International Research Journal of Environmental Sciences ISSN 2319–1414
Vol. **10(2),** 24-37, April **(2021)** *Int. Res. J. Environmental Sci.*

GIS–based soil fertility mapping in agro ecological units of central part of Kerala, India

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Available online at: www.isca.in, www.isca.me
Received 2nd July 2020, revised 24th December 2020, accepted 7th February 2021

Abstract

This study was conducted to evaluate and map the fertility status of soils in Thrissur District located at central part of Kerala, comprising six agro ecological units. A total of 5120 surface soil samples (0-15cm) were collected (one soil sample @ 1ha) along with associated informations on farmer's name, soil type, fertilizer application, irrigation etc. The collected samples were air dried and sieved through 2mm sieve. The analyzed soil data were classified as low, medium and high categories based on soil fertility ratings, and parker's nutrient index was calculated. Each agro ecological unit was characterized based on soil nutrient index value with respect to each soil parameter such as pH, EC, OC, N, P, K, Ca, Mg and S. In the study area soil pH varied from acidic to slightly alkaline (2.9 - 7.7). Soil reaction index was neutral in northern coastal plain and acidic in all the others. Salt index was normal in six AEUs. Among the six agro ecological units, status of N, P and K was high in northern and southern high hills. Acute deficiency of K and S was well observed in northern central laterite. High accumulation P was observed in all the agro ecological units.

Keywords: Agro ecological units, primary and secondary nutrients, soil fertility, soil nutrient index.

Introduction

Sustainable agricultural development requires systematic efforts towards the land management practices in most appropriate way. Agro ecological zoning is the practical approach is to subdivide the area of interest into smaller zones with similar biophysical attributes[1]. FAO has developed and successfully applied the agro ecological zones methodology to analyze solutions to various problems of land resources for planning and management for sustainable agricultural development at regional, national and sub national levels. World's population increasing rapidly at the same time natural resources such as soil and water declining both in quality and quantity. The basic problem is that the productive capacity of land is mainly set by climate, soil and land forms conditions. In this context agro ecological zoning can be regarded as a set of applications leading to an assessment of land suitability and potential productivity in terms of climate, soil and landforms conditions[2]. Soil fertility is dynamic natural resources which can change under the influence of natural and manmade activities. It is essential that the nutrient supplying capacity of soil be continuously monitored to ensure and improve sustainability of agriculture. Continuous cropping with increased yield dose of chemical fertilizers remove substantial amounts of nutrients from the soil that must be replaced to sustain soil health and increase crop productivity.

For improving crop production, soil should provide the essential macro and micro nutrients in optimum level and farmers should know the fertility status of their own soil. Soil testing is the important method for evaluating the health of the soil and giving fertilizer recommendations to farmers.

The varying environmental situations have resulted in a greater variety of soils. Therefore the systematic appraisal of agro ecological regions has tremendous scope in grouping relatively homogeneous regions in terms of soil[3]. This study indicates which areas likely to have soil fertility problems and provide valuable information to diagnoses and predict fertilization needs. The site specific nutrient management practices reduce the cost of cultivation and environmental pollution due to the imbalanced application of chemical fertilizers. As fertilizers make up a small share of the total production costs in many developed countries, farmers often apply fertilizers in excess of recommended levels in order to ensure high yields. Such oversupply of nutrients leads to environmental contamination. Through proper soil management, the farmer should know what amendments are necessary to optimize the productivity of soil for specific crops. This study mainly focused on the fertility evaluation of soils in the central part of Kerala, comprising sic agro ecological units, and spread over entire area in Thrissur District.

Materials and methods

Study area: Study area is situated in the central part of Kerala covering the entire area in Thrissur District lying between north latitudes 10°31' and 10°52' and east longitudes 76°13' and 76° 21', the district is bound on the north by Malappuram and Palakkad districts, east by Palakkad district, south by Ernakulam district and west by Lakshadweep Sea. Administratively, the district is divided into 5 taluks, one corporation, 6 municipalities, 254 villages, 17 block panchayats and 92 grama panchayats covering a geographical area of 3032km^2. Descending from the heights of Western Ghats in the east, the land slopes towards the west forming three distinct natural divisions, the highland, the mid land and sea board. The district has a tropical humid climate with an oppressive hot season and plentiful seasonal rainfall. Annual rainfall is about 3000mm.

Archaean crystalline formation (gneiss, schist and charnockite), tertiary formation, sub-recent laterite and recent riverine alluvium are the major geological formations of the district. Five rivers and their tributaries drain the district: Periyar, Chalakkudy, Karuvannur, Karumali and Bharathapuzha. They all take their origin from the mountains in the east, flow westward and discharge into the Kole lands or sea. Major soil types in the district include laterite soil, brown hydromorphic soils, hydromorphic saline soils, coastal alluvium, riverine alluvium and forest loamy soil. Sandy loam soil is found in the part of Mukundapuram, Thrissur and Chavakkad taluks. Laterite soil is common in eastern part of Thrissur and western part of Thalappally taluks. Clayey soil is found in Mukundapuram taluk and portions of Chavakkad taluk. Hydromorphic saline soil is seen in coastal tracts of Thrissur, where during rainy season the fields are flooded leaving the area almost free of salt.

Thrissur district is spread over different agro ecological units such as northern central laterite, northern coastal plain, kole lands, pokkali lands, northern high hills and southern high hills.

Methods: A total of 5120 surface soil samples (0-15cm) were collected randomly from various agro ecosystems of the study area, depending on the size of the land under cultivation @ one sample ha $^{-1}$ of each agro ecosystem belonging to six agro ecological units in the district. The details of soil samples collected are given in Table-2. The details regarding farmer's name, soil type, fertilizer application, irrigation etc. were recorded. The collected samples were then air dried and sieved through 2mm sieve. The processed soil samples were analyzed for pH in 2:5 soil water suspension and electrical conductivity by using conductivity meter[4], organic carbon[5] wet digesion method and available phosphorous by using spectrophotometer[6]. Exchangeable K, Ca and Mg were estimated from neutral ammonium acetate extract of the soil and the filtrate was used to determine K using digital type Elico (CL-360) flame photometer[4]. The same filtrate was used to estimate Ca and Mg using atomic absorption spectrophotometer (Varian model. 240). Sulphur was extracted by 0.15% $CaCl_2$ solution and extract is measured by turbidimetric procedure[7].

Parker's nutrient index: In order to compare the levels of soil fertility of one area with those of another, it is necessary to obtain a single value for each nutrient. The percentage of samples in each of the three classes; low, medium and high were multiplied by 1, 2 and 3 respectively. The sum of the figure thus obtained was divided by 100 to give the index or weighted average[8].

