the help of a burette, and the volume of the pycnometer was noted. Then the Bulk density of soil samples was calculated by using the formula given below:

$$\text{Bulk density} = \frac{\text{Mass of the soil}}{\text{Volume of the soil}}$$

3.4.2 Particle density

The particle density of the soil sample was determined by using a pycnometer described by Black, 1965. Firstly the weight of the clean and dry pycnometer was taken with the help of weighing balance. With the help of a burette, water was filled in a pycnometer and weighed. 10g of soil and 10 ml of water was added to a beaker and boiled on a hot plate to expel the air. Then the pycnometer was filled with the contents and water up to its brim and weighed along with the stopper. The particle density of soil samples was calculated by using the formula given below:

$$\text{Particle density} = \frac{10}{(\text{W2} + 10) - \text{W3}}$$

- Mass of empty, clean, dry pycnometer (g) = W1
- Mass of pycnometer + water (g) = W2
- Mass of pycnometer + water + soil (g) = W3
- Mass of soil (Ws) = 10g

3.4.3 Porosity

Porosity was calculated by using bulk density and particle density values of the soil by using the formula given below:

$$\text{Porosity (\%)} = \left[1 - \frac{\text{Bulk density}}{\text{Particle density}}\right] \times 100$$

3.4.4 Water holding capacity

The water holding capacity of the water samples was determined by Piper's method (1966) using a keen box. A round filter paper was placed inside the keen box, and the weight of the box was noted. The soil was filled inside the box by tapping 20-30 times approximately. A Petri dish containing water was taken, and a keen box and filter paper were kept in the dish for about an hour. The soil in the box absorbed the maximum amount of water. The wet soil weight was noted after removing excess water by placing the keen box on filter paper. Wet soil in the keen box was oven-dried at 105˚C for 24hrs, and the weight of oven-dried soil was noted.

$$\text{Saturation (\%)} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times 100$$

3.5 Nutrient Index

To evaluate one area's soil fertility compared to another, it was essential to obtain a sole value for each nutrient. The nutrient index approach suggested by Parker *et al.* (1951) used to calculate the nutrient supplying capacity of soil to plants. This index is used to measure soil fertility status based on the sample percentage in each of three class, i.e. low, medium and high.

Nutrient Index (N.I.) = (NL × 1 + NM × 2 + NH × 3) / NT

Where, NL = Indicates number of samples falling in the low class of nutrient status

NM = Indicates number of samples falling in medium class of nutrient status

NH = Indicates number of samples falling in the high class of nutrient status

NT = Indicates the total number of samples analyzed for a given area.

Table 3.2: Rating Chart of Nutrient Index

S.No.	**Nutrient Index**	**Value**	**Interpretation**
1	Low	<1.67	Low fertility status of the area
2	Medium	1.67-2.33	Medium fertility status of the area
3	High	>2.33	High fertility status of the area

3.9 Statistical Analysis

The statistical data, i.e. standard deviation, range, mean, correlation coefficient, and coefficient of variation for soil and water, was estimated using SPSS statistical software. Data obtained from all the observations were computed by formulas given below:

1. Standard Deviation = $\sqrt{\frac{\Sigma X^2 - \frac{\Sigma X^2}{n}}{n-1}}$

Where, Σx^2 = Sum of all samples

$(\Sigma x)^2$ = Sum of squares of all samples

n = Total number of samples

2. Coefficient of Variation = $\frac{STANDARD\ DEVIATION}{MEAN} \times 100$

3. Range = Largest value (L) – Smallest value (S)

4. Mean = $\frac{Sum\ of\ all\ samples}{Total\ number\ of\ samples}$

5. Coefficient of Correlation (Pearson) = $\frac{SS(XY)}{\sqrt{[SS(X)\ ][SS(Y)]}}$

Where, SS (XY) = Sum of the product of x and y

SS(X) = Sum of squares of x

SS(Y) = Sum of squares of y

Chapter IV

RESULTS AND DISCUSSION

The present investigation entitled **''Appraisal of available macro and micro nutrient in soil of Nisija Kaimur by using G.P.S. and G.I.S. system ''** was conducted in 2022 to determine the fertility state of Nisija's soil. The data collected during the research was statistically analysed in order to draw appropriate conclusions. This chapter presents and critically discusses the differential reactions demonstrated by adjusting experimental factors on various components.

4.1 Physical characteristics of soil

4.2 Chemical characteristics of soil

4.3 Macronutrient that is available in the soil

4.4 Secondary nutrients in the soil

4.5 Available micronutrients

4.6 Nutrient index

4.7 Nutrient spatial variability map

4.8 Relationships between physical and chemical properties of soil.

4.1 Physical characteristics of soil

Data on soil physical parameters were collected. Table 4.1 shows the results. The bulk density values of soil samples ranged from 1.1 to 1.4 Mg m-3, with a mean value of 1.20 Mg m-3. Bulk density has a standard deviation of 0.06 and a coefficient of variation of 5.04 percent.

Table 4.1: BD, P.D and porosity of soils

S.No.	Cropping Pattern	B.D (Mg/M^3)	P.D(Mg/M^3)	POROSITY%
1	Rice -Chick Pea	1.25	2.45	49.0
2	Rice -Chick Pea	1.24	2.13	41.6
3	Rice -Chick Pea	1.24	2.16	42.4
4	Rice -Chick Pea	1.15	2.09	44.9
5	Rice -Chick Pea	1.19	2.18	45.4
6	Rice -Chick Pea	1.19	2.23	46.6
7	Rice -Chick Pea	1.21	2.34	48.5
8	Rice -Chick Pea	1.24	2.13	42.0
9	Rice -Chick Pea	1.19	2.04	41.5
10	Rice -Chick Pea	1.20	2.00	40.2
11	Rice-Mustard	1.23	2.51	50.8
12	Rice-Mustard	1.26	2.16	41.8
13	Rice-Mustard	1.23	2.22	44.6
14	Rice-Mustard	1.25	2.12	41.2
15	Rice-Mustard	1.25	2.34	46.8
16	River Bank	1.23	2.27	46.0
17	River Bank	1.19	2.02	41.0
18	River Bank	1.20	2.04	41.4
19	River Bank	1.17	2.03	42.6
20	River Bank	1.14	2.07	44.8
21	Undulated	1.16	2.50	53.4
22	Undulated	1.13	2.41	53.3
23	Undulated	1.14	2.43	52.9
24	Undulated	1.15	2.23	48.3
25	Undulated	1.15	2.18	47.1
26	Rice-Pea	1.16	2.08	44.1
27	Rice-Pea	1.17	2.87	59.5

S.No.	Cropping Pattern	B.D (Mg/M^3)	P.D(Mg/M^3)	POROSITY%
28	Rice-Pea	1.17	2.05	43.2
29	Rice-Pea	1.16	2.27	48.7
30	Rice-Pea	1.17	2.13	45.2
31	Arhar-Urd	1.14	2.18	47.5
32	Arhar-Urd	1.15	2.17	47.2
33	Arhar-Urd	1.27	2.61	51.4
34	Arhar-Urd	1.21	2.21	45.4
35	Arhar-Urd	1.25	2.91	56.9
36	Arhar-Urd	1.37	2.56	46.5
37	Arhar-Urd	1.26	2.72	53.7
38	Arhar-Urd	1.30	2.56	49.2
39	Arhar-Urd	1.12	2.17	48.2
40	Arhar-Urd	1.28	2.58	50.4
41	Rice-Wheat	1.11	1.94	42.5
42	Rice-Wheat	1.24	2.29	45.9
43	Rice-Wheat	1.15	1.95	41.0
44	Rice-Wheat	1.13	1.97	42.7
45	Rice-Wheat	1.14	1.98	42.4
46	Rice-Wheat	1.22	2.37	48.5
47	Rice-Wheat	1.18	2.43	51.4
48	Rice-Wheat	1.41	2.52	44.0
49	Rice-Wheat	1.18	2.34	49.6
50	Rice-Wheat	1.23	2.15	42.8
	Mean	1.20	2.27	46.5
	Range	1.1-1.4	1.94-2.91	40.2-59.5
	S.D.	0.06	0.23	4.44
	C.V. %	5.04	10.30	9.53

Table 4.1.1: Mean, range, standard deviation and covariance of physico-chemical properties of soils

Soil parameter	Mean	Range	S.D±	C.V (%)
Bulk density (Mg/m$^{3)}$	1.20	1.1-1.4	0.06	5.04
Particle density (Mg/m^3)	2.27	1.94-2.91	0.23	10.30
Water holding capacity (%)	40.71	29.8-51.7	5.20	12.77
Porosity (%)	46.53	40.2-59.5	4.44	9.53
pH	7.80	6.8-9.1	0.40	5.09
EC(dSm^{-1})	0.23	0.1-1.0	0.17	71.73
Organic carbon (%)	0.44	0.3-0.5	0.03	7.65

Because of the modest organic carbon content, the R-W cropping pattern had the lowest bulk density (0.54 percent). Because of the low organic carbon content (0.42 percent) and the compacted soil caused by heavy cropping, the R-W cropping pattern had the maximum bulk density (R-W). As a result of the research, it was discovered that bulk density is influenced by organic matter content and is inversely connected with it. Lego and Buraka (2019) came up with similar results.

The particle density ranged from 1.94 to 2.91 Mg m^{-3} on average, with an average of 2.27 Mg m^{-3}. The rice-chick pea pattern has the maximum particle density, while rice-wheat had the lowest.

Porosity ranged from 40.20 percent to 59.5 percent, with a mean of 46.53 percent. Rice-mustard cropping pattern has the lowest porosity, while rice-pea cropping pattern has the highest porosity. The porosity of a soil is nearly entirely determined by its organic matter content and texture. Rice-mustard had the lowest porosity because of its high bulk density of 1.26 Mg m^{-3}, whereas rice-pea had the maximum porosity because of its low bulk density of 1.17 Mg m^{-3}

4.2 Chemical characteristics of soil

Table 4.1 contains information on soil chemical characteristics, which is illustrated in Figure 1. (Fig no. 4.1 to 4.6.) pH levels ranged from 6.8 to 9.1 on average, with an average of 7.80. Rice-chickpea had the lowest pH level. In contrast, the greatest pH was found in a river bank sample, with an SD of 0.40 and a CV of 5.09 percent (Table-4.1.1) and is represented in (Fig.-4.1 &4.4). The pH of the sampled area of the Nisija's agricultural lands is generally slightly alkaline in reaction (42%) and moderately alkaline in reaction (20%). The remaining 16% of soils are neutral. The soils ranged from neutral to strongly alkaline, which could be attributable to the production of sodium and potassium carbonates. In the presence of water, alumino-silicate minerals carbonate (Through rainfall). Singh *et al.* found similar results as well (2018).

The average EC of soil samples was 0.23 dSm^{-1}, with a range of 0.1 to 1.0 dSm^{-1}. The rice-chickpea had the lowest EC value, while the rice-mustard cropping scheme had the highest. The SD and CV of soil EC were 0.17 and 71.73 percent, respectively, as shown in table 4.1.1. (Fig.-4.2&4.5). The results revealed that 100% of the samples fell inside the allowed limit, making them suitable for any crop. The electrical conductivity of soil is a measurement of the number of ions in the solution.

Organic carbon concentration in soil samples ranged from 0.3 to 0.5 percent, with an average of 0.3 percent. The coefficient of variation for organic carbon was 7.65 percent, and the standard deviation was 0.03, as shown in table (4.1.1). (Fig.-4.3&4.6). The rice-wheat farming pattern had the lowest organic carbon value, whereas the arhar-urd cropping pattern had the highest. The results showed that 100 percent of the soil samples had low organic carbon content. Due to intensive cropping patterns achieved by current mechanisation techniques and the use of chemical fertilisers for plant nutrition, all of the samples have low organic carbon content, reducing the build up of organic matter in the soil.

Table 4.2: pH, EC and O.C of soils

S.No.	Cropping Pattern	pH	Ec (dsm^{-1})	O.C (%)
1	Rice -Chick Pea	7.7	0.4	0.47
2	Rice -Chick Pea	8.2	0.2	0.48
3	Rice -Chick Pea	7.7	0.2	0.38
4	Rice -Chick Pea	7.8	0.3	0.39
5	Rice -Chick Pea	7.2	0.3	0.42
6	Rice -Chick Pea	7.7	0.3	0.38
7	Rice -Chick Pea	6.8	0.2	0.43
8	Rice -Cheak Pea	8.3	0.2	0.45
9	Rice -Cheak Pea	7.1	0.2	0.47
10	Rice -Cheak Pea	8.3	0.2	0.45
11	Rice-Mustard	8.1	0.1	0.47
12	Rice-Mustard	7.1	0.1	0.45
13	Rice-Mustard	7.7	0.2	0.47
14	Rice-Mustard	8.1	0.9	0.45
15	Rice-Mustard	7.6	1.0	0.48
16	River Bank	8.1	0.1	0.40
17	River Bank	7.8	0.1	0.45
18	River Bank	7.9	0.1	0.46
19	River Bank	7.9	0.1	0.46
20	River Bank	9.1	0.2	0.45
21	Undulated	7.3	0.2	0.47
22	Undulated	7.6	0.2	0.47
23	Undulated	8.1	0.1	0.45
24	Undulated	7.4	0.2	0.48
25	Undulated	7.2	0.2	0.47
26	Rice-Pea	7.7	0.1	0.43
27	Rice-Pea	7.8	0.2	0.39

S.No.	Cropping Pattern	pH	Ec (dsm^{-1})	O.C (%)
28	Rice-Pea	7.9	0.2	0.45
29	Rice-Pea	7.8	0.3	0.47
30	Rice-Pea	8.1	0.3	0.48
31	Arhar-	8.1	0.2	0.49
32	Arhar-Urd	8.1	0.2	0.43
33	Arhar-Urd	7.8	0.2	0.45
34	Arhar-Urd	8.1	0.2	0.46
35	Arhar-Urd	7.8	0.1	0.45
36	Arhar-Urd	8.1	0.1	0.41
37	Arhar-Urd	8.1	0.2	0.41
38	Arhar-Urd	7.9	0.2	0.43
39	Arhar-Urd	8.2	0.2	0.41
40	Arhar-Urd	8.1	0.2	0.48
41	Rice-Wheat	7.8	0.2	0.45
42	Rice-Wheat	7.6	0.2	0.47
43	Rice-Wheat	8.1	0.2	0.45
44	Rice-Wheat	7.6	0.2	0.39
45	Rice-Wheat	7.8	0.2	0.41
46	Rice-Wheat	7.4	0.2	0.48
47	Rice-Wheat	7.2	0.5	0.34
48	Rice-Wheat	7.8	0.4	0.46
49	Rice-Wheat	7.3	0.2	0.43
50	Rice-Wheat	7.8	0.3	0.38
	Mean	7.80	0.23	0.44
	Range	6.8-9.1	0.1-1.0	0.3-0.5
	S.D	0.40	0.17	0.03
	C.V%	5.09	71.73	7.65