NIV = No. of samples (low) x 1 + No. of samples (medium) x 2 + No. of samples (high) x 3) / Total No. of samples.

Major nutrients - if the index < 1.67 - low fertility, 1.67 to 2.33 - medium fertility, > 2.33 - high fertility[9]

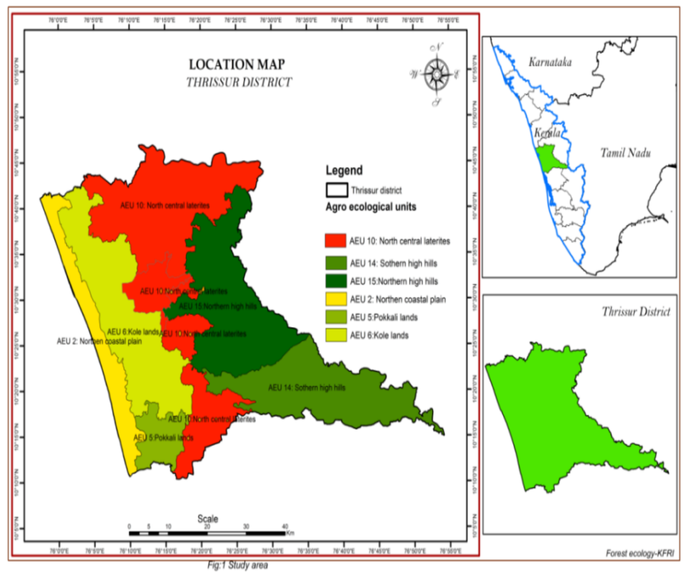

Figure-1: Location map of Thrissur district.

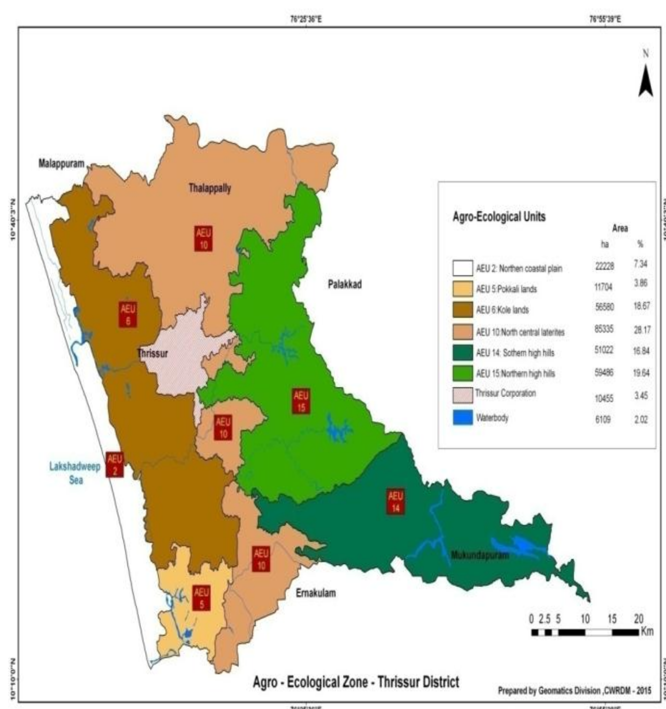

Figure-2: Agro ecological units of Thrissur district.

Table-1: Agro ecological units (AEUs) in Thrissur district[10].

Agro ecological zones	Area(ha)	% of TGA	Mean annual temperature (^{0}C)	Mean annual rainfall (mm)
AEU1: Northern central laterite	85,335	28.17	27.6	2934
AEU2: Northern coastal plain	22,228	7.34	27.6	3183
AEU3:Kole lands	56,580	18.67	27.6	2902
AEU4:Pokkali lands	11,704	3.86	27.8	3359
AEU5:Northern high hills	51,022	16.84	21.6	4034
AEU6:Southern high hills	59,486	19.64	27.3	2963

Table-2: Details of soil samples collected from the study area.

Agro ecological units						Total No. of samples
Northern coastal plain	Northern central laterite	Kole lands	Pokkali lands	Northern high hills	Southern high hills	
983	2061	418	424	811	423	5120

Soil fertility mapping: The data on various properties of 600 georeffered soil samples were used to prepare thematic soil fertility maps. Soil samples were representing different agro ecological units of Thrissur district and geo referencing was done using a hand held GPS. Thematic maps were generated for each of the soil nutrients using inverse distance weighted (IDW) interpolation using Arc GIS10 software (CWRDM, Kozhikode). Base map of the Thrissur district was digitized and georeferenced. Polygons were superimposed on the georeffered map. Latitude, longitude and analysed data were entered into attribute table and linked to Arc GIS10 software for making thematic maps.

Results and discussion

In order to evaluate the fertility status of soils in the study area, different indices like soil reaction index, salt index and nutrient index with respect to soil pH, electrical conductivity, organic carbon, nitrogen, available phosphorous, potassium, calcium, magnesium and sulfur were calculated based on soil fertility rating chart and then fertility maps were drawn.

Basic properties of soils: The pH of the soils of various AEUs varied from 2.9 to 8.4 indicating extremely acidic to slightly alkaline in reaction (Table-3). The measure of soil pH is an important parameter which helps in identification of chemical nature of the soil as it measures hydrogen ion concentration in the soil to indicate its acidic and alkaline nature.

The mean pH of all the AEUs were belongs to the soil reaction index I, which indicate the acidic category acidic (<6). The pH in Varahi river basin in Rajasthan varied from 7.04 to 7.99 indicating neutral to slightly alkaline nature and belongs to soil reaction index II, which indicate neutral (6 - 8)[11].

The acidity of the study area is aggravated by heavy input of acidic fertilizers and lack of inputs to neutralize acidity. High rain fall coupled with leaching of bases from the soil and increased the activity of exchangeable aluminum in the soil lead to the development of soil acidity[12].

The data on the extent of area under different classes of pH (Table-8) revealed that, the moderately acidic soils were distributed in larger area (37.84%) extending to about 1146.6 km^2. This was followed by strongly acidic (858.12km^2), slightly acidic (441.29km^2), very strongly acidic (430.44km^2), extremely acidic (91.91km^2), neutral (61.27km^2) and slightly alkaline (0.37km^2) (Table-8).

Elevated levels of soil acidity is due to intensive rainfall that could leach soluble nutrients such as Ca and Mg, and with subsequent replacement by aluminum and hydrogen ions. Soils of the central laterite and high hills were strongly acidic to moderately acidic. Continuous use of acid forming inorganic fertilizers on acid soils also aggravate soil acidity. In order to tackle the problem with high acidity, liming of soils in accordance with soil test results is recommended.