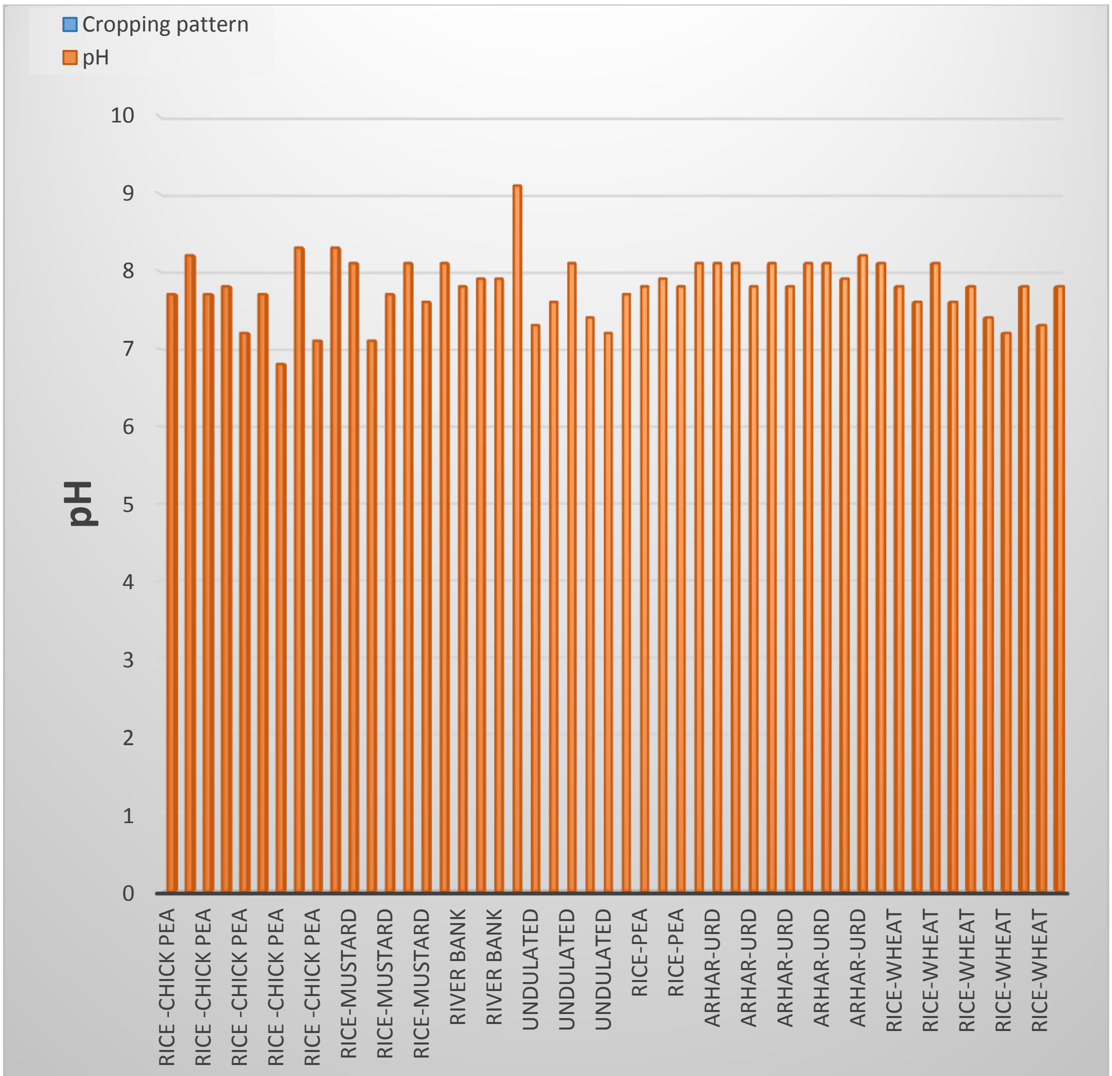

Fig. 4.1: pH of soils of village Nisija

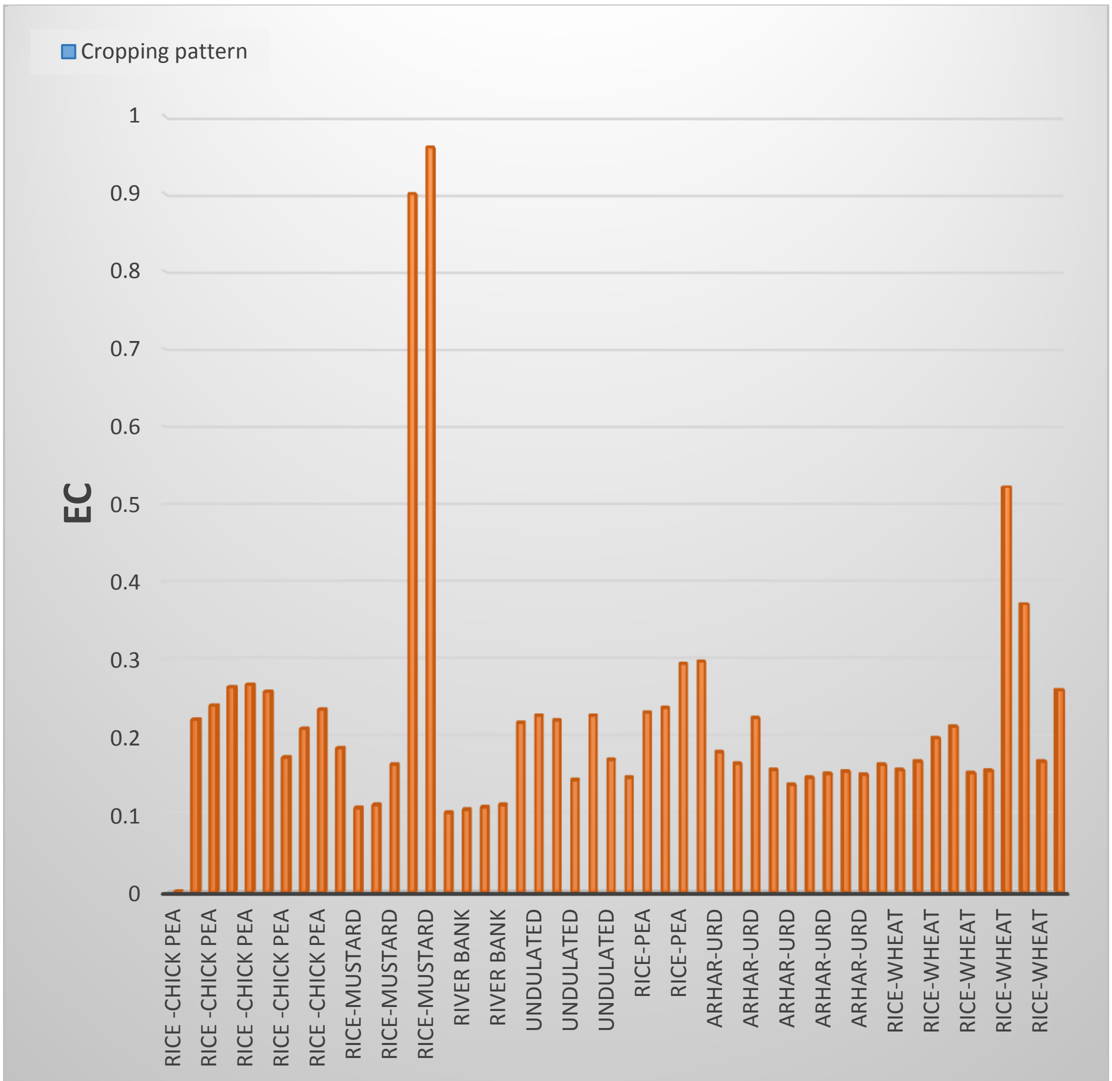

Fig. 4.2: EC of soils village Nisija

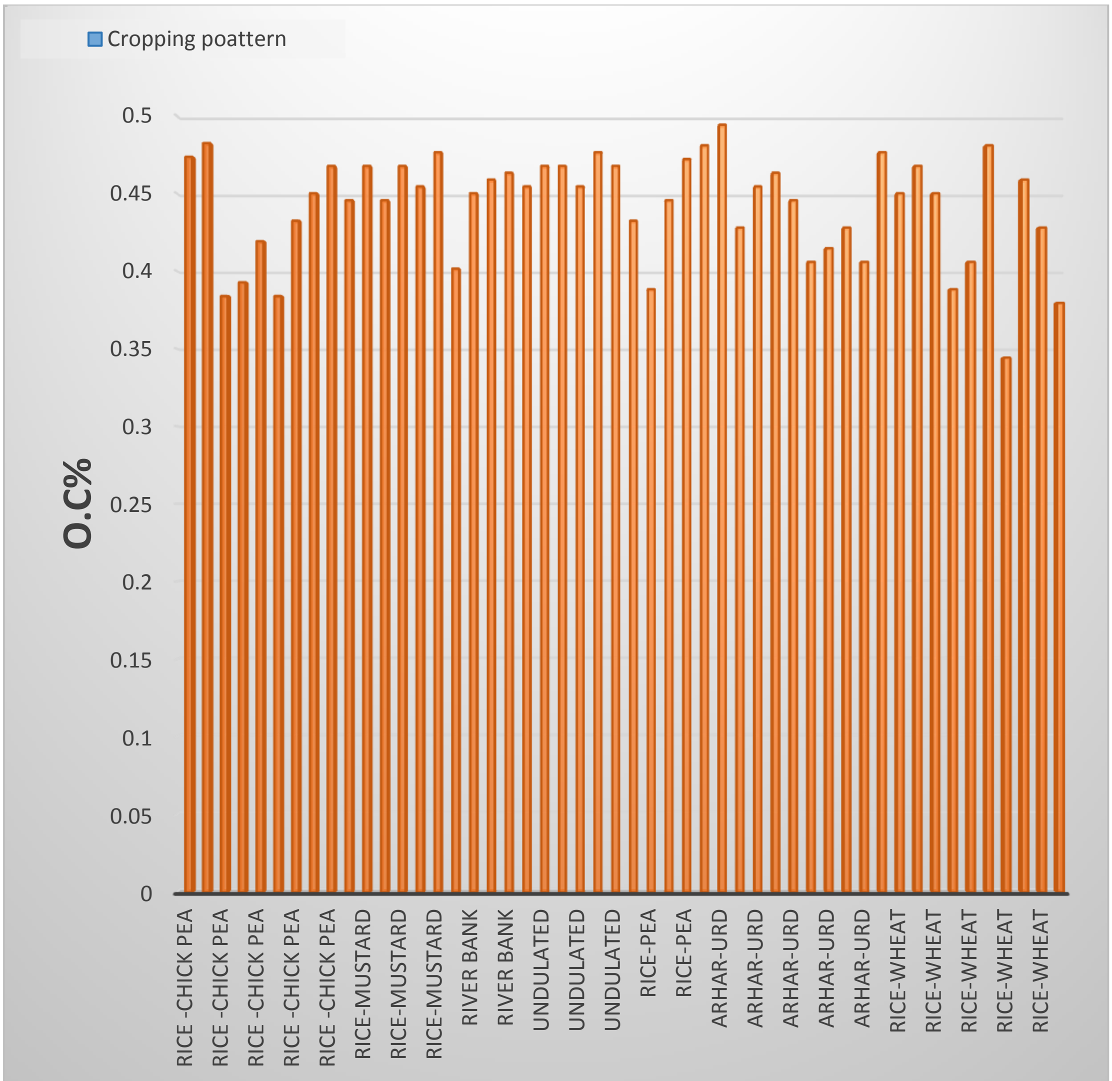

Fig. 4.3: O.C of soils of village Nisija

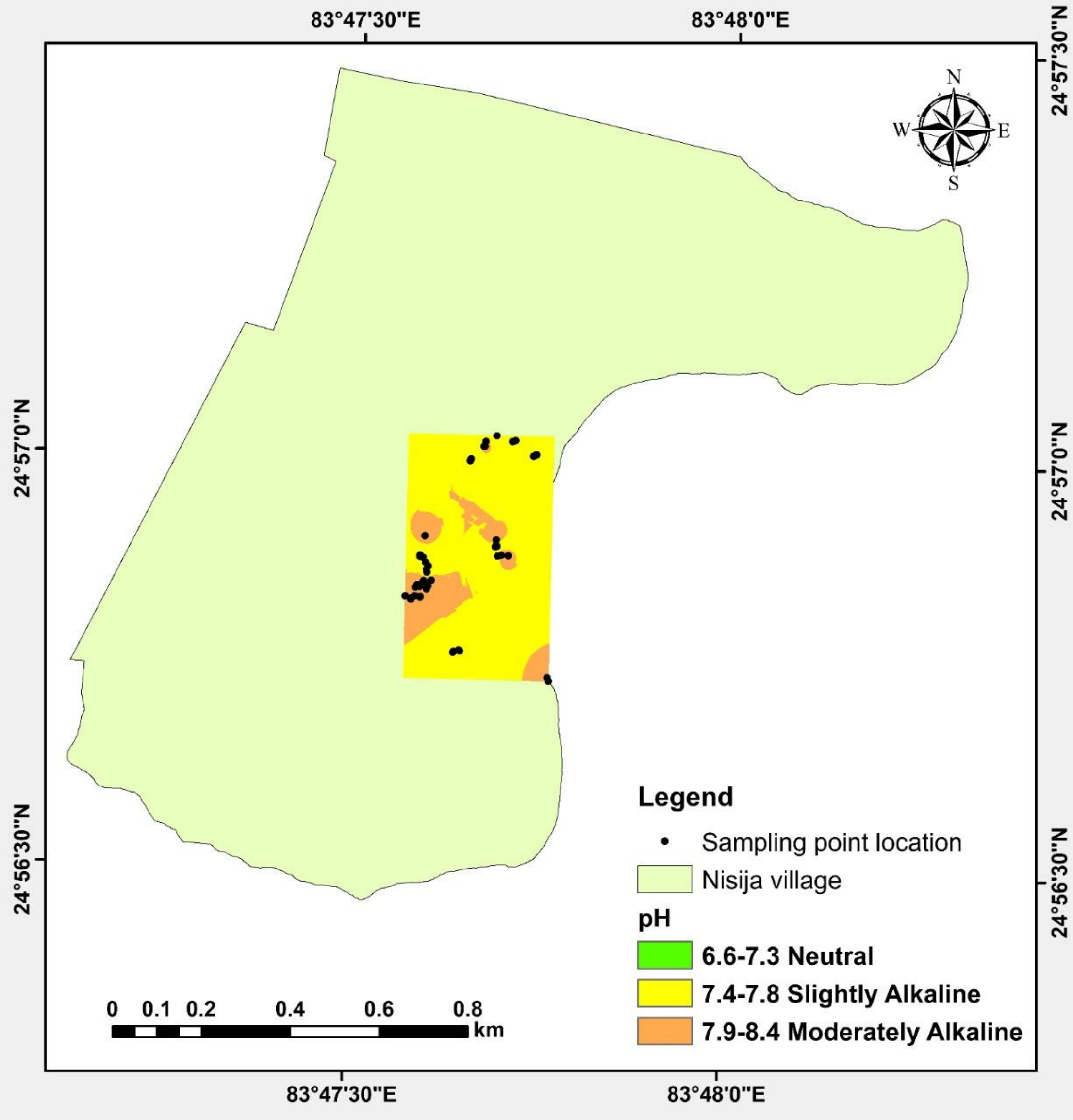

Fig. 4.4: Spatial variability map of pH in soils

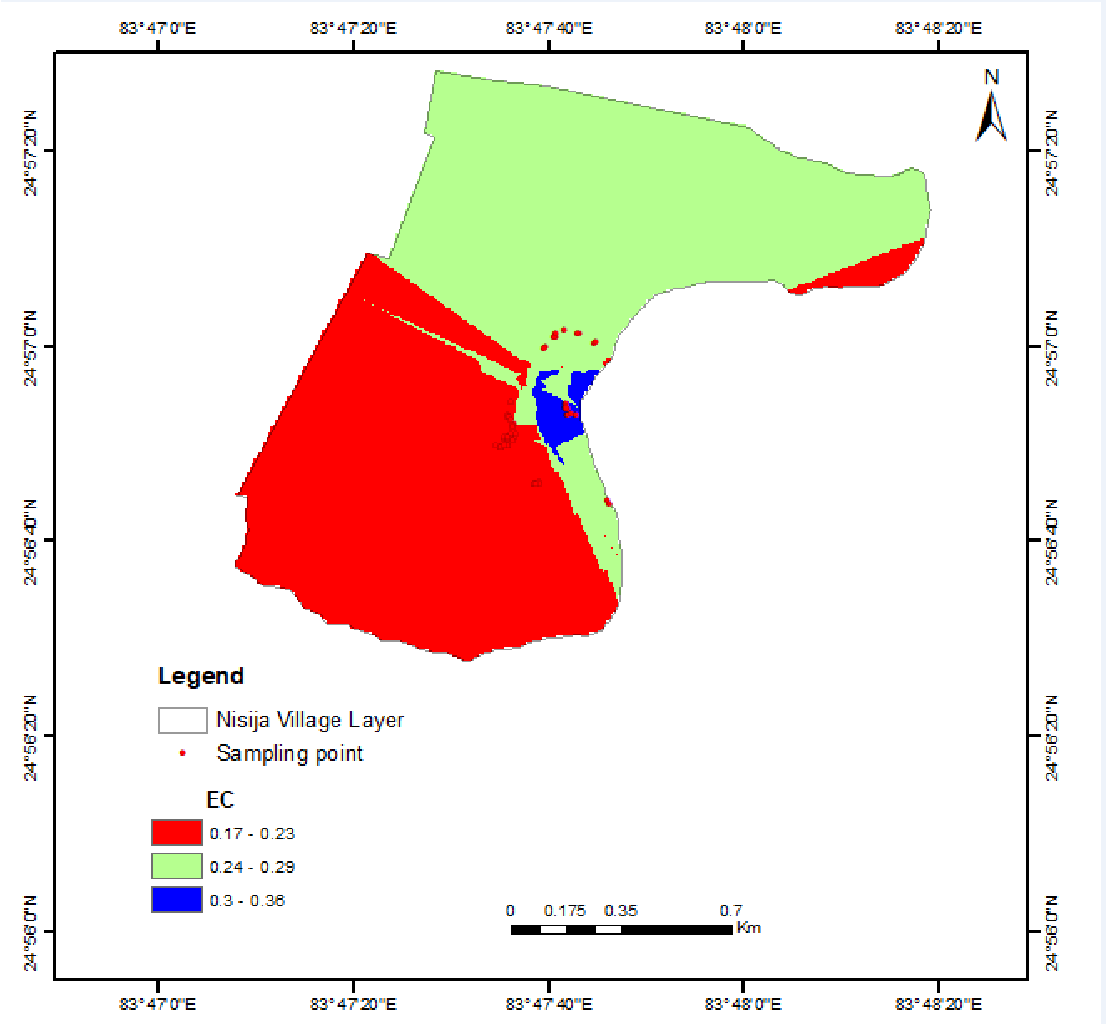

Fig. 4.5: Spatial variability map of EC in soils

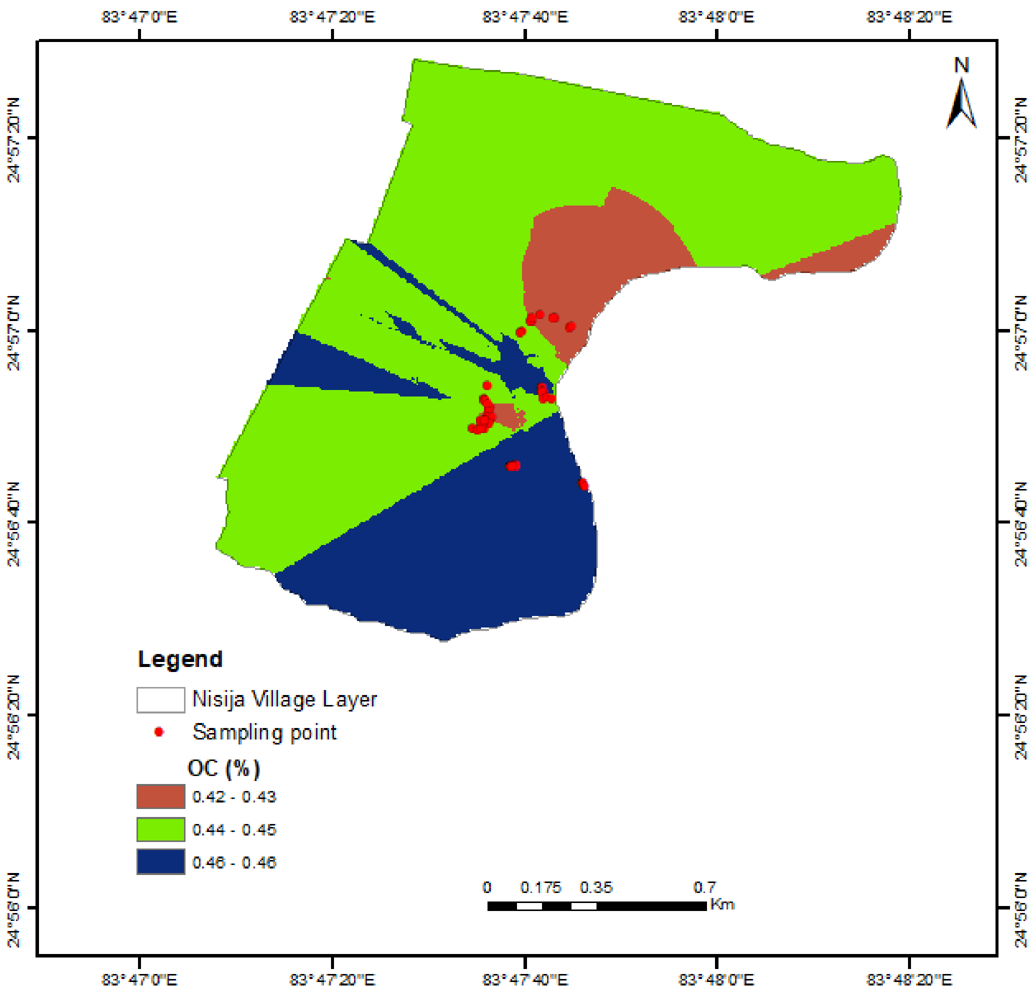

Fig. 4.6: Spatial variability map of O.C in soils

4.3 Macronutrient that is available in soil

Table 4.4 shows the status of accessible macronutrients, which is displayed in (Fig 4.7 to 4.12).The amount of nitrogen available per hectare ranged from 100.4 to 263.0 kg ha^{-1}, with an average of 175.44 kg ha^{-1}. The available nitrogen standard deviation and coefficient of variation were 58.99 and 33.62 percent, respectively (table:-4.5) (Fig.-4.7 &4.10). The arhar –urd cropping pattern had the lowest nitrogen concentration, while undulated land had the highest nitrogen level. Out of the total soil samples, 48 percent had low nitrogen levels, 2% had medium nitrogen levels, and none had high nitrogen levels (0 percent). Because there is less organic carbon in the soil, the available nitrogen content is low. Singh *et al*. (2018) found a similar outcome in the Varanasi district of eastern Uttar Pradesh.

The amount of accessible phosphorus in soil samples ranged from 8.0 to 12.5 kg ha^{-1}, with a mean of 10.45 kg ha^{-1}. The lowest phosphorus value was discovered in the R-W cropping pattern, whereas the highest value was recorded in the sample arhar–urd cropping pattern. Phosphorus had a standard deviation of 1.0 and a coefficient of variation of 9.92 percent, respectively. In terms of phosphorus concentration, 98 percent of soil samples were in the low range, 2% were in the medium range, and 0% were in the high range (table-4.5) and illustrated in (Fig:-4.8&4.11). The presence of CaCO3 in the soil, as well as the effects of varying soil qualities and agronomic techniques, may cause variations in phosphorus availability. Such findings also recorded by Bharambe *et al.* (2002).

The potassium level of soil samples ranged from 107.6 to 236.8 kg per hectare, with an average of 177.49 kg per hectare. River bank had the lowest phosphorus content, whereas the highest value content in the R-W cropping pattern, with SD and CV values of 33.15 and 18.68 percent, respectively (table-4.5) and shown in (Fig.:-4.9&4.12). In all, 12 percent of soil samples were in the low potassium range, 88 percent of soil samples were in the medium range, and none of the samples (0%) were in the high potassium range. The research location has a high potassium content, which could be attributable to the presence of elite, rich potassium minerals in the soil. Jain *et al*., (2014) reported similar findings in their paper.

Table 4.3: Available macro nutrient in soils

S.No.	Cropping Pattern	N(kg/ha)	P(kg/ha)	K(kg/ha)
1	Rice -Chick Pea	163.07	11.67	146.4
2	Rice -Chick Pea	187.81	11.15	191.2
3	Rice -Chick Pea	250.88	10.17	157.6
4	Rice -Chick Pea	175.62	10.59	135.2
5	Rice -Chick Pea	187.81	10.83	168.8
6	Rice -Chick Pea	112.90	12.09	191.2
7	Rice -Chick Pea	187.81	11.85	200.6
8	Rice -Chick Pea	150.53	11.06	216
9	Rice -Chick Pea	125.44	10.17	208.4
10	Rice -Chick Pea	163.07	11.71	205.2
11	Rice-Mustard	112.90	12.87	210.8
12	Rice-Mustard	175.26	17.89	219.6
13	Rice-Mustard	250.88	15.27	197.2
14	Rice-Mustard	213.25	12.19	198.8
15	Rice-Mustard	225.79	12.37	210.2
16	River Bank	130.46	14.84	210.8
17	River Bank	171.85	14.56	180
18	River Bank	213.25	13.49	198.4
19	River Bank	154.29	14.09	180
20	River Bank	200.70	13.02	113.6
21	Undulated	188.16	12.88	158.4
22	Undulated	251.23	11.95	213.2
23	Undulated	213.95	11.15	147.2
24	Undulated	263.42	11.76	225.6
25	Undulated	163.07	12.09	225.2
26	Rice-Pea	150.53	16.33	124.8
27	Rice-Pea	175.62	16.99	180.8

S.No.	Cropping Pattern	N(kg/ha)	P(kg/ha)	K(kg/ha)
28	Rice-Pea	125.44	15.49	169.6
29	Rice-Pea	129.35	17.69	192
30	Rice-Pea	187.81	14.51	200.6
31	Arhar-Urd	150.53	15.87	169.6
32	Arhar-Urd	130.46	14.84	169.6
33	Arhar-Urd	137.98	18.53	147.2
34	Arhar-Urd	100.35	19.13	192
35	Arhar-Urd	187.81	19.97	125.6
36	Arhar-Urd	163.07	18.53	124.4
37	Arhar-Urd	195.33	20.16	192.8
38	Arhar-Urd	137.98	19.18	150.8
39	Arhar-Urd	142.90	18.34	113.6
40	Arhar-Urd	163.07	12.93	147.2
41	Rice-Wheat	188.16	10.08	198.6
42	Rice-Wheat	263.42	12.04	200.2
43	Rice-Wheat	163.07	10.83	236.8
44	Rice-Wheat	112.90	12.27	192
45	Rice-Wheat	100.35	12.09	158.4
46	Rice-Wheat	170.43	12.88	192
47	Rice-Wheat	125.44	12.79	169.6
48	Rice-Wheat	132.90	12.27	107.6
49	Rice-Wheat	175.26	12.97	128.4
50	Rice-Wheat	123.35	12.83	180.8
	Mean	170.43	10.45	177.49
	Range	100.4-263.4	8.0-12.5	107.6-236.8
	S.D	44.0	2.86	33.15
	C.V%	25.83	20.67	18.68

Table 4.3.1: Mean, range, standard deviation and covariance of available macronutrients of soils

Soil parameters	Range	Mean	SD±	C.V (%)
Nitrogen (kg ha^{-1})	100.4-263.4	175.44	58.99	33.62
Phosphorus (kg ha^{-1})	8.0-12.5	13.82	2.86	20.67
Potassium (kg ha^{-1})	107.6-236.8	177.49	33.15	18.68