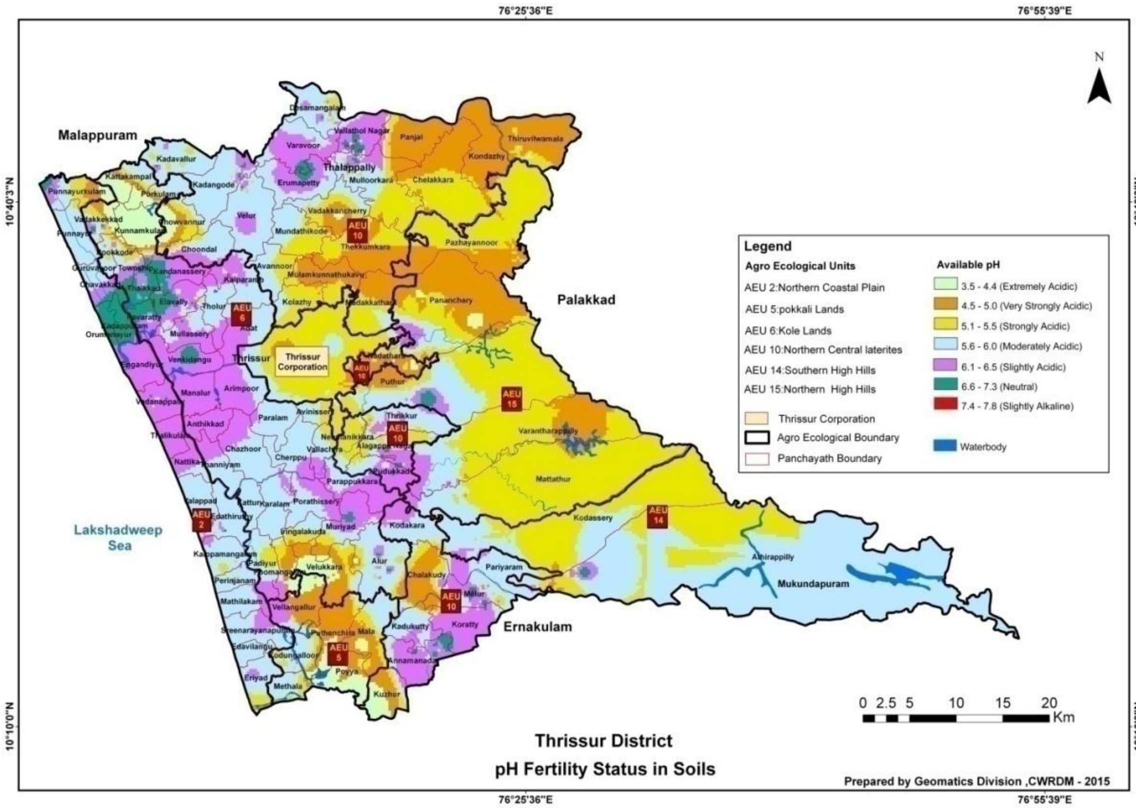

Figure-3: Status of soil pH in various agro AEUs in Thrissur district.

Table-3: Descriptive statistics of basic properties of soils in six agro ecological units of the study area.

Soil nutrients	Agro ecological units	Mean	Std. Deviation	CV	Std. Error	Minimum	Maximum
pH	AEU1	5.4	0.8	14.8	0.01	2.7	8.4
	AEU2	6	0.4	6.7	0.02	4	7.4
	AEU3	5.8	0.9	15.5	0.04	3.3	7.7
	AEU4	4.9	0.8	16.3	0.03	2.9	7.2
	AEU5	5.6	0.7	12.5	0.02	3.2	7.5
	AEU6	5.6	0.5	8.9	0.03	4	7.2
Electrical conductivity (dS/m)	AEU1	0.1	0.2	200	0.01	0.01	3.5
	AEU2	0.1	0.1	100	0.01	0.01	1.5
	AEU3	0.2	0.4	200	0.02	0.01	3.5
	AEU4	0.7	1.4	200	0.06	0.01	6.4
	AEU5	0.1	0.2	200	0.01	0.01	3.7
	AEU6	0.1	0.2	200	0.02	0.02	2.4
Organic Carbon (%)	AEU1	1.4	0.8	57.1	0.01	0.1	8.9
	AEU2	1.1	0.9	81.8	0.03	0.1	5.2
	AEU3	1.3	1	76.9	0.04	0.1	7.7
	AEU4	1.5	1.1	73.3	0.04	0.1	9.5
	AEU5	1.7	0.8	47.1	0.03	0.1	7.6
	AEU6	1.9	0.6	31.6	0.04	0.8	3.9

Nitrogen (%)	AEU1	0.019	0.011	60.4	0.0002	0.001	0.12
	AEU2	0.0152	0.012	79.4	0.0004	0.001	0.07
	AEU3	0.0178	0.014	78.4	0.0006	0.001	0.11
	AEZU4	0.0209	0.015	71.5	0.0006	0.001	0.13
	AEU5	0.0231	0.011	49.7	0.0004	0.001	0.11
	AEU6	0.0265	0.009	34.2	0.0006	0.01	0.05
Phosphorous (kg ha^{-1})	AEU1	34.9	24.6	70.5	0.5	0.2	85.1
	AEU2	107.7	13.1	12.2	0.4	85.1	130.4
	AEU3	148.3	10.7	7.2	0.4	130.6	168
	AEU4	196.8	17.6	8.9	0.7	168.2	229.4
	AEU5	340	77.6	22.8	2.4	229.5	509
	AEU6	628.8	103	260.4	124.5	509.3	987.4
Potassium (kg ha^{-1})	AEU1	88.1	36.3	41.2	0.7	1.5	160.2
	AEU2	193.1	19.6	10.2	0.7	160.2	228.5
	AEU3	263.7	21.2	8	0.8	228.5	300.2
	AEU4	338.4	23.1	6.8	0.9	300.2	378.6
	AEU5	518.5	111.6	21.5	3.4	378.6	793
	AEU6	1281.4	591	46.1	37.5	794.2	5754.6
Calcium (mg kg^{-1})	AEU1	609.9	371.4	60.9	6.8	20.6	3780
	AEU2	481.1	323	67.1	10.8	28.5	1500
	AEU3	520.2	345.4	66.4	13.7	75	1888.5
	AEU4	308.6	259.8	84.2	10.5	32.6	1306.2
	AEU5	484.3	237	48.9	7.3	45.2	1525
	AEU6	506	302.6	59.8	19.2	21.4	1476
Magnesium (mg kg^{-1})	AEU1	103	70.1	68.1	1.3	0.2	722
	AEU2	41.3	22	53.3	0.7	5.4	211.5
	AEU3	97.7	63.7	65.2	2.5	5.7	516.3
	AEU4	46.6	26.2	56.2	1.1	7.7	366
	AEU5	90.6	71.6	79	2.2	9.2	500.3
	AEU6	86.9	56.2	64.7	3.6	2.4	282.6
Sulphur (mg kg^{-1})	AEU1	9.7	15.2	156.7	0.3	0.03	441.3
	AEU2	15.7	24.8	158	0.8	0.1	575
	AEU3	15.7	28.9	184.1	1.1	0.1	196
	AEU4	86.1	110.8	128.7	4.5	0.1	583.6
	AEU5	11.3	10.3	91.2	0.3	0.1	61.4
	AEU6	9	8.5	94.4	0.5	0.1	54.7

Table-4: Correlation coefficient of soil characteristics with respect to soil nutrients.

Soil parameters	Nitrogen	Phosphorous	Potassium	Calcium	Magnesium	Sulphur
pH	.428**	.224**	.209**	.853**	.376**	.183**
Electrical conductivity	.420**	.066**	.074**	.230**	.191**	.843**
Organic carbon	.972**	.291**	.286**	.475**	.460**	.436**

** Correlation is significant at the 0.01 level (2-tailed).

Table-5: Index values of soil basic properties in six AEUs of Thrissur district.

Agro ecological units	pH	Electrical conductivity (dS/m)	Organic carbon (%)
	Soil reaction index	Salt index	Nutrient index
AEU1	Acidity	Normal	Medium
AEU2	Neutral	Normal	Medium
AEU3	Acidity	Normal	Medium
AEU4	Acidity	Normal	Medium
AEU5	Acidity	Normal	High
AEU6	Acidity	Normal	High

Table-6: Nutrient Index values in the soils of soil nutrients in six AEUs in Thrissur district.

Soil nutrients	AEU1	AEU2	AEU3	AEU4	AEU5	AEU6
Nitrogen (%)	2.2	1.9	2	2.1	2.4	2.7
Phosphorus (kg ha^{-1})	2.4	3	3	3	3	3
Potassium (kg ha^{-1})	1.3	2	2.3	3	3	3
Magnesium (mg kg^{-1})	2.5	1.5	2.4	1.6	2.2	2.2
Sulphur (mg kg^{-1})	1.6	1.9	1.8	2.3	1.8	1.7

Table-7: Nutrient Index based fertility status of six AEUs in Thrissur district.

Soil nutrients	AEU1	AEU2	AEU3	AEU4	AEU5	AEU6
Nitrogen (%)	Medium	Medium	Medium	Medium	High	High
Phosphorous (kg ha^{-1})	High	High	High	High	High	High
Potassium (kg ha^{-1})	Low	Medium	Medium	High	High	High
Magnesium (mg kg^{-1})	High	Low	High	Low	Medium	Medium
Sulphur (mg kg^{-1})	Low	Medium	Medium	High	Medium	Medium

Electrical conductivity of the soils of various AEUs in the study area varied from 0.01-6.4dS/m. Conductivity is the measure of current carrying capacity and it gives a clear idea of soluble salts present in the soil. High conductivity is usually associated with clay rich soils and low conductivities are associated with sandy and gravelly soils[11]. The mean values of EC in all the AEUs in the study area belongs to the salt index I, which indicate the normal range (< 1dS/m). Similaring results were obtained in Rajasthan, where the EC varied from 0.03 to 0.23 dS/m, and belonging to the salt index I[11]. A significant positive correlation of EC with all the macronutrients were also noted in this study. The soils with EC greater than 4 dS/m were considered as saline[13]. In light of this in Pokkali lands 4.4% of samples were saline in nature.

The data on the extent of soils under different classes of EC (Table-8) revealed that the major area of the district was non saline (2901.08km^2). Medium saline soils were spread over 110.85km^2 area and high saline soils confined only to 18.07km^2. Lesser salinity might be due to the leaching of cations by heavy rainfall in the study area, and the high saline areas are located adjacent to the coastal area. The accumulation of high soluble salts normally not expected in areas of high rainfall, and acidic soils such as those of the present study area.

Table-8: Extent of area under different classes of soil parameters.

Soil Parameter	Range	Status	Area (km^2)	% Area
pH	3.5 – 4.4	Extremely Acidic	91.91	3.03
	4.5 – 5.0	Very Strongly Acidic	430.44	14.21
	5.1 – 5.5	Strongly Acidic	858.12	28.32
	5.6 – 6.0	Moderately Acidic	1146.6	37.84
	6.1 – 6.5	Slightly Acidic	441.29	14.56
	6.6 – 7.3	Neutral	61.27	2.02
	7.4 – 7.8	Slightly Alkaline	0.37	0.01
	Total		3030	100
EC (ds/m)	< 1	Low	2901.08	95.75
	1 – 3	Medium	110.85	3.66
	> 3	High	18.07	0.6
	Total		3030	100
OC (%)	< 0.76	Low	352.5	11.63
	0.76 – 1.50	Optimum	1133.11	37.4
	> 1.50	Above optimum	1544.39	50.97
	Total		3030	100
N (%)	< 0.01	Low	687	22.67
	0.01 – 0.02	Optimum	1301.56	42.96
	> 0.02	Above optimum	1041.44	34.37
	Total		3030	100
P (kg ha^{-1})	< 10	Low	34.5	1.14
	10 – 24	Optimum	55.18	1.82
	> 24	Above optimum	2940.32	97.04
	Total		3030	100
K(kg ha^{-1})	< 115	Low	463.01	15.28
	115 – 275	Optimum	1369.78	45.21
	> 275	Above optimum	1197.21	39.51
	Total		3030	100
Ca (mg kg^{-1})	< 150	Very Low	67.37	2.22
	151 – 300	Low	198.83	6.56
	> 300	Optimum	2763.8	91.21
	Total		3030	100
Mg (mg kg^{-1})	< 60	Very Low	698.09	23.04
	60 – 120	Low	1842.01	60.79
	> 120	Optimum	489.9	16.17
	Total		3030	100
S(mg kg^{-1})	< 5	Low	574.93	18.97
	5 – 10	Optimum	1242.51	41.01
	> 10	Above optimum	1212.56	40.02
	Total		3030	100

Organic carbon content of the soils of various agro AEUs varied from 0.1- 9.5% indicating its wide variation in the study area. Soils of high hills had relatively high content of OC and this on decomposition might be releasing more carbon into the soil[12]. Heavy leaching of OC through running water coupled with lack of replenishment might be the reason for its deficient levels in other agro ecological units. Based on soil nutrient index, the OC status was high in high hills and medium in all the other AEUs. But in Karnataka low status of OC was reported in all the soil samples, they analysed[11].