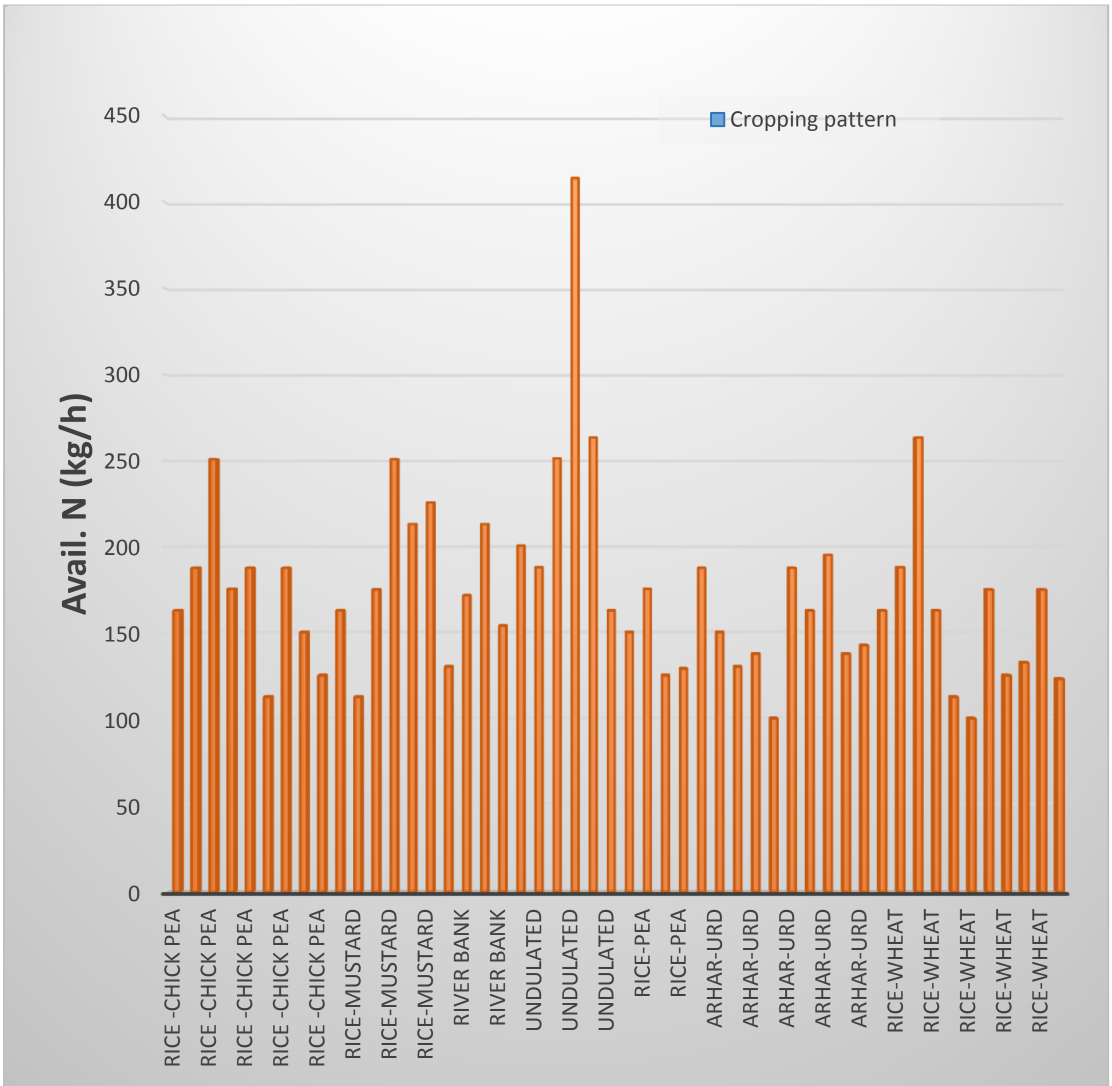

Fig. 4.7: Avail.N in soils of village Nisija

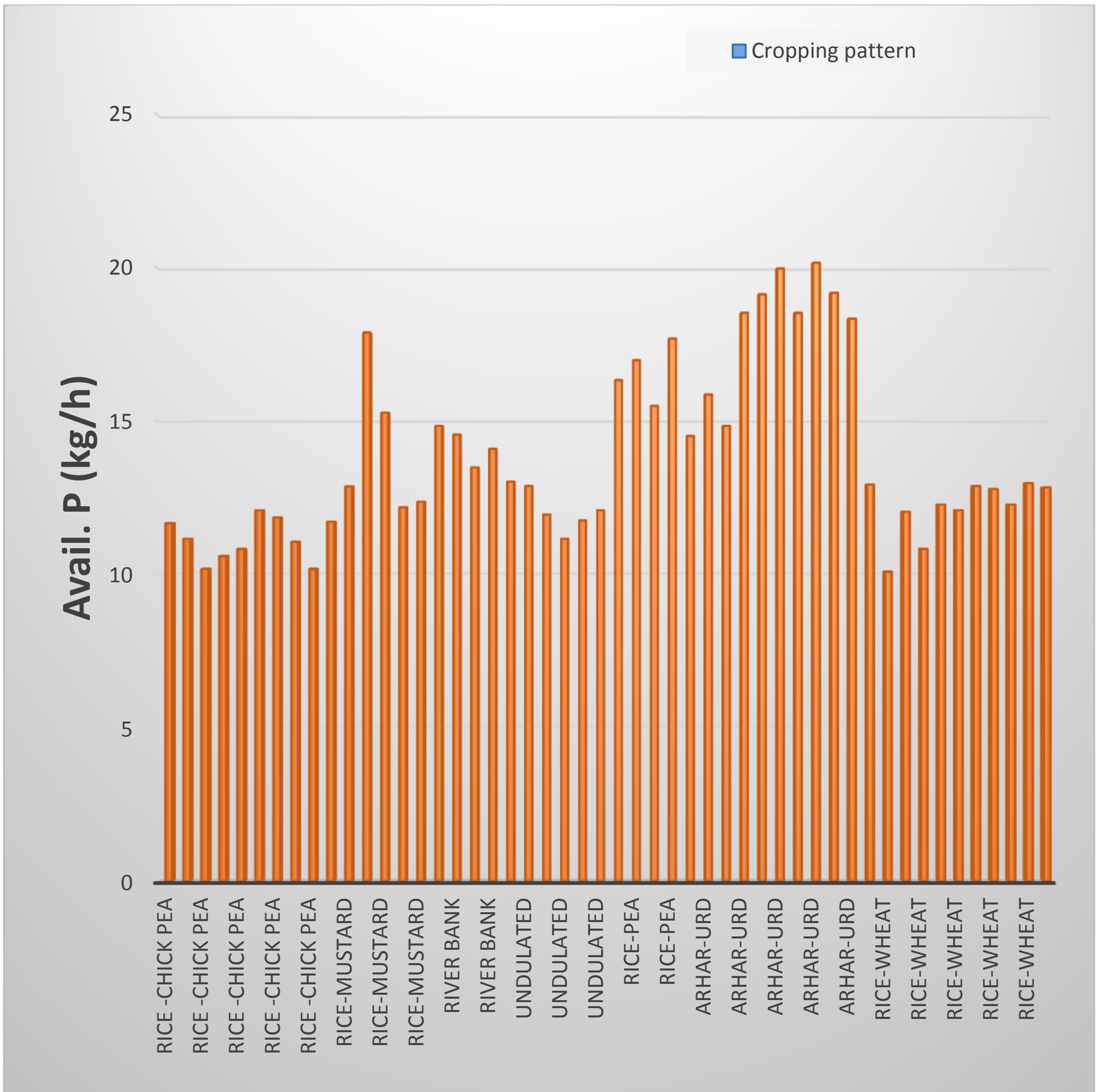

Fig. 4.8: Avail.P in soils of village Nisija

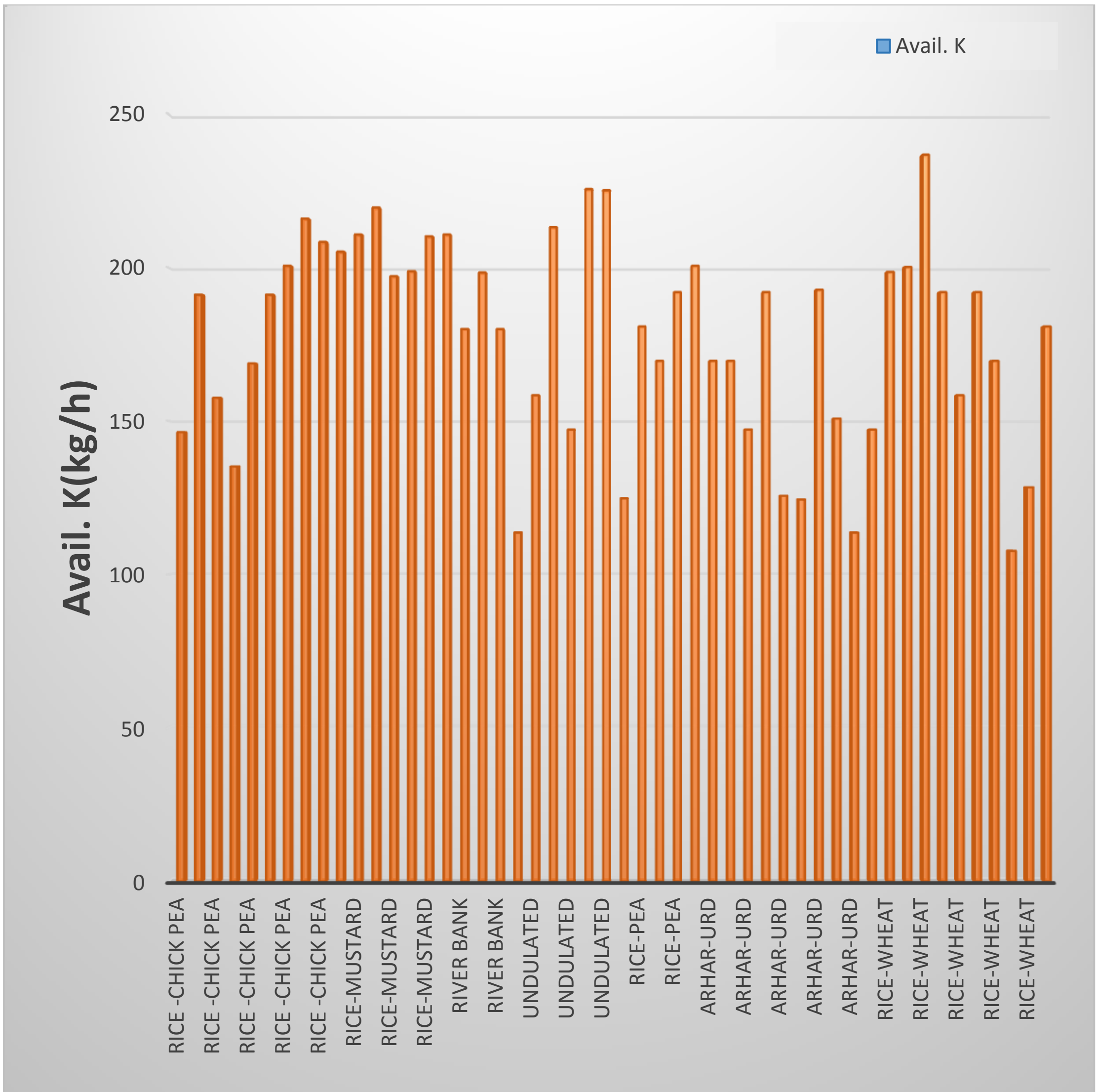

Fig. 4.9: Available K in soils of village Nisija

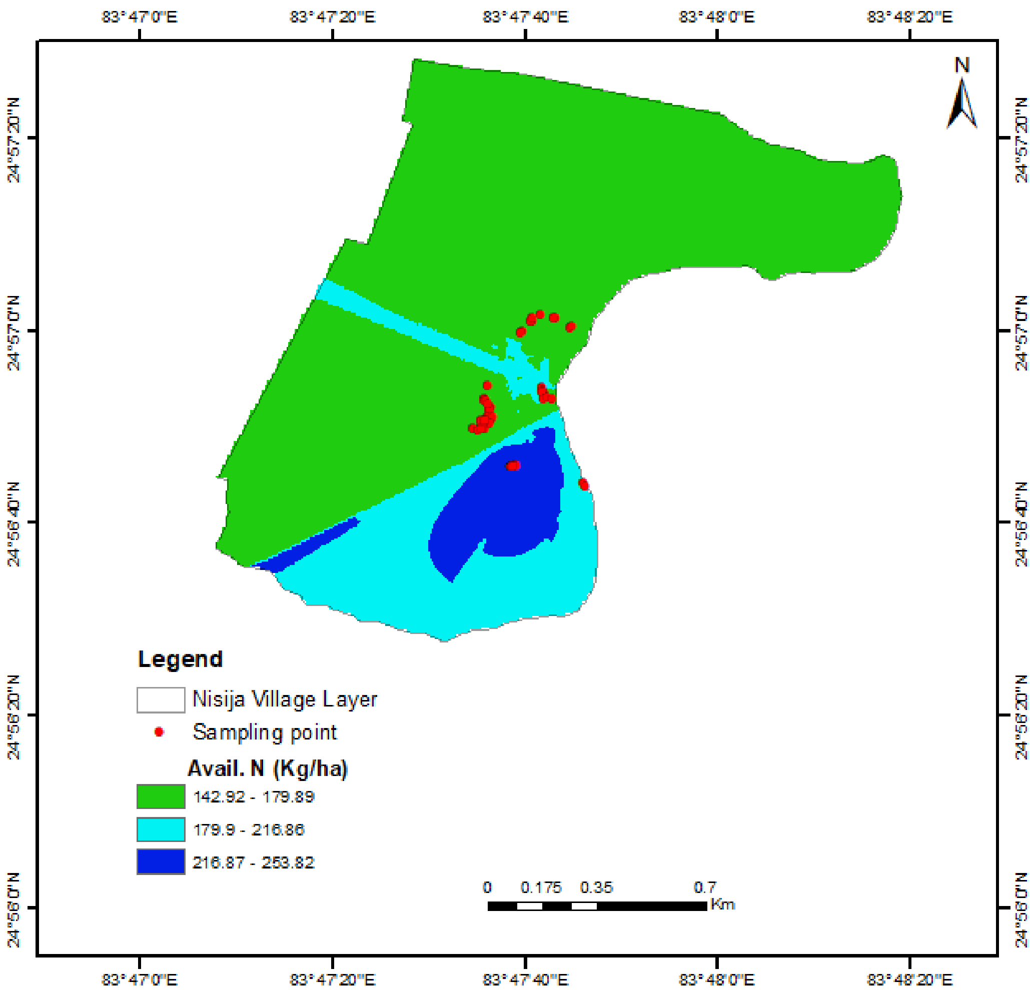

Fig 4.10: Spatial variability map of available Nitrogen in soils

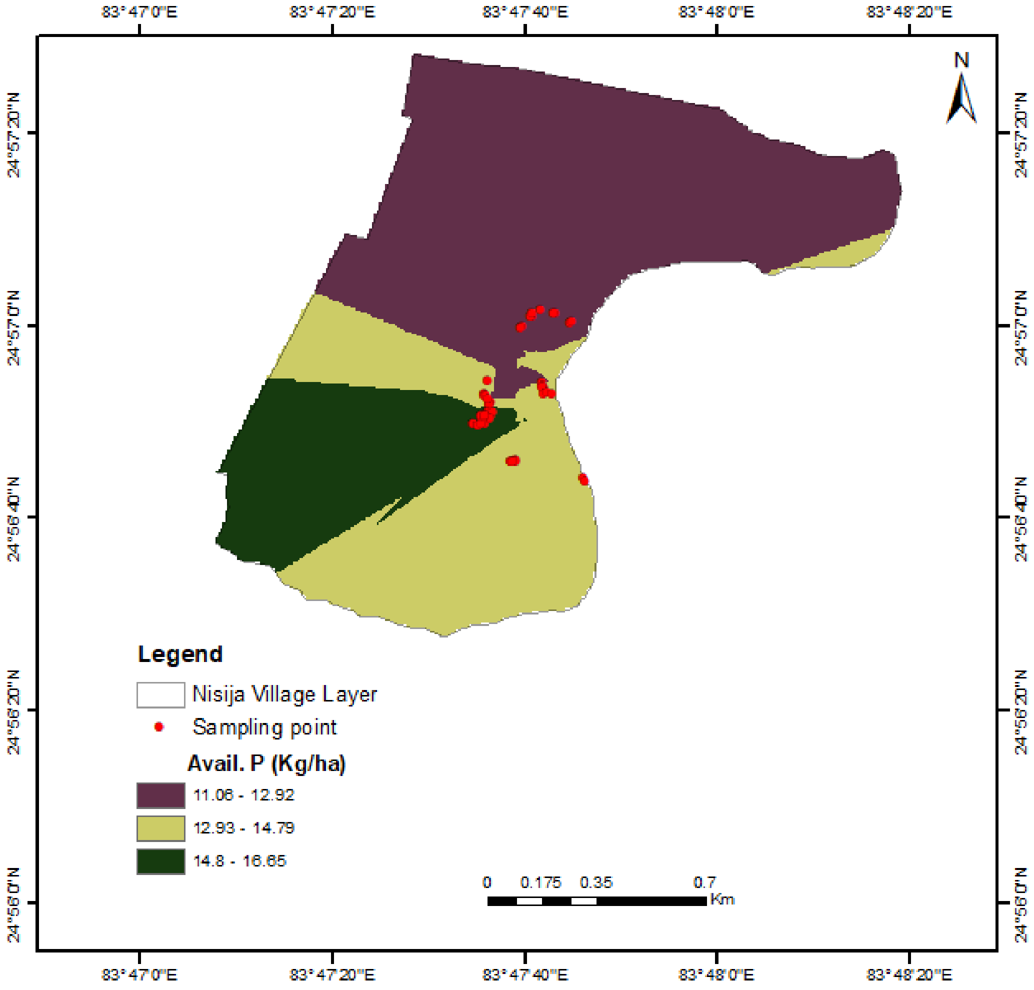

Fig. 4.11: Spatial variability map of available phosphorus in soils

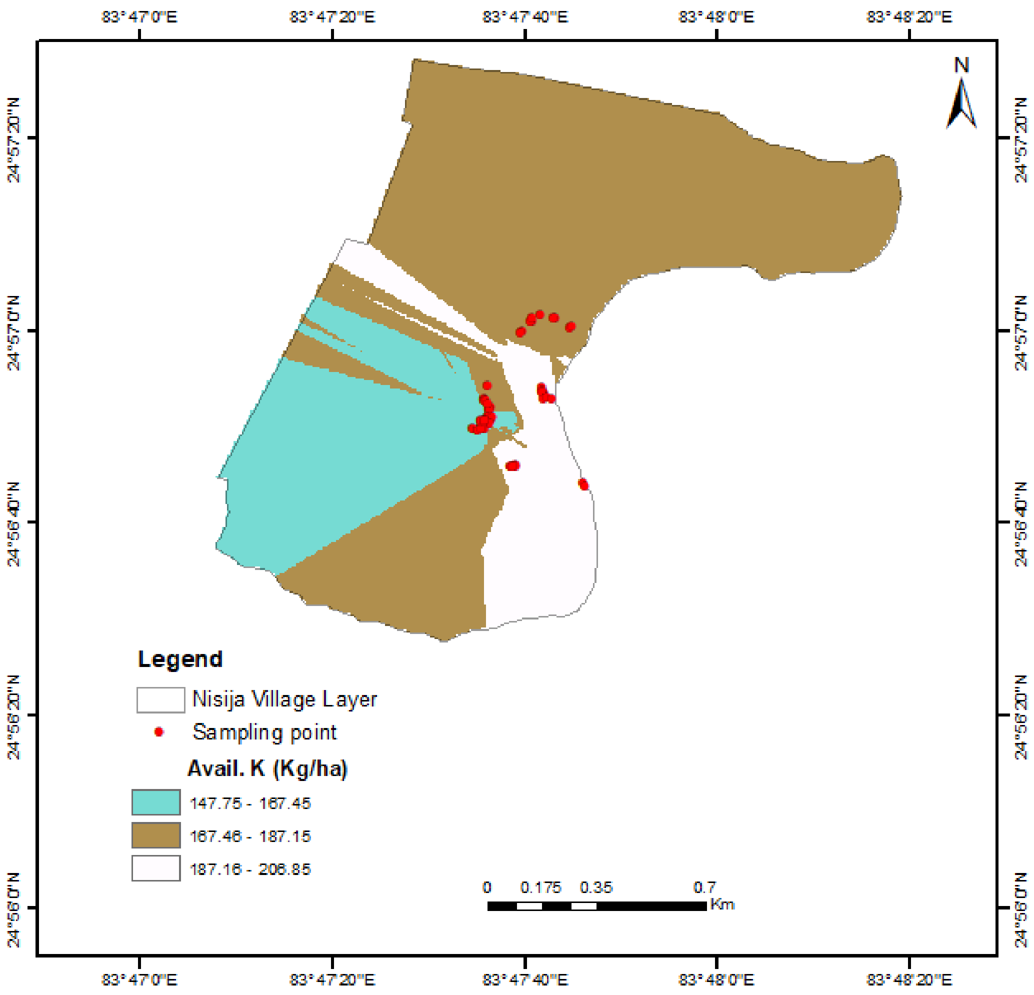

Fig. 4.12: Spatial variability map of available potassium in soils

4.4 Secondary nutrients in the soil

Table 4.5 shows the results of the analysis of secondary macronutrients in soil. And it's portrayed in (Fig.-4.13 to 4.18). The calcium level ranged from 0.9 to 5.5 Meq/100g, with 2.80 Meq/100g being the norm. The rice–wheat farming pattern had the lowest calcium level, while the river bank had the highest calcium concentration. The standard deviation and coefficient of variance were 0.92 and 32.98 percent, respectively, (table:-4.4.1) and (Fig.-4.13&4.16). 92 percent of the total soil samples had a high calcium content.

The magnesium level of the soil samples ranged from 1.4 to 9.8 Meq/100g, with a mean value of 4.90 Meq/100g. The standard deviation and coefficient of variance were 1.92 and 39.29 percent, respectively (table.-4.4.1) and (Fig-4.14 &4.17). The smallest amount of magnisium. Rice-pea had the lowest magnisium content, whereas R-W pattern had the highest. One hundred percent of the 50 soil samples collected were in the high range, and none (0%) were in the low range.

Soil samples had a sulphur concentration ranging from 2.1 to 5.9 mg $kg^{-1,}$ with a mean value of 3.94 mg kg^{-1}. Sulphur's standard deviation and coefficient of variation were 0.74 and 18.90 percent, respectively (table 4.4.1), as seen in the graph below (Fig. 4.5 &4.18). arhar-urd had the lowest sulphur concentration, whereas rice-pea had the highest. Out of 50 soil samples collected, 100 percent had low sulphur concentration and 0 percent had excessive sulphur content.

Table 4.4: Available secondary nutrient in soils

S.No.	Cropping Pattern	Ca (Meq/100g)	Mg (Meq/100g)	S (mg/kg)
1	Rice -Chick Pea	2.6	6.8	3.79
2	Rice -Chick Pea	2.1	7.1	3.89
3	Rice -Chick Pea	2.4	8.6	3.85
4	Rice -Chick Pea	2.9	6.1	3.76
5	Rice -Chick Pea	2.2	6.8	3.81
6	Rice -Chick Pea	3.8	2.8	3.86
7	Rice -Chick Pea	1.7	3.5	3.81
8	Rice -Chick Pea	2.4	3.8	3.85
9	Rice -Chick Pea	2.4	3.8	3.76
10	Rice -Chick Pea	3	5.2	3.85
11	Rice-Mustard	3.4	4.4	3.59
12	Rice-Mustard	3.1	1.9	3.55
13	Rice-Mustard	3	3.2	3.59
14	Rice-Mustard	3.2	2.8	3.60
15	Rice-Mustard	4.6	1.6	3.56
16	River Bank	4	3.4	3.24
17	River Bank	5.5	2.1	4.56
18	River Bank	1.8	2.8	3.71
19	River Bank	2	6	4.70
20	River Bank	2.3	5.9	3.03
21	Undulated	3.2	4.2	4.99
22	Undulated	3	5.4	3.04
23	Undulated	2.6	5.6	3.09
24	Undulated	2.9	4.3	4.36
25	Undulated	3.9	4.1	3.39
26	Rice-Pea	3.4	1.4	3.93

S.No.	Cropping Pattern	Ca (Meq/100g)	Mg (Meq/100g)	S (mg/kg)
27	Rice-Pea	3.4	4.6	4.96
28	Rice-Pea	3.9	3.7	4.99
29	Rice-Pea	2.2	5.8	5.94
30	Rice-Pea	2.7	5.3	4.01
31	Arhar-Urd	3.2	2.8	3.81
32	Arhar-Urd	2.8	5.4	4.86
33	Arhar-Urd	1.4	4.8	3.76
34	Arhar-Urd	2.4	5.8	3.80
35	Arhar-Urd	3.7	4.7	3.81
36	Arhar-Urd	3	3.8	2.88
37	Arhar-Urd	2.9	4.9	3.90
38	Arhar-Urd	2.1	7.9	2.10
39	Arhar-Urd	3	6.2	3.08
40	Arhar-Urd	3.2	2.8	4.05
41	Rice-Wheat	0.9	6.1	4.44
42	Rice-Wheat	1.2	9.8	2.46
43	Rice-Wheat	1.7	9.3	3.41
44	Rice-Wheat	4.4	3.8	4.66
45	Rice-Wheat	2.8	5.2	3.64
46	Rice-Wheat	4.2	4	4.64
47	Rice-Wheat	2.8	5.4	4.69
48	Rice-Wheat	1.3	8.7	5.73
49	Rice-Wheat	1.9	5.7	4.75
50	Rice-Wheat	1.7	4.7	4.50
	Mean	2.80	4.90	3.94
	Range	0.9-5.5	1.4-9.8	2.1-5.9
	S.D	0.92	1.92	0.74
	C.V%	32.98	39.29	18.90

Table 4.4.1: Range,mean standard deviation & covariance of secondary nutrients of soils