The data on OC given in Table-8 revealed that the soils with higher OC are distributed in larger area (1544.39km^2) followed by those with optimum levels (1133.11km^2). The soils with low content of OC was distributed only in smaller area extending to about 352.5km^2. The high content of OC in high hills might be due to the slow rate of mineralization and decomposition whereas its accumulation in special AEUs such as pokkali and kole lands is attributed to the deposition of peat occurred during the evolution of landscapes millions of years ago.

Primary nutrients: Content of nitrogen in the soils of various AEUs varied from 0.001-0.13%. Soils of high hills had relatively high content of OC and this on decomposition might be enriching the soil with more N. Heavy leaching of N through running water and insufficient stock of organic carbon to supply N might be the reason for its deficient levels in other AEUs. Nitrogen was significantly and positively correlated with OC similar to the results observed in Kodagu district[14] and in selected regions of Karnataka[15]. This indicates enhanced availability of N with higher organic matter content.

About 42.96% of the area, extending about 1301.56km^2 optimum in the content of N in the soils of the district, 34.37% (1041.44km^2) above optimum and 22.67% (687km^2) low (Table-8).

High status was noted mainly in high hills, which is attributed to the decomposition and further release of N from higher levels of organic matter in the soil.

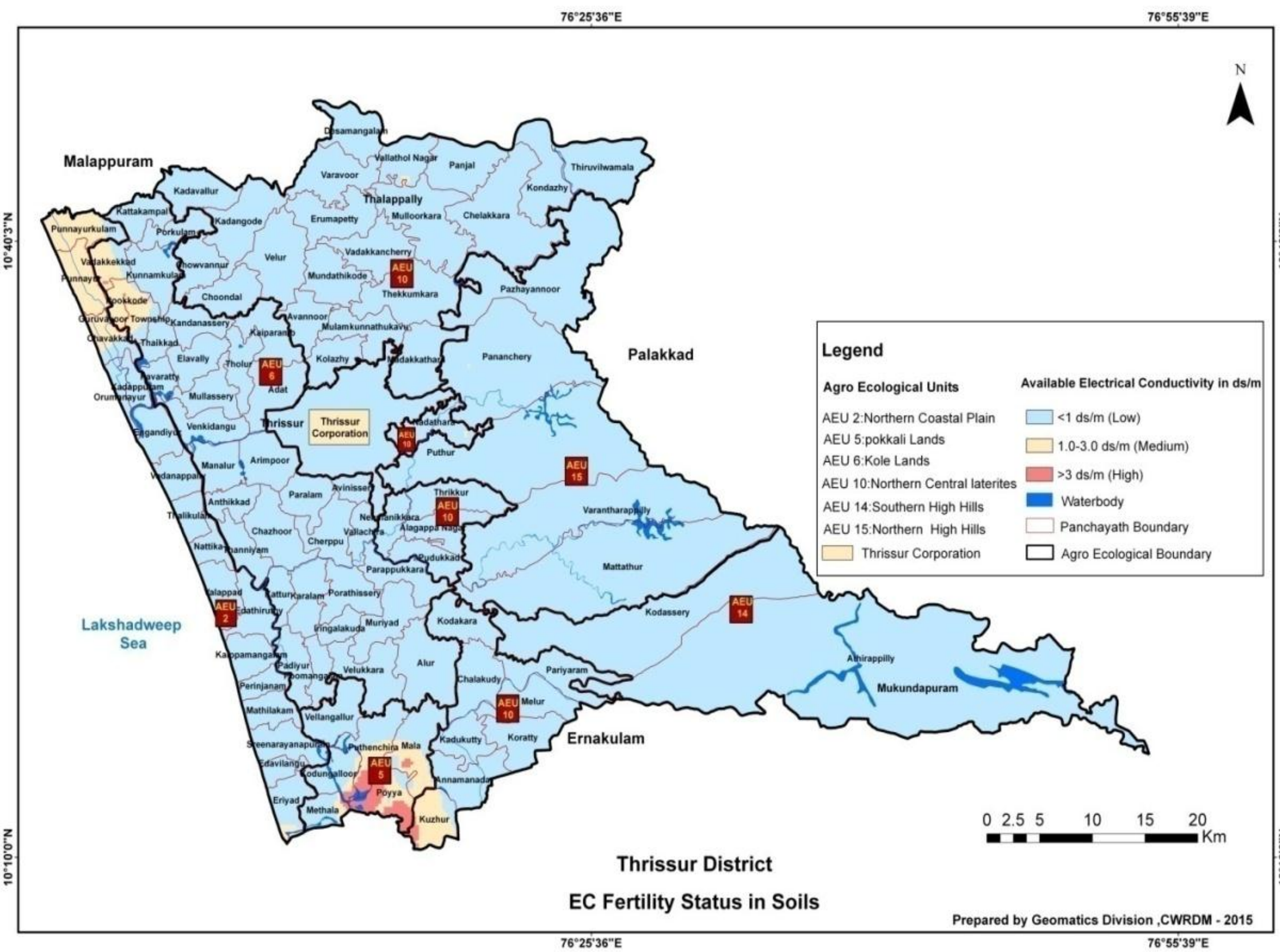

Figure-4: Status of EC in the soils of various AEUs in Thrissur district.

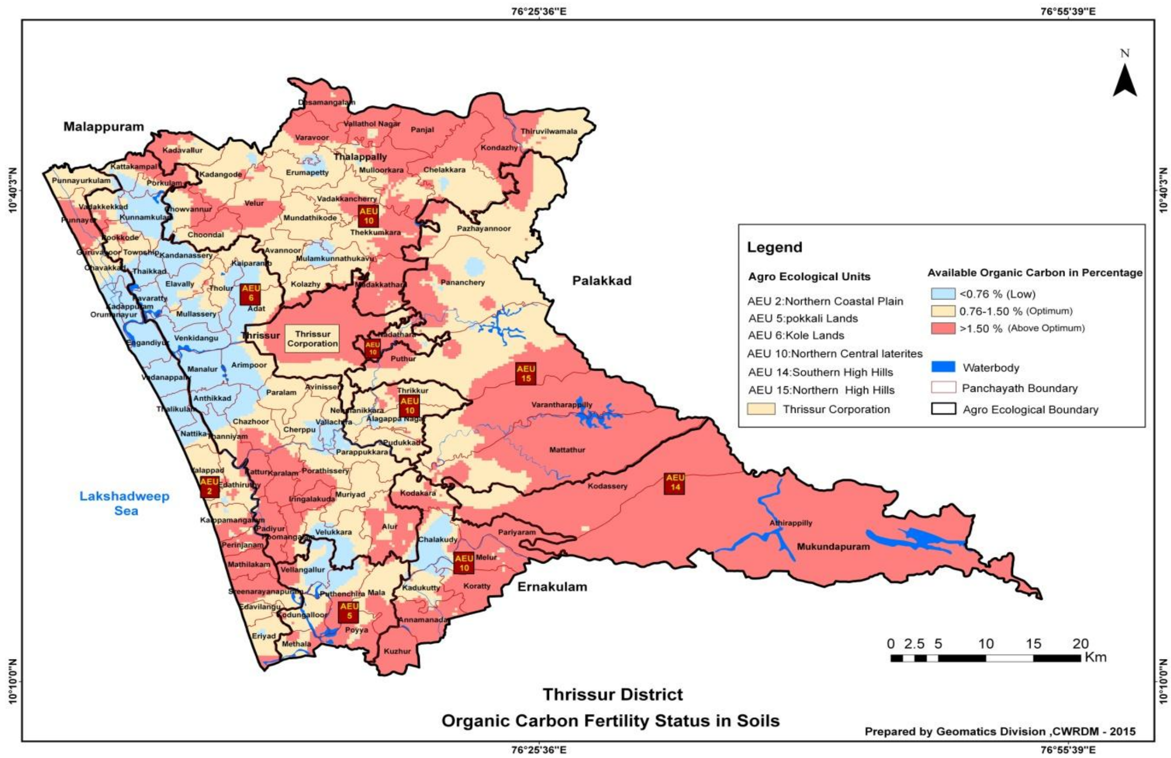

Figure-5: Status of OC in the soils of various AEUs in Thrissur district.

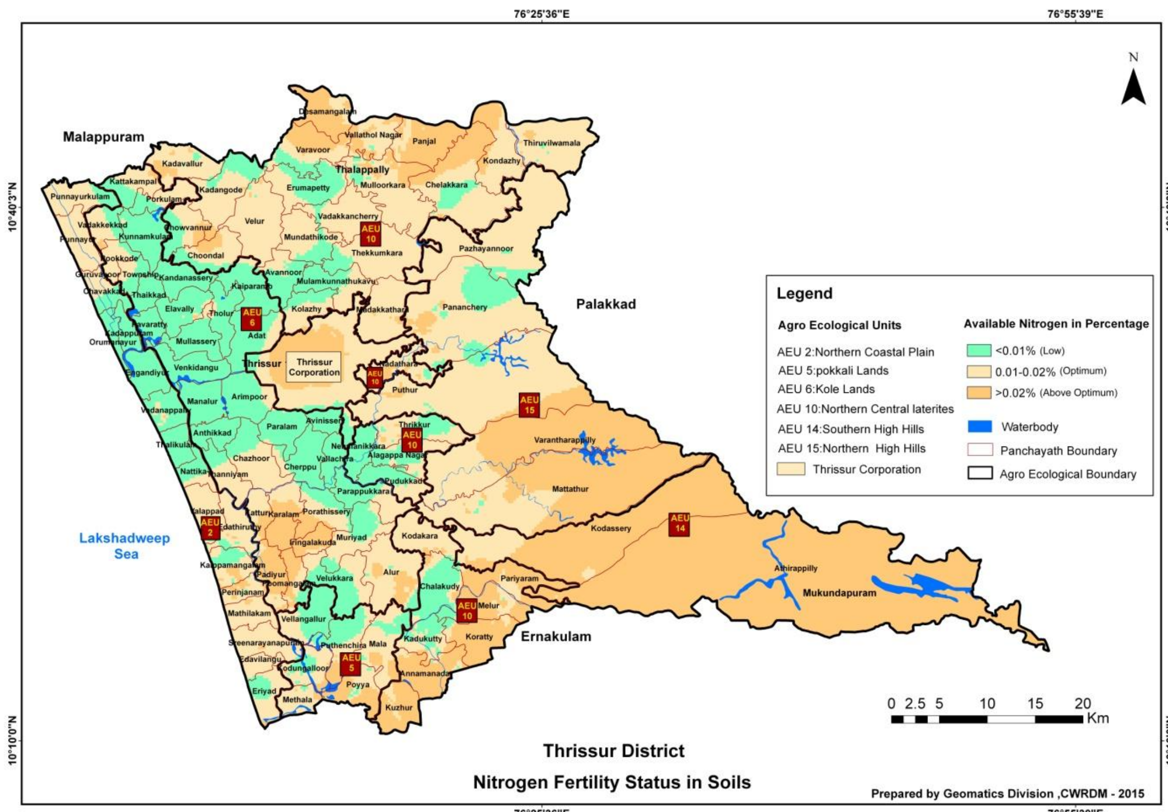

Figure-6: Status of N in the soils of various AEUs in Thrissur district.

Phosphorus content of the soils of various AEUs varied from 0.2-987.4kg ha^{-1}. P was significantly high in northern coastal plain (518.5kg ha^{-1}) and low in northern central laterite (34.9kg ha^{-1}). Occurrence of excess levels of P was well observed in the study area. Fertility status of P was high in the entire AEUs of Thrissur district[16]. Results in general point to the need for applying the phosphatic fertilizers only based on soil test results and skipping its application in cases of its excess levels.

The data on extent of area under different classes of P in the soils (Table-8) pointed out that 97.04% of the area in the district (2940km^2) were with high levels, while those with low and optimum status of P confined only to 1.14% (34.5km^2) and 1.82 % (55.18km^2) respectively. High content of P in the soil not only impairs the availability and uptake of essential nutrients by plants but also leads to soil and water pollution.

Potassium content of the soils of various AEUs varied from 1.5 - 987.4kg ha^{-1}. K was significantly high in southern high hills (628.8kg ha^{-1}) and low in northern central laterite (88.1kg ha^{-1}). Deficiency level of K was well pronounced in northern central laterite (80%) and absent in all the others. According to the nutrient index developed for six agro ecological units, K was low only in northern central laterite.

The data on the extent of area under different classes of K (Table-8) revealed that, optimum status was distributed in large area extending to about 1369.78km^2 (45.21%). This was followed by above optimum (45.21%) and low (15.28%) status. Above optimum level of K was less prominent in the study area, might be due to the high leaching as well as low fixing soils.

Secondary nutrients: Calcium content of the soils of various AEUs varied from 20.6-3780ppm. Relatively low levels of Ca in these soils might be due to continuous addition of acidifying chemical fertilizers and heavy leaching. The correlation studies revealed a significant and positive correlation between pH and Ca in all the agro ecosystems (Table-6). This is supported by the findings of Mahapatra and Sahu[17] and Medhe *et al*.[18]. Usually content of calcium in the soils are affected by drainage, soil type, pH and liming practices[19].