Soil parameters	Range	Mean	SD±	C.V (%)
Calcium (Meq/100g)	0.9-5.5	2.80	0.92	32.98
Magnesium (Meq/100g)	1.4-9.8	4.90	1.92	39.29
Sulphur (mg kg^{-1})	2.1-5.9	3.94	0.74	18.90

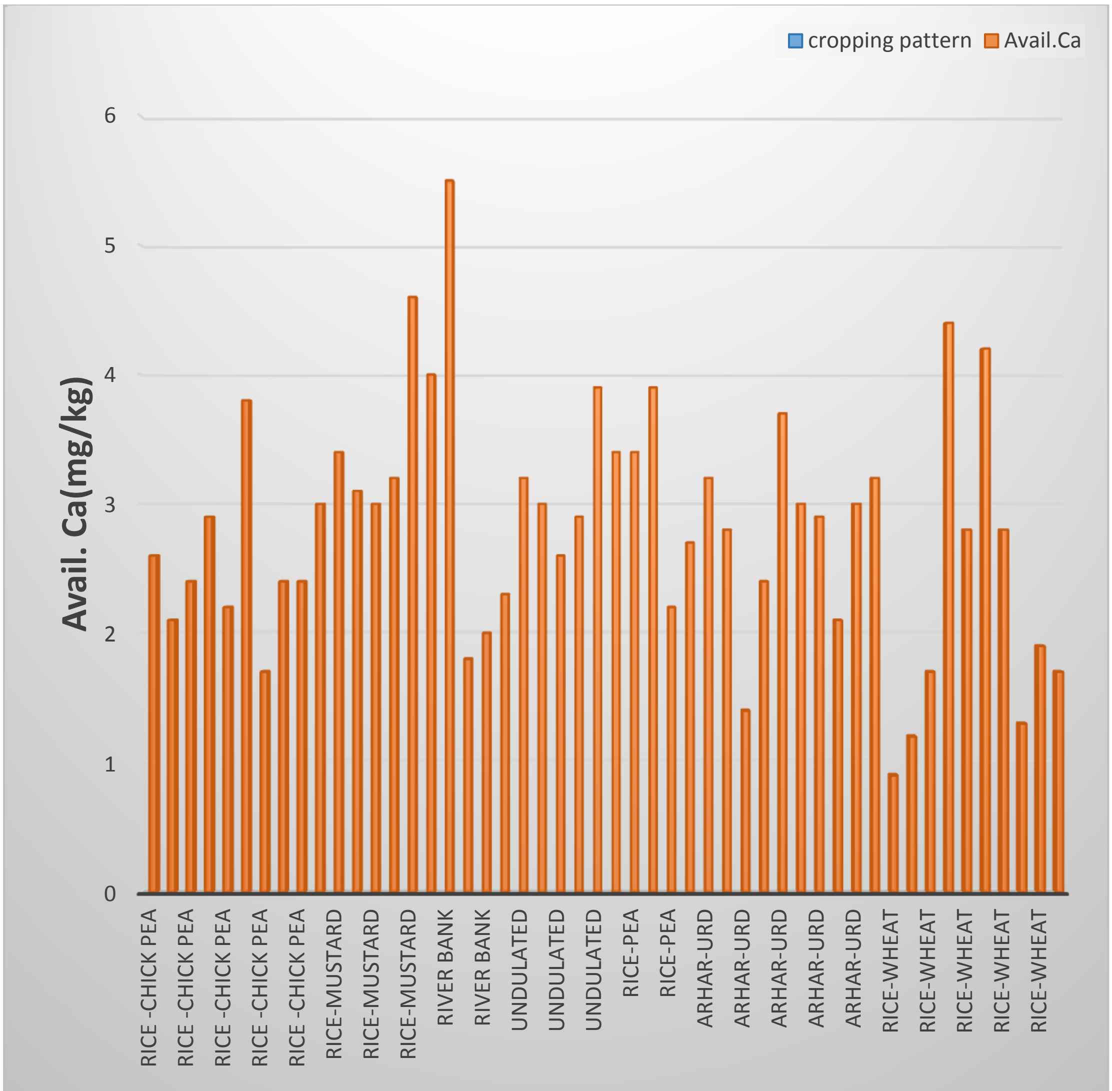

Fig. 4.13: Available Ca in soils of village Nisija

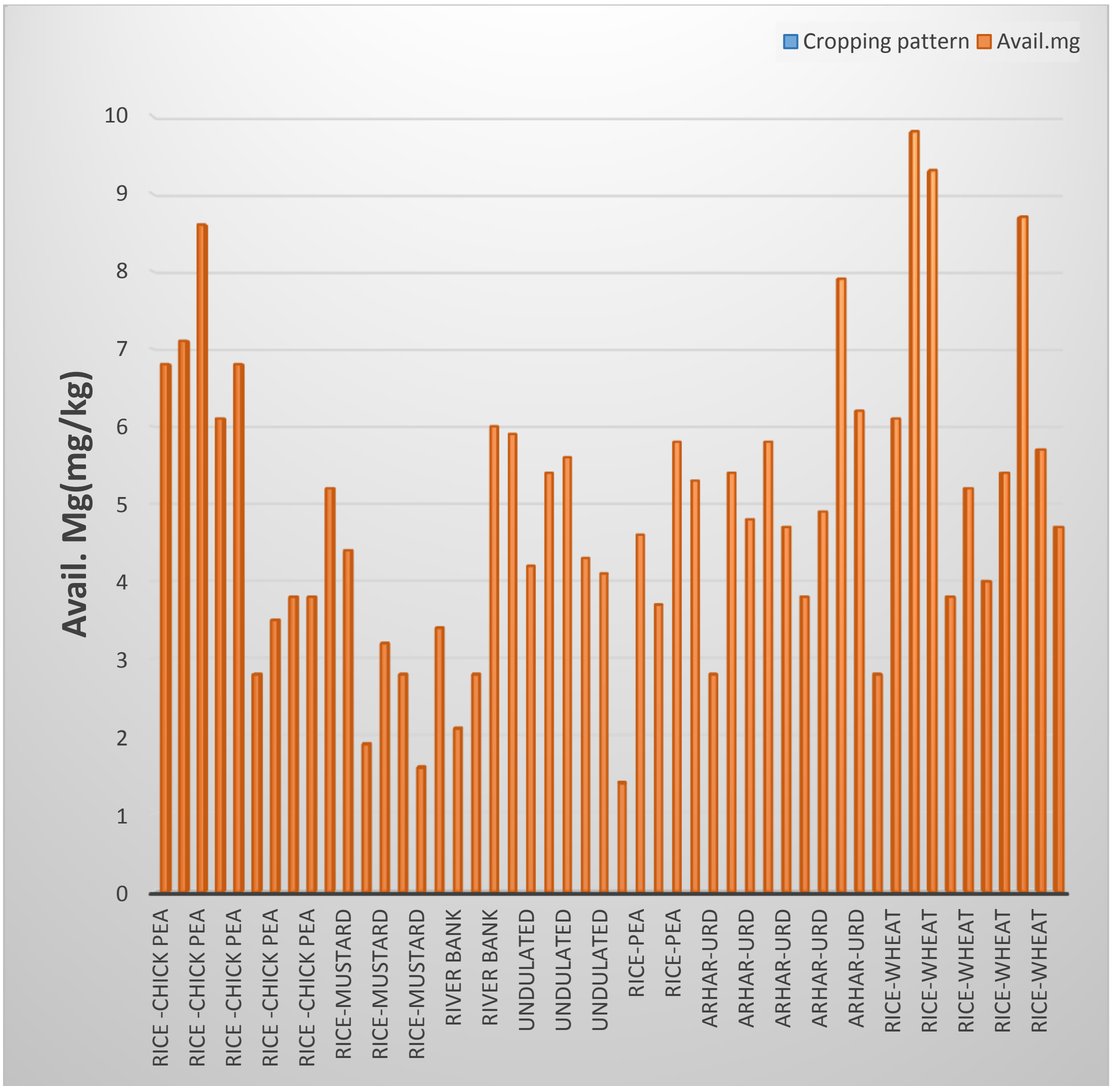

Fig 4.14: Avail. Mg in in soils of village Nisija

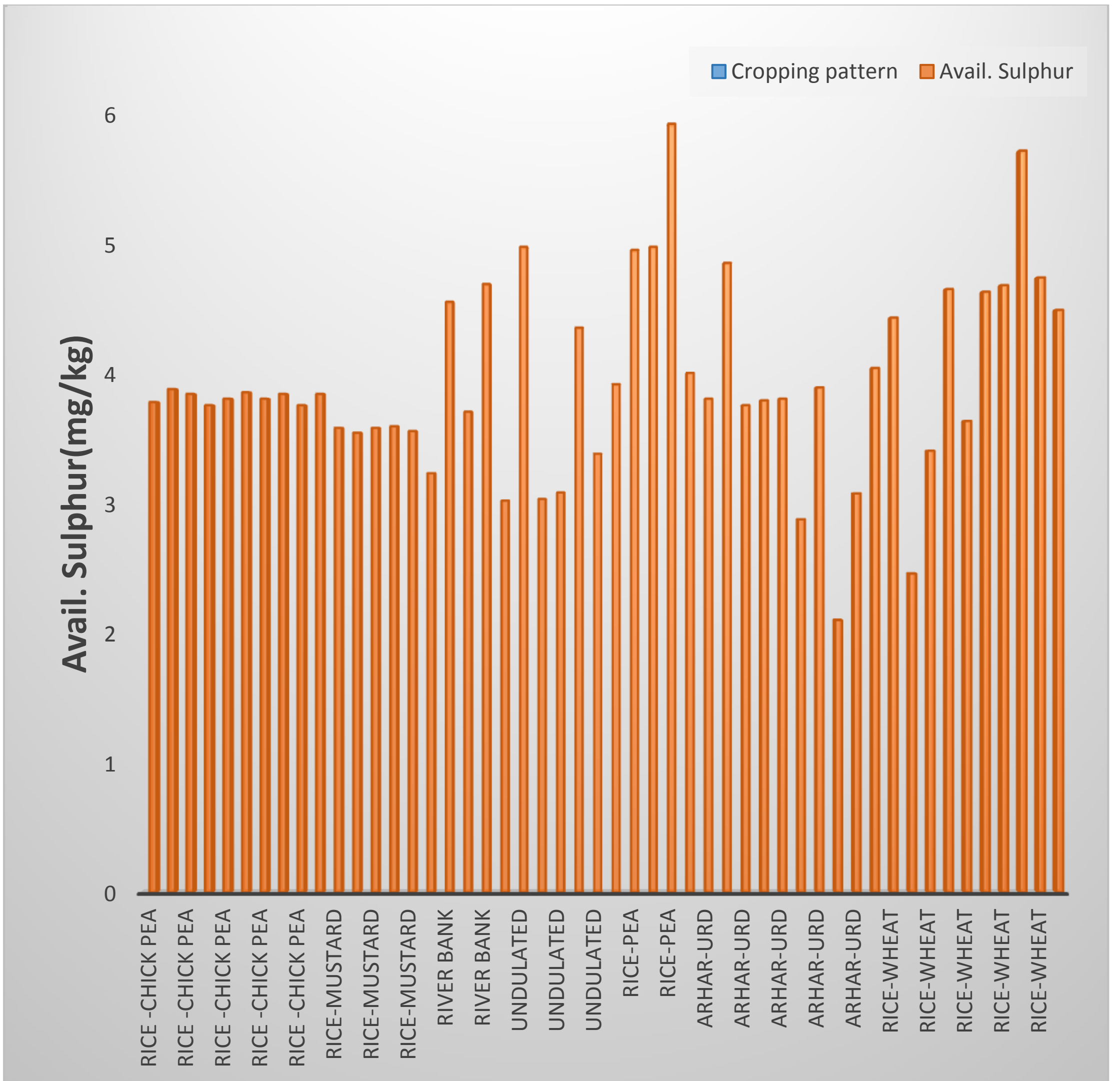

Fig. 4.15: Avail. S in soils of village Nisija

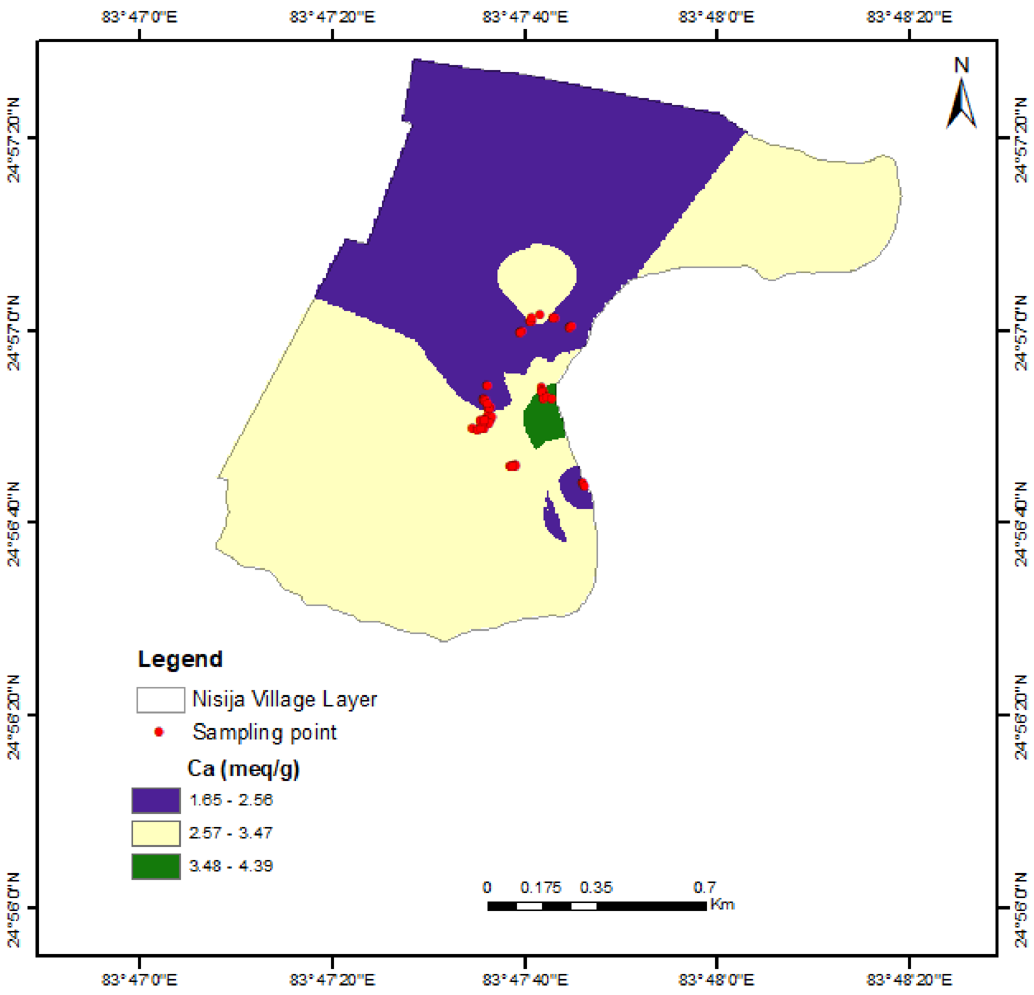

Fig. 4.16: Spatial variability map of available Ca in soils

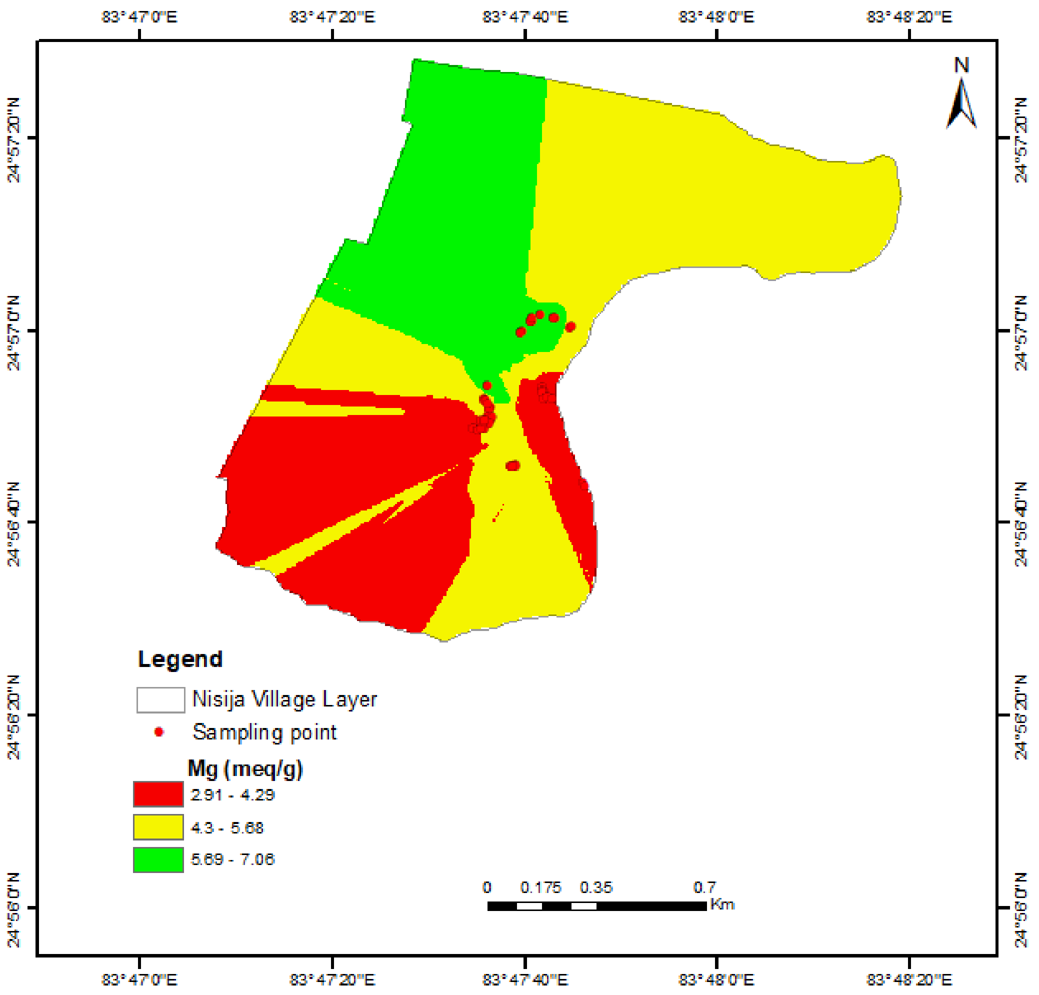

Fig. 4.17: Spatial variability map of available Mg in soils.