The data on extent of area under different classes of Ca (Table 8) revealed that the optimum status was distributed in large area extending to about 2763.8Km^2 (91.21%) of the soils followed by low (8.78%) status. Deficiency of Ca was well pronounced in pokkali, kole lands and in northern coastal plain and this might be due to soils with low pH, high exchangeable and extractable Al and Mn, intensive cultivation and use of Ca poor inorganic fertilizers, causing depletion of Ca as reported by Saikh *et al*.[20] and Aitken *et al*.[21].

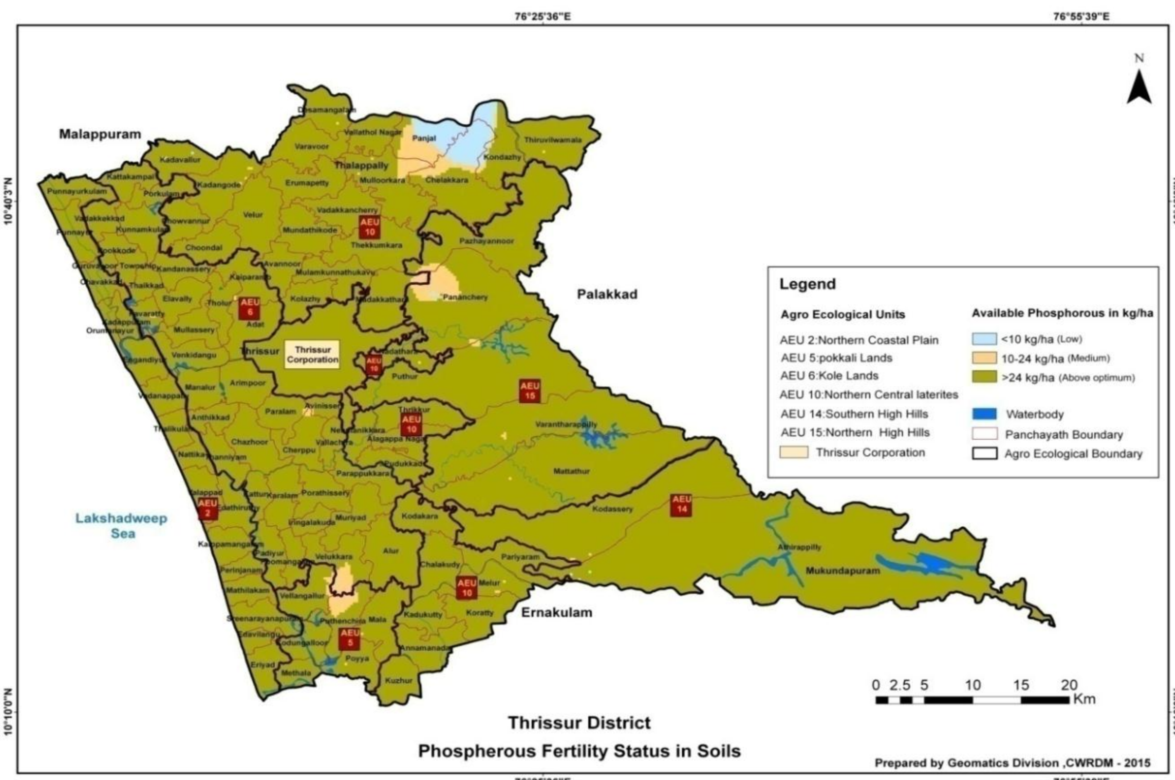

Figure 7: Status of P in the soils of various AEUs in Thrissur district

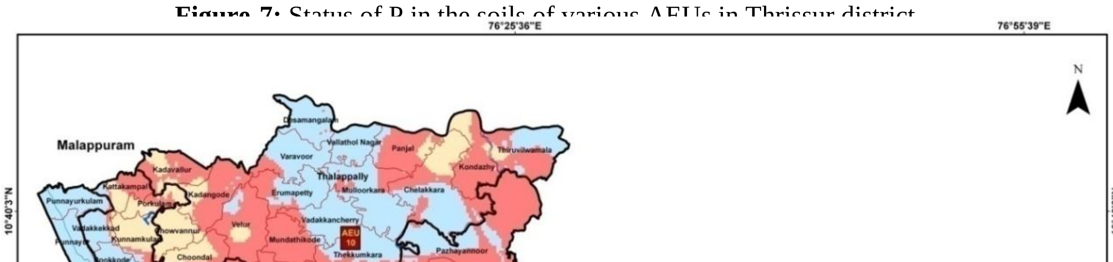

Figure-8: Status of K in the soils of various AEUs in Thrissur district.

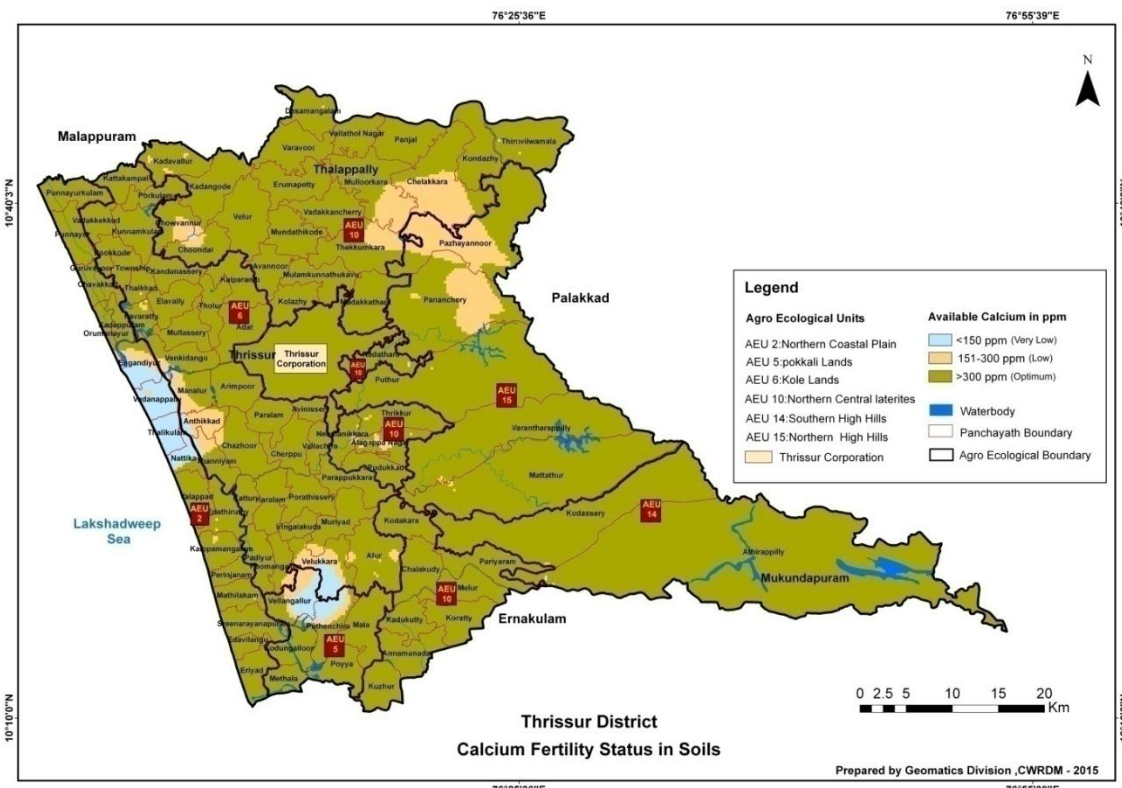

Figure-9: Status of Ca in the soils of various AEUs in Thrissur district.