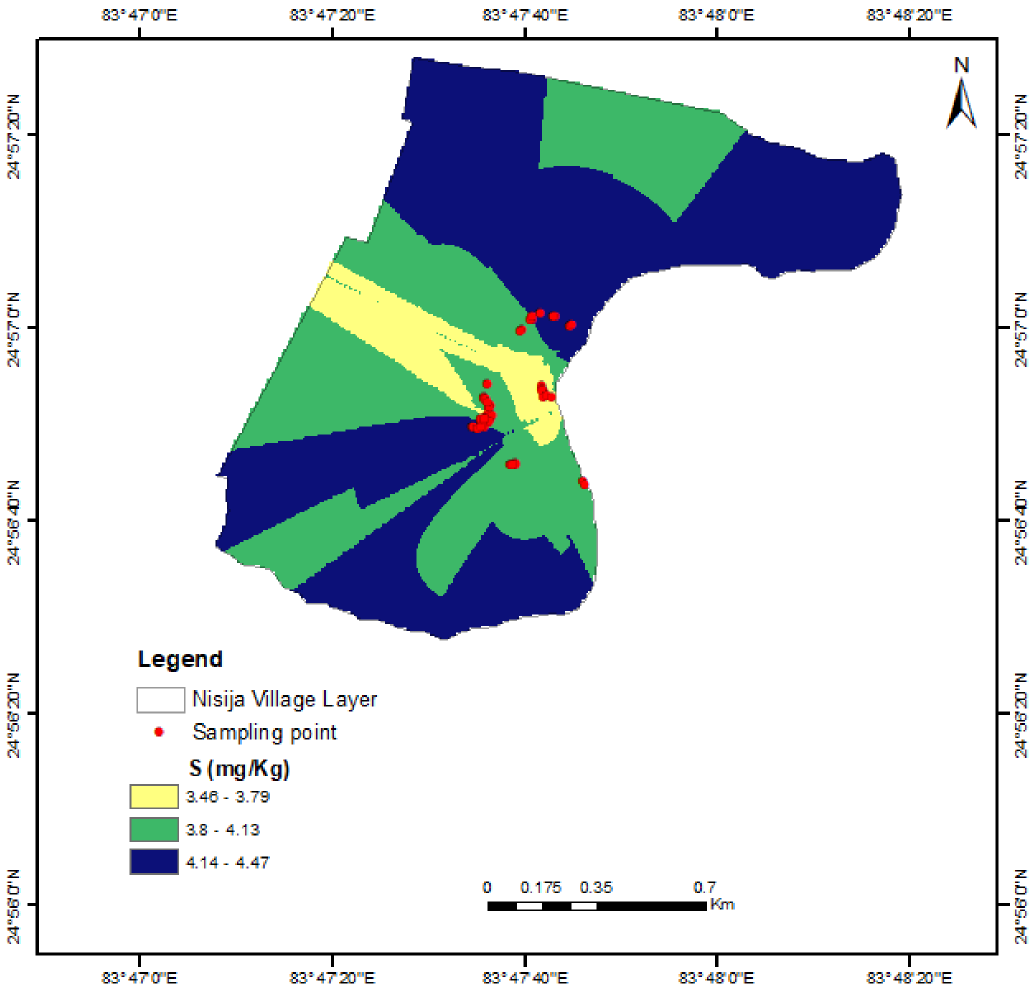

Fig. 4.18: Spatial variability map of available sulphur in soils

4.5 Available Micronutrients

Micronutrient deficit in soil is caused by intensive farming systems that use only chemical fertilisers and high yield varieties. As a result, it's critical to keep track of the micronutrients (Fe, Mn, Zn, and Cu) in soil on a frequent basis. Table 4.5 contains the results of the soil micronutrient analysis, which are depicted in Figures 4.19 to 4.26.

The iron concentration of the soil samples ranged from 2.2 to 5.9 mg kg^{-1}, with an average of 3.81 mg kg^{-1}. Rice-chick pea cropping pattern had the lowest Fe level, while rice-mustard cropping pattern had the greatest. The standard deviation and coefficient of variation of iron were 1.05 and 27.71 percent, respectively (Table-4.5.1) and (Fig.-4.19&4.23).74% of the soil samples were found to be contaminated. The soil samples had a low iron concentration, with only 26% having a suitable amount. Kumar and Babel (2010) revealed similar findings in the district of Jhunjhunu block of Rajasthan's district Sikar.

Manganese concentrations in soil samples ranged from 5.4 to 13.8 mg kg^{-1}, with an average of 9.36 mg kg-1. Rice-pea planting pattern had the lowest Mn concentration, while rice-wheat cropping pattern had the greatest. The standard deviation and coefficient of variation were 2.27 and 24, respectively, as shown in (Fig.-4.20 &4.24). 74 percent of soil samples had a high accessible Mn concentration, whereas 26 percent had an insufficient amount of Mn content (as per the critical limit suggested by (Lindsay and Norvell, 1978)

The average Zn content in soil samples was 1.90 mg kg^{-1}, with values ranging from 0.3 to 11.7 mg kg^{-1}. The standard deviation and coefficient of variation of zinc were 2.41 and 126.78 percent, respectively, (table.-4.5.1) and (Fig.-4.21&4.25). The rice-chick pea cropping pattern had the lowest zinc concentration, while the rice-mustard cropping pattern had the greatest. Out of 50 soil samples, 52 percent had high zinc level, whereas the remaining 48 percent had marginal zinc content.

Copper levels in soil samples ranged from 0.6 to 1.6 mg kg^{-1} on average, with an average of 1.03 mg kg^{-1}. Cu had a standard deviation of 0.28 and a coefficient of variation of 27.55 percent (table.-4.5.1) and was represented in the rice-mustard cropping pattern had the lowest copper concentration, while the rice-chick pea cropping pattern had the greatest. According to Lindsay and Norvell's (1978) critical limit, 100 percent of total soil samples were determined to be rich in accessible copper.

Table 4.5: Available Micro Nutrient in soils

S.No	Cropping Pattern	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
1	Rice -Chick Pea	3.9	13.24	1.4	1.2
2	Rice -Chick Pea	3.4	12.3	0.8	0.3
3	Rice -Chick Pea	3.7	13.34	0.6	1.1
4	Rice -Chick Pea	3.5	8.34	1.4	1.2
5	Rice -Chick Pea	2.3	10.78	1.0	0.9
6	Rice -Chick Pea	3.2	12.46	1.6	0.5
7	Rice -Chick Pea	3.5	8.72	0.6	1.0
8	Rice -Chick Pea	2.2	10.56	0.8	1.3
9	Rice -Chick Pea	2.4	12.62	1.2	1.1
10	Rice -Chick Pea	5.4	10.78	0.8	2.3
11	Rice-Mustard	5.7	11.5	0.6	2.6
12	Rice-Mustard	5.9	10.6	1.4	3.7
13	Rice-Mustard	2.5	9.84	1.0	3.9
14	Rice-Mustard	2.8	8.78	0.7	11.7
15	Rice-Mustard	2.9	7.98	1.2	10.7
16	River Bank	3.8	5.92	1.2	0.9
17	River Bank	2.6	6.84	1.0	10.5
18	River Bank	3.2	8.5	0.8	0.8
19	River Bank	4.0	7.38	1.0	0.9
20	River Bank	3.0	8.08	0.8	1.2
21	Undulated	2.8	5.88	0.8	0.6
22	Undulated	2.9	9.88	1.2	0.6
23	Undulated	3.8	8.62	1.3	0.8
24	Undulated	2.6	7.34	1.4	0.5
25	Undulated	3.6	8.64	0.7	0.9
26	Rice-Pea	5.2	7.84	1.0	1.3
27	Rice-Pea	5.1	6.54	1.3	0.6

28	Rice-Pea	4.1	5.44	1.2	1.0
29	Rice-Pea	5.8	12.02	0.8	1.4
30	Rice-Pea	4.4	13.74	0.7	1.0
31	Arhar-Urd	4.7	12.34	1.4	1.6
32	Arhar-Urd	3.3	8.32	0.8	1.3
33	Arhar-Urd	3.6	8.6	1.2	1.7
34	Arhar-Urd	3.3	7.2	1.2	1.9
35	Arhar-Urd	3.1	6.6	0.8	1.2
36	Arhar-Urd	3.2	8.8	1.4	1.4
37	Arhar-Urd	3.6	10.4	0.7	1.4
38	Arhar-Urd	3.5	8.6	1.0	1.5
39	Arhar-Urd	4.0	8.8	0.8	1.6
40	Arhar-Urd	4.6	7.8	0.7	1.3
41	Rice-Wheat	2.3	5.78	1.4	1.3
42	Rice-Wheat	2.7	6.64	1.0	0.9
43	Rice-Wheat	3.6	8.22	1.6	1.4
44	Rice-Wheat	5.1	9.22	0.8	1.7
45	Rice-Wheat	4.8	9.2	0.8	1.5
46	Rice-Wheat	5.9	10.4	1.2	1.8
47	Rice-Wheat	5.7	13.82	0.8	1.6
48	Rice-Wheat	4.2	12.8	1.0	1.5
49	Rice-Wheat	4.4	10.6	1.4	1.3
50	Rice-Wheat	4.7	9.4	1.2	1.0
	Mean	3.81	9.36	1.03	1.90
	Range	2.2-5.9	5.4-13.8	0.6-1.6	0.3-11.7
	S.D	1.05	2.27	0.28	2.41
	C.V%	27.71	24.26	27.55	126.78

Table 4.5.1: Range, mean and standard deviation and covariance of available micronutrient of soils

Soil parameters	Range	Mean	SD±	C.V (%)
Available Fe (mg kg^{-1})	2.2-5.9	3.81	1.05	27.71
Available Mn (mg kg^{-1})	5.4-13.8	9.36	2.27	24.26
Available Zn (mg kg^{-1})	0.3-11.7	1.90	2.41	126.78
Available Cu (mg kg^{-1})	0.6-1.6	1.03	0.28	27.55

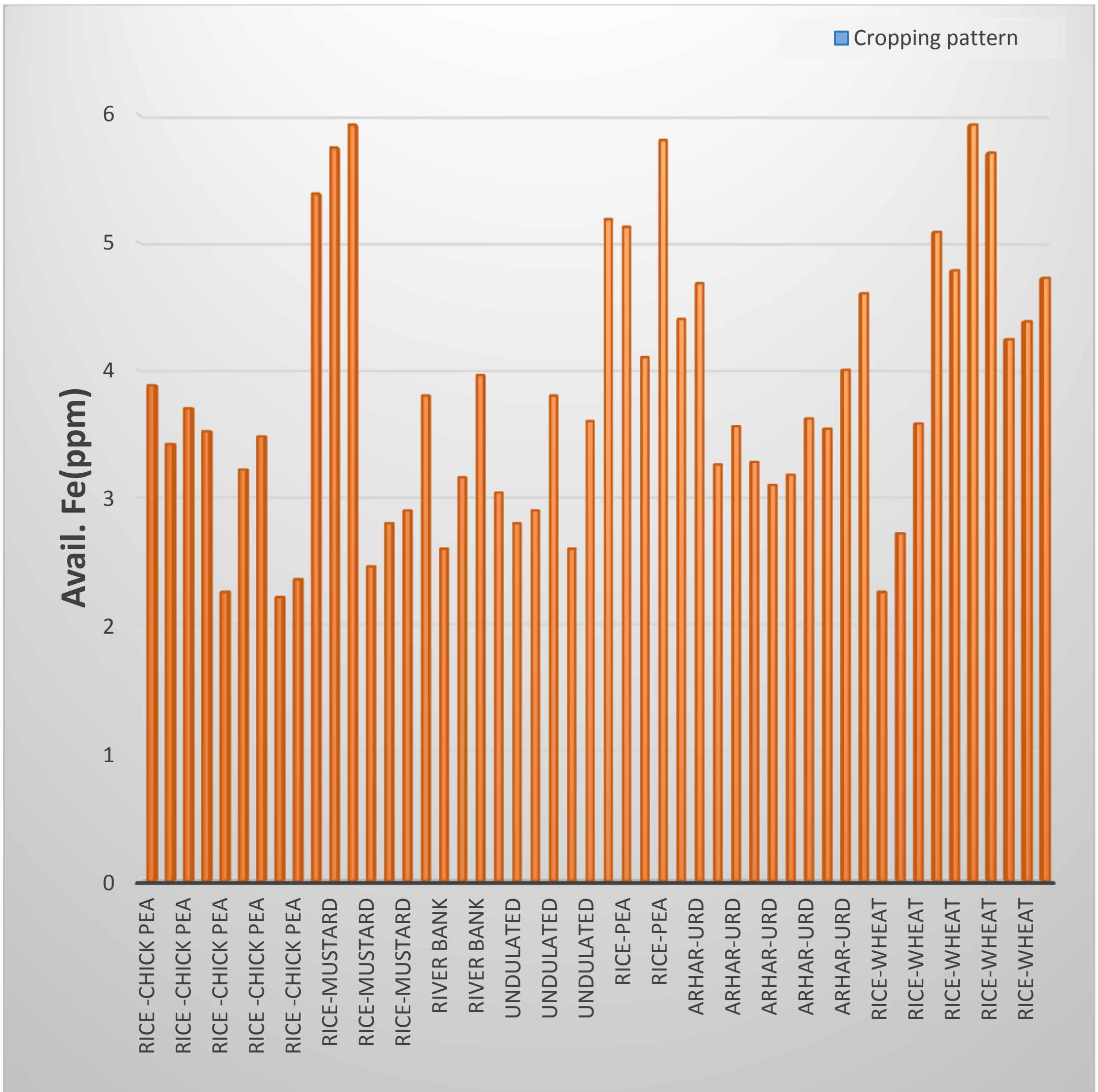

Fig. 4.19: Avail. Fe in soils of village Nisija

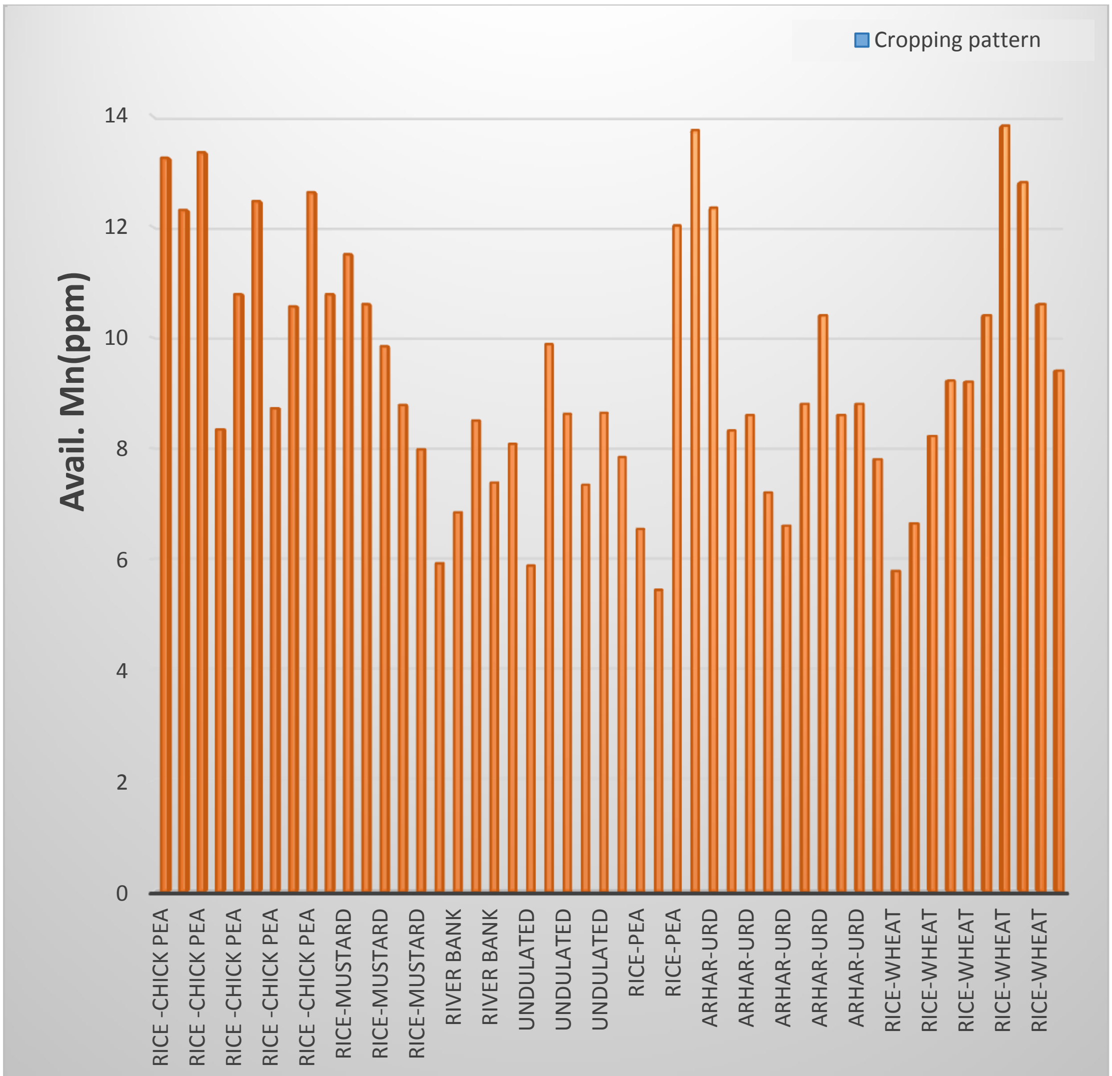

Fig. 4.20: Avail.Mn in soils of village Nisija

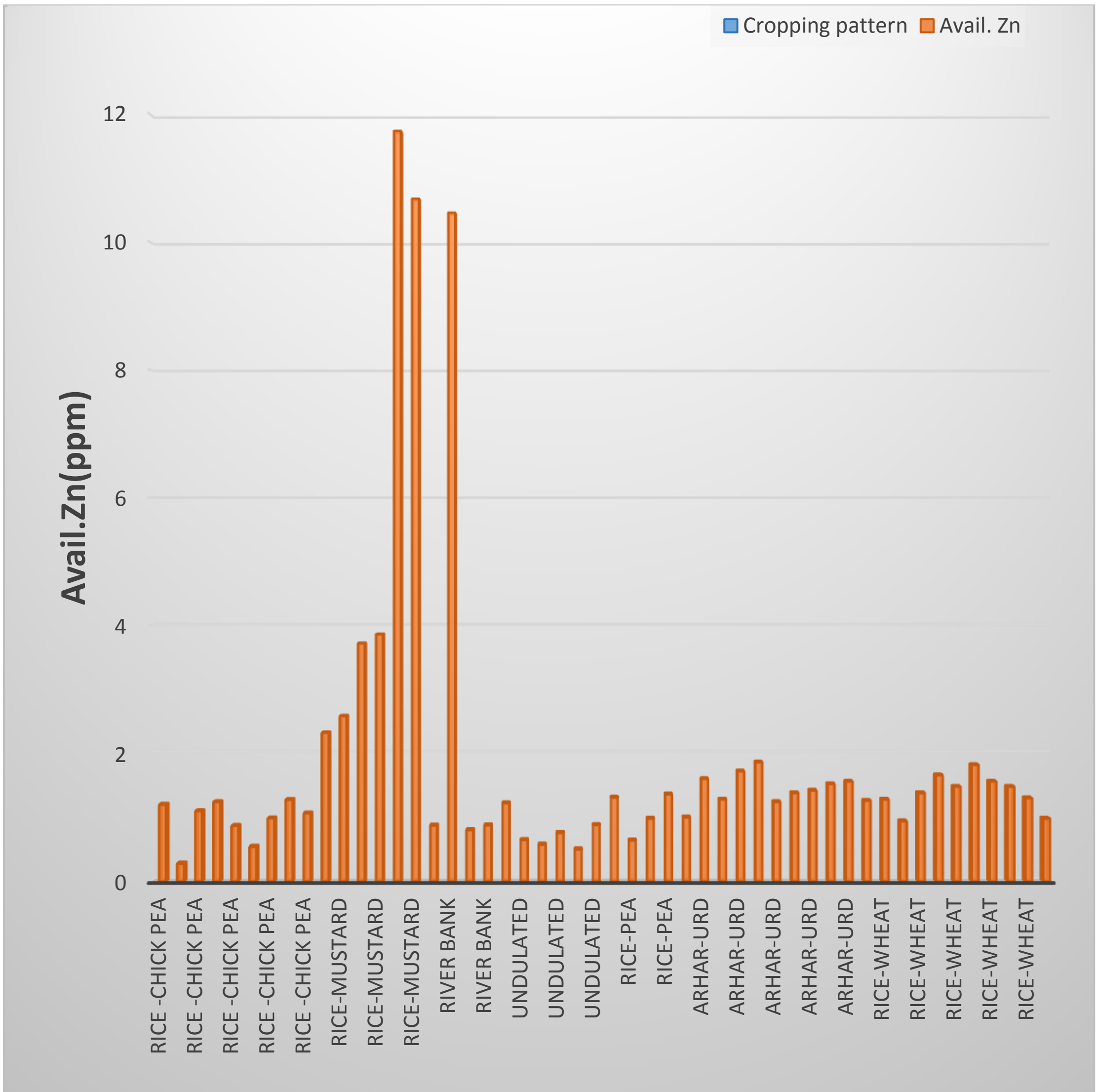

Fig. 4.21:Avail. Zn in soils of village Nisija

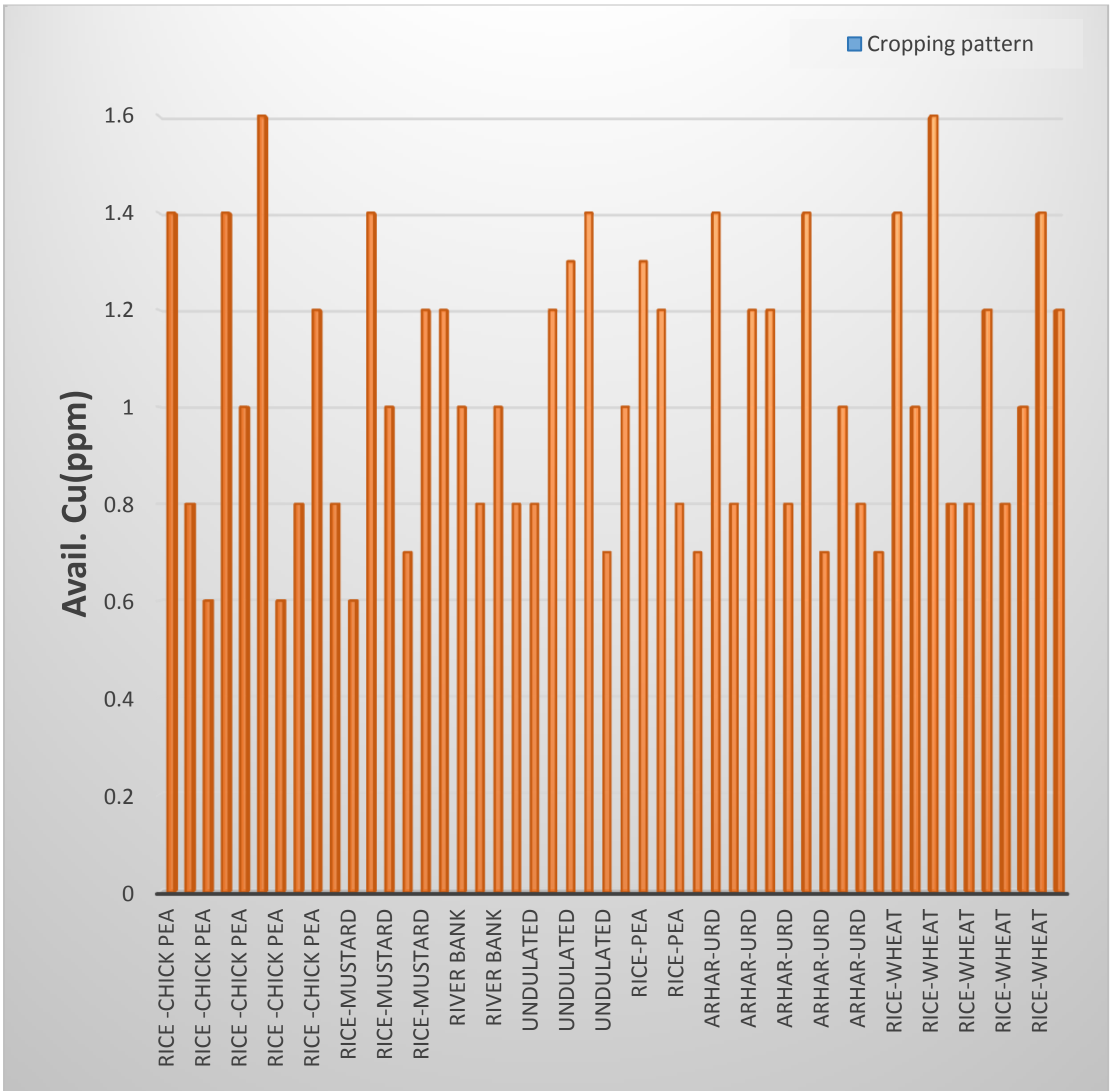

Fig. 4.22: Avail. Cu in soils of village Nisija

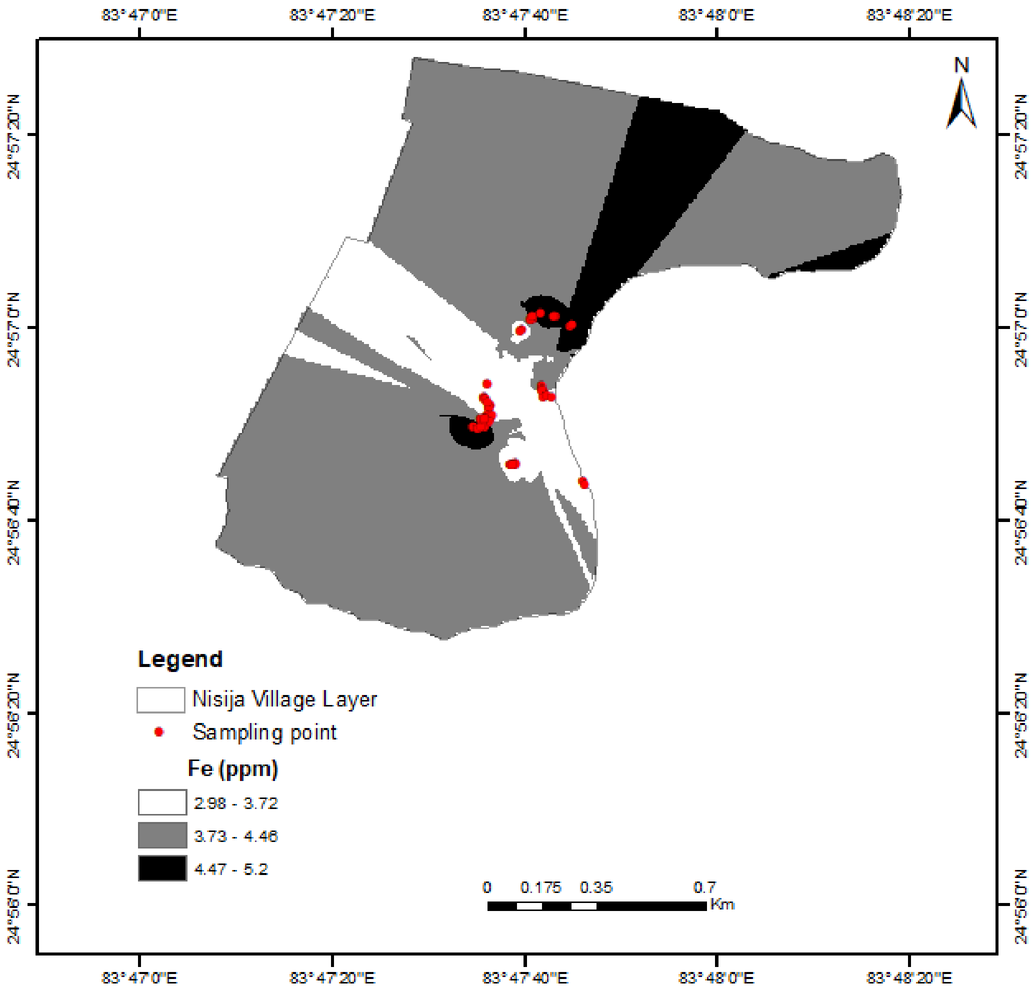

Fig. 4.23: Spatial variability map of available Fe in soils

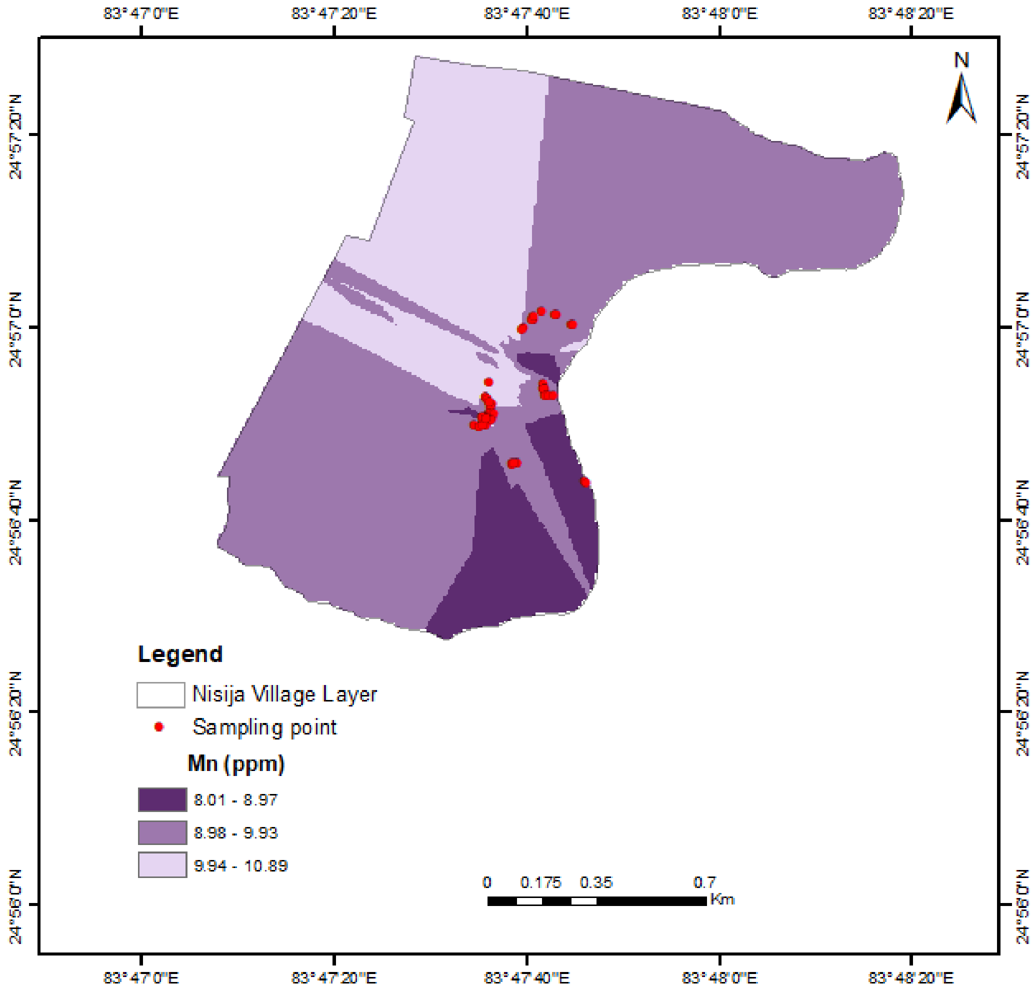

Fig. 4.24: Spatial variability map of available Mn in soils.

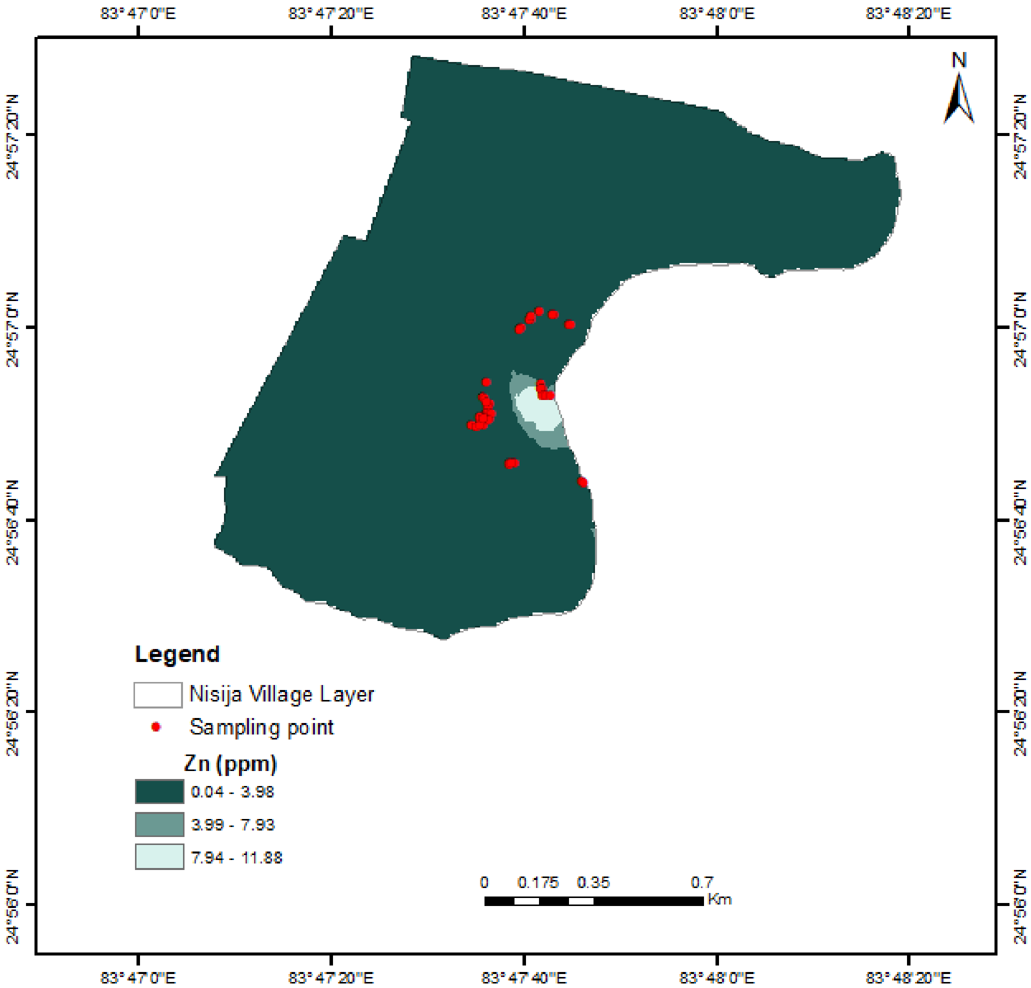

Fig.4.25: Spatial variability map of available Zn in soils

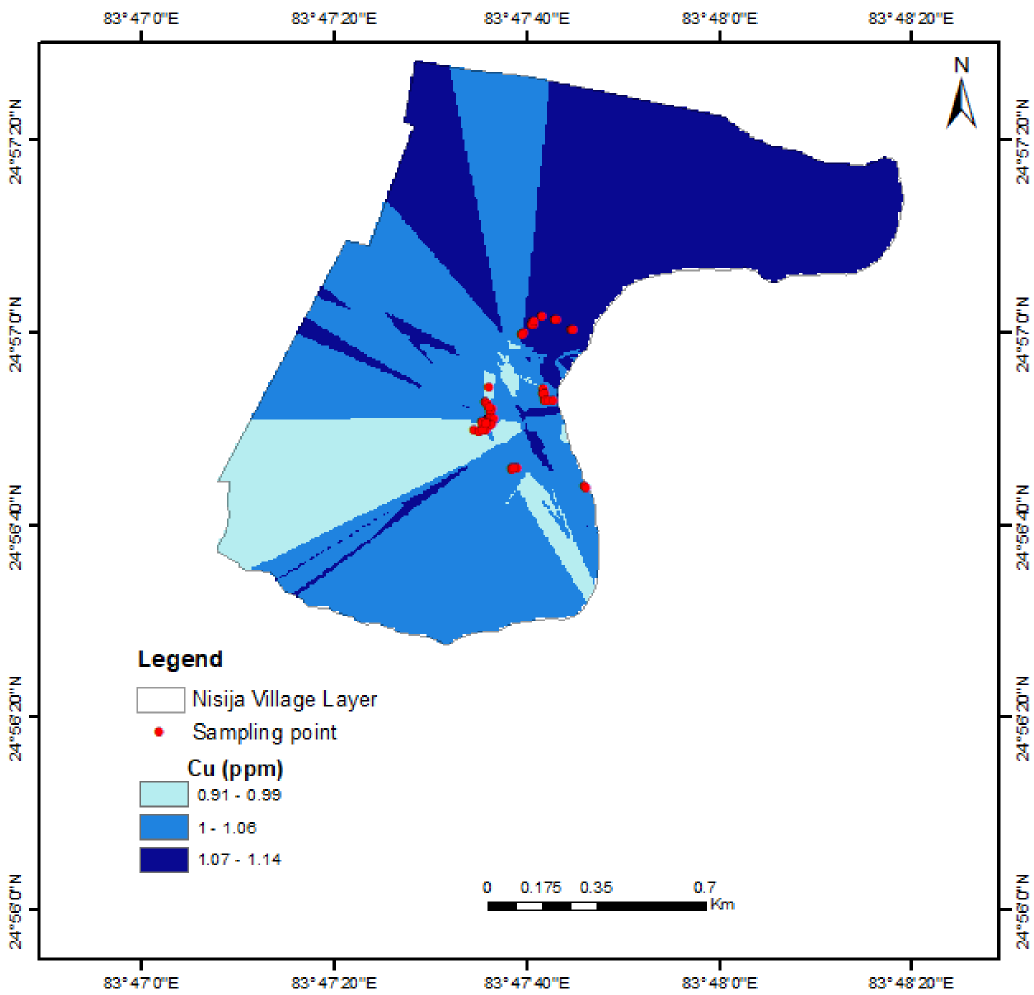

Fig. 4.26: Spatial variability map of available Cu in soils

4.6 Nutrient index

A single number for each nutrient was necessary to compare the soil fertility of one place to another. For assessing soil nutrient supplying capability to plants, Parker *et al*. (1951) presented a nutrient index approach. The soil fertility index is calculated using the sample proportions in each of three classes: low, medium, and high. The nutritional index values for organic carbon, nitrogen, sulphur, iron, and manganese in Nisija village are low, whereas phosphorus and potassium are medium.

Table 4.6.: Nutrient Index values of soils.

S.No.	Available nutrient	Nutrient index values	Category
1	Nitrogen	1.04	Low
2	Phosphorus	1.76	Medium
3	Potassium	1.86	Medium
4	Sulphur	1	Low
5	Organic carbon	1	Low
6	Copper	3	High
7	Manganese	1.08	Low
8	Iron	1.28	Low
9	Zinc	2.5	High

4.7 Correlation matrix between Physical and Chemical properties of soil of village Nisija dristict Kaimur Bihar

The pH of the soil samples was positively correlated with EC (t = 0.271**), which was significant at the 5% and 1% level of significance in the overall sample observation, and nitrogen (t = 0.134*). Phosphorus (t = 0.069), organic carbon (t = 0.098), calcium (t = 0.036), magnesium (t = 0.146), and zinc (0.027) were positively non-significantly correlated, whereas potassium (t = -0.229), sulphur (t = -0.207), sodium, iron (t = -0.039), and copper (t = -0.124) were negatively non-significantly correlated.

The EC of the soil samples was found to be positively associated to sulphur (t = 0.086*).

The EC of the soil samples was favourably non-significantly connected with nitrogen (t = 0.076), OC (t = 0.023), magnesium (t = 0.105), potassium (t=0.072), and calcium (t=). Phosphorus (t = -0.995) and calcium (t = -0.128) were negatively non-significantly correlated.

The bulk density of soil samples was negatively linked with porosity (t = -0.007**), which is significant at the 5% and 1% levels of significance, respectively. Water holding capacity (t = -0.30), particle density (t = -0.487), organic carbon (t = -0.044), nitrogen (t = -0.117), calcium (t = 0-.125), and sulphur (t =- 0.104) were likewise negatively non-significantly associated. Phosphorus (t = 0.918), potassium (t = 0.209), and magnesium (t = 0032) were positively non-significantly associated.

The particle density of soil samples was shown to be positively linked with porosity (t = 0.871**) and nitrogen (t = 0.129*), which is statistically significant at 5%.e soil samples' EC levels were positively non-significantly associated.

The particle density of soil samples was shown to be positively linked with porosity (t = 0.871**) and nitrogen (t = 0.129*), which is significant at the 5% and 1% levels of significance, respectively. Particle density was also positively non-significantly associated to water holding capacity (t = 0.004), organic carbon (t = 0.043), phosphorus (t=0.025), and sulphur (t = 0.011), but negatively non-significantly connected to potassium (t = -0.015), calcium (t = -0.052), and magnesium (t = -0.032).

Organic carbon (t = 0.31*) was favourably significant, as were nitrogen (t = 0.042), phosphorus (t = 0.036), potassium (t = 0.098), calcium (t = 0.153), and sulphur (t = 0.122), but magnesium (t = -0.010) was negatively non-significantly associated.

The porosity of the soil samples was shown to be positively associated to

Organic carbon (t = 0.056*), nitrogen (t=0.224*), phosphorus (t=0.071), and sulphur (t=0.034) were all positively significant, while potassium (t = -0.244), calcium (t = -0.119), and magnesium (t = -0.001) were all negatively non - significantly associated.

Organic carbon in soil samples was positively connected with nitrogen (t = 0.268**), calcium (t = 0.058**), and manganese (t = 0.065*) at the 5% and 1% level of significance, respectively, although phosphorus (t=0.589) was positively non-significantly correlated. And there was a non-significant negative connection between OC of soil and copper (t = -0.019).

Phosphorus (t = -0.078), copper (t = -0.049), manganese (t = -0.0036), and sulphur (t=-0.321) were negatively non-significantly correlated with available nitrogen in soil samples, while potassium (t=0.088), calcium (t = 0.073), magnesium (t = 0.105), and zinc (t=-0.179) were positively non-significantly correlated. The available phosphorus in soil samples was positively correlated with calcium (t = 0.150**), which is significant at the 5% and 1% levels of significance, as well as negatively non-significantly correlated with sulphur (t = -0.051) and copper (t = -0.024), but positively non-significantly correlated with potassium (t = 0.267), calcium (t=0.150).

The exchangeable potassium was shown to have a positive connection with calcium (t= 0.109**), manganese (t = 0.078**), and iron (t = 0.016*) at the 5% and 1% levels of significance. And soil K had a non-significant positive relationship with magnesium (t = 0.186), sulphur (t = 0.054), and copper (t = 0.033).

The calcium content of soil was shown to have a positive connection with magnesium (t= 0.628**) and sulphur (t= 0.047*), both of which are statistically significant at the 5% and 1% levels of significance, respectively. Calcium in soil has a positive association with magnesium (t= 0.628**) and sulphur (t= 0.047*), all of which are statistically significant at the 5% and 1% levels of significance, respectively. It is also negatively linked with zinc (t = -0.444). Copper (t = 0.087), iron (t = 0.94), and manganese (t = 0.165) were all positively non-significantly connected, but zinc (t = -0.398) was negatively non-significantly correlated.

The exchangeable Cu in soil was shown to have a positive connection with Zinc (t =0.071**) at the 1% and 5% level of significance. Cu has a substantial association with Zn in the overall sample observation. Zinc has a favourable relationship with manganese, iron, and copper. Manganese has a strong positive connection with available Fe in soil (t = 0.310**).

In our total sample observation, accessible Fe in soil revealed a significant positive association with manganese (t = 0.310**) at the 5% and 1% level of significance, as well as a positive non-significant relationship with Zinc (t = -0.148).

Table 4.7: Correlation matrix between physical and chemical properties of soil

	pH	*EC*	*B.D*	*P.D*	*POROSITY*	*W.H.C*	*O.C*	*N*	*P*	*K*	*Ca*	*Mg*	*Sulphur*	*Fe*	*Mn*	*Cu Zn*
pH	1															
EC	0.271**	1														
B.D	0.029	0.159	1													
P.D	-0.083	0.024	-0.487	1												
POROSITY	-0.129	-0.049	-0.007**	0.871**	1											
W.H.C	-0.079	-0.359	-0.030	0.004	-0.019	1										
O.C	0.098	0.023	-0.044	0.043	-0.056	0.031*	1									
N	0.034*	0.076	-0.117	0.129**	0.224*	-0.042	0.268**	1								
P	0.069	0.995	0.198	0.025	-0.071	-0.361	0.589	0.073*	1							
K	-0.229	0.072	-0.209	-0.303	-0.244	0.098	0.243	0.088	0.072	1						
Ca	0.036	-0.128	-0.125	-0.052	-0.119	-0.153	-0.058**	-0.073	0.140**	0.109**	1					
Mg	0.146	0.105	0.073	-0.032	-0.001	-0.010	-0.065	0.105	-0.117	-0.186	-0.628*	1				
Sulphur	-0.207	0.086*	-0.104	-0.011	0.034	0.122	-0.033	-0.321	0.040	-0.054	0.047*	-0.087	1			
Fe	-0.039	-0.101	-0.022	0.104	0.133	0.131	-0.187	-0.345	-0.125	-0.078**	0.163	-0.094	0.323	1		
Mn	-0.106	0.189	0.197	-0.024	-0.107	-0.091	-0.036	-0.105	0.191	0.016**	-0.148	0.165	0.102	0.310**	1	
Cu	-0.124	-0.020	-0.064	-0.034	0.002	0.163	-0.016	0.069	-0.027	0.033	-0.035	-0.009	-0.050	-0.089	-0.121	1
Zn	0.027	0.622	0.170	-0.121	-0.244	-0.179	0.151	0.071	0.648	0.161	0.444*	-0.398	-0.039	-0.148	-0.111	-0.071*1

Chapter V

SUMMARY AND CONCLUSION

The present study entitled **“*Appraisal of available macro and micro nutrient in soil of Nisija Kaimur by using G.P.S. and G.I.S. system*”**The collected soil samples were processed and analysed for availble nutrients in laboratory following standard procedures.An attempt was made to get the correlation of soil with nutrient and spatial variability map of sampled areas.The data recorded in the study were analysed statistically and the results are summarized below and presented under following headings:-

- The values of Bulk density and Particle density in the soil samples ranged from 1.1 to 1.4 Mg/m^3 and 1.94 to 2.91Mg/m^3 with a mean values of 1.20 and 2.27 Mg/m^3 respectively.
- The Porosity percentage in the soil samples ranged from 40.20% to 59.5 with a mean value of 46.53%, and the water holding capacity in the soil samples ranged from 29. 8% to 51.7%, with a mean value of 40.71%.
- The pH of the soil samples ranged from 6.8 to 9.1 with a mean value of 7.8 which revealed that soils of Nisija are neutral to strongly alkline. It was observed that 16%are neutal in reaction 42% are slightly alkaline and 40% are moderately alkline and rest 2% are strongly alkaline in reaction.
- The Electrical Conductivity in the soil samples of village Nisija ranged from 0.1 to 1.0 dSm^{-1} with a mean value of 0.23 dSm^{-1}. It was observed that 100% of the samples are in permissible range and none of the samples are higher than the permissible range.
- The organic carbon content in the soil samples ranged from 0.3 to 0.5% with a mean value of 0.44%. All samples are in low organic carbon content.
- The nitrogen content in soil of village Nisija ranged from 100.4 to 414.0 Kg ha^{-1} with a mean value of 175.44 Kg ha^{-1}.Majority of soil samples were in low catogery.

- Available phosphorus content in the soils of village Nisija ranged from 8.0 to 12.5 Kg ha^{-1} with a mean value of 10.45 Kg ha^{-1}. Out of 50 sample 98% of soil samples were in low range, 2%% were in medium range
- The potassium content in the soil of villager Nisija ranged from 107.6 to 236.8 Kg ha^{-1} with a mean value of 10.45 Kg ha^{-1}. Out of 50 sample 12% of the samples were in low potassium range, 88% of the soil samples were in medium range.
- The calcium content in soils of village Nisija is in high range. The exchangeable calcium in the soil samples ranged from 0.9 to 5.5 Meq/100g with a mean value of 2.80 Meq/100g. Out of 50 sample 92% of the soil samples were in high &8% of the soil samples were in low range.
- The magnesium content in soils of village Nisija ranged from 1.4 to 9.8 Meq/100g with a mean value of 4.90 Meq/100g. All the samples is in high range.
- The sulphur content in soil samples are in low range. The available sulphur ranged from 2.1 to 5.9 mg kg^{-1} with a mean value of 3.94 mg kg^{-1}. All the samples were in low status of sulphur.
- The DTPA extractable iron in soils of village Nisija ranged from 2.2 to 5.9 mg kg^{-1} with the mean value of 3.81 mg kg^{-1}. Out of 50 samples 74% of the soil samples were in low concentration of iron where as 26% were in medium.
- The DTPA extractable manganese content in soils of village Nisija ranged from 5.4 to 13.8 mg kg^{-1} with a mean value of 9.36 mg kg^{-1}. Majority of samples arwe in sufficient range of Mn concentration.
- The DTPA extractable zinc content in soils pof village Nisija are ranged from 0.3 to 11.7 mg kg^{-1} with the mean value of 1.90 mg kg^{-1}. Out of 50 sample 42% of the samples were in low zinc content,6% of were found medium in Zn content and 52% are in high content.

- The copper content of the soils of vuillage Nisija ranged from 0.6 to 1.6 mg kg^{-1} with the mean value of 1.03 mg kg^{-1}. All the samples are high in available copper content

The nutrient index range of soil samples were low for organic carbon, nitrogen and sulphur, medium for phosphorus and potassium and high for micronutrient cations Cu, Zn & low for Mn and Fe.

Conclusion

The soil analytical data of Village Nisija clearly indicates that soils are neutral to strongly alkaline in reaction with normal soluble salt content. The content of organic carbon, nitrogen, sulphur,Iron and Manganese classified as in low category, phosphorus and potassium in medium category and micronutrient cations (Cu and Zn) in high category. The information of the present study could be useful for farmers regarding the quality of produce, increasing the percentage yield of crops through soil conservation and better environmental protection.

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