Magnesium content of the soils of various AEUs in the study area varied from 0.2-722ppm. Application of high dose of NPK fertilizers, inherent high soil acidity, lack of application of Mg containing amendments, heavy leaching are the various reasons attributed to the deficiency of this nutrient in the soil. The coastal sandy soils have low content of organic matter and bases, low water and nutrient retention. It is essential to maintain high levels of organic matter in these soils to enhance nutrient levels especially bases and water retention capacity for maintaining favourable chemical and biological environment.

The data on the extent of area under different classes of Mg (Table-8) pointed out that large area extending to about 2540.1 km^2 (83.83%) as low status followed by optimum (16.17%). Deficiency of Mg was well pronounced in the district and its severity was more in northern coastal plain, pokkali and kole lands. Application of high dose of NPK fertilizers, inherent high soil acidity, lack of application of Mg containing amendments and heavy leaching are the various reasons attributed to the deficiency of this nutrient in the district.

Sulphur content of the soils of various AEUs in the study area varied from 0.03–583.6ppm. Status of S was low in northern central laterite, high in pokkali lands, and medium in all the other AEUs (Table-7). Mini *et al*[22] reported deficiency of S in 18% of the samples from coconut based systems of sandy soils of Onattukara region in Kerala.

The data on the extent of area under different classes of S (Table-8) showed that optimum status was distributed in large area extending to about 1242.5km^2 (41.01%) followed by high (40.02%) and low (18.97%) status. The deficiency level of S was very low in the study area, might be due to the contribution from applied phosphatic fertilizers containing S as an additional constituent. Relatively high status of S in pokkali lands is definitely due to the inhereal content of iron pyrites in these soils.

Conclusion

Based on the above study it is concluded that soil fertility status of Thrissur District varied between various agro ecological units. Among the agro ecological units, status of N, P and K was high in northern and southern high hills. Acute deficiency of K and S was well observed in northern central laterite. High accumulation of P was observed in all the agro ecological units. However, site and crop specific amendments/ nutrient inputs are suggested for enhanced productivity in all the agro ecological units.

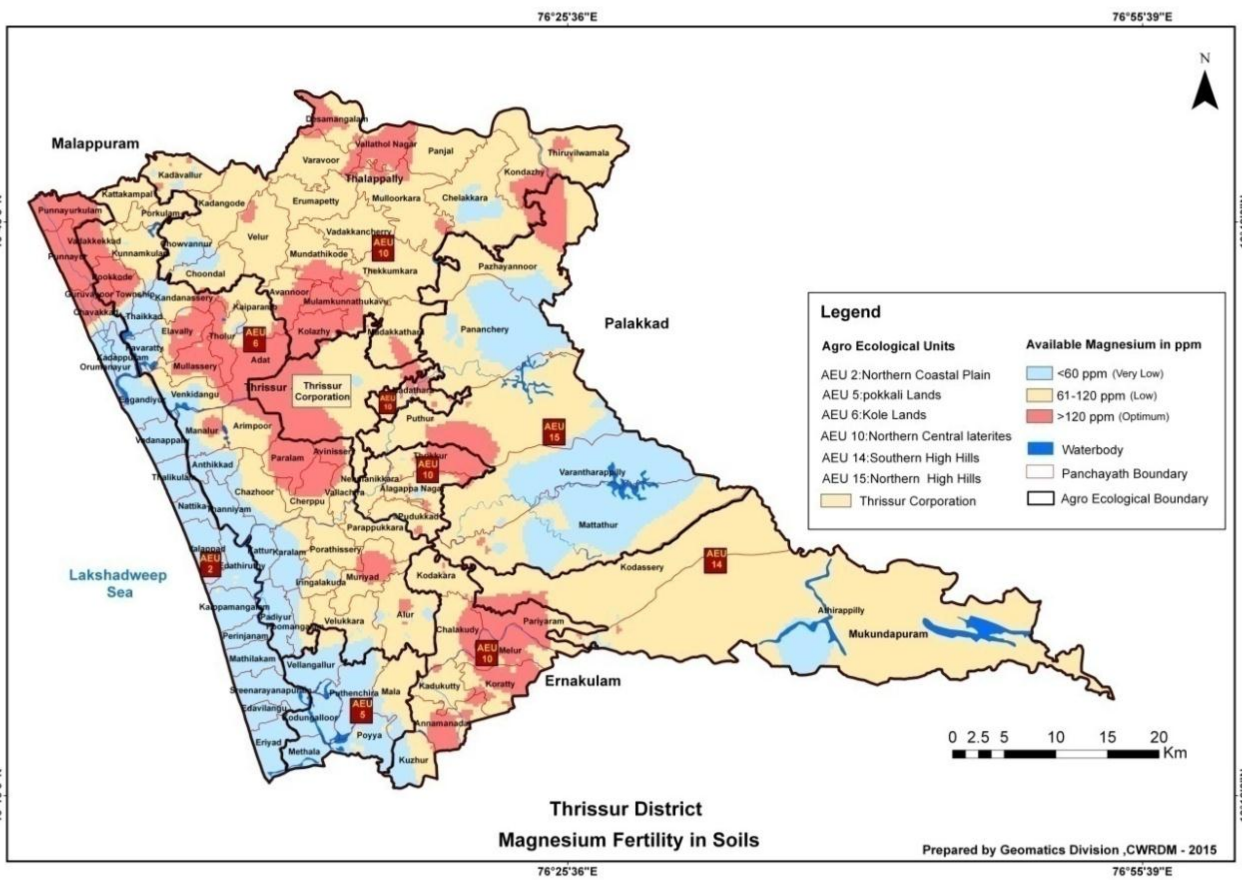

Figure-10: Status of Mg in the soils of various AEUs in Thrissur district.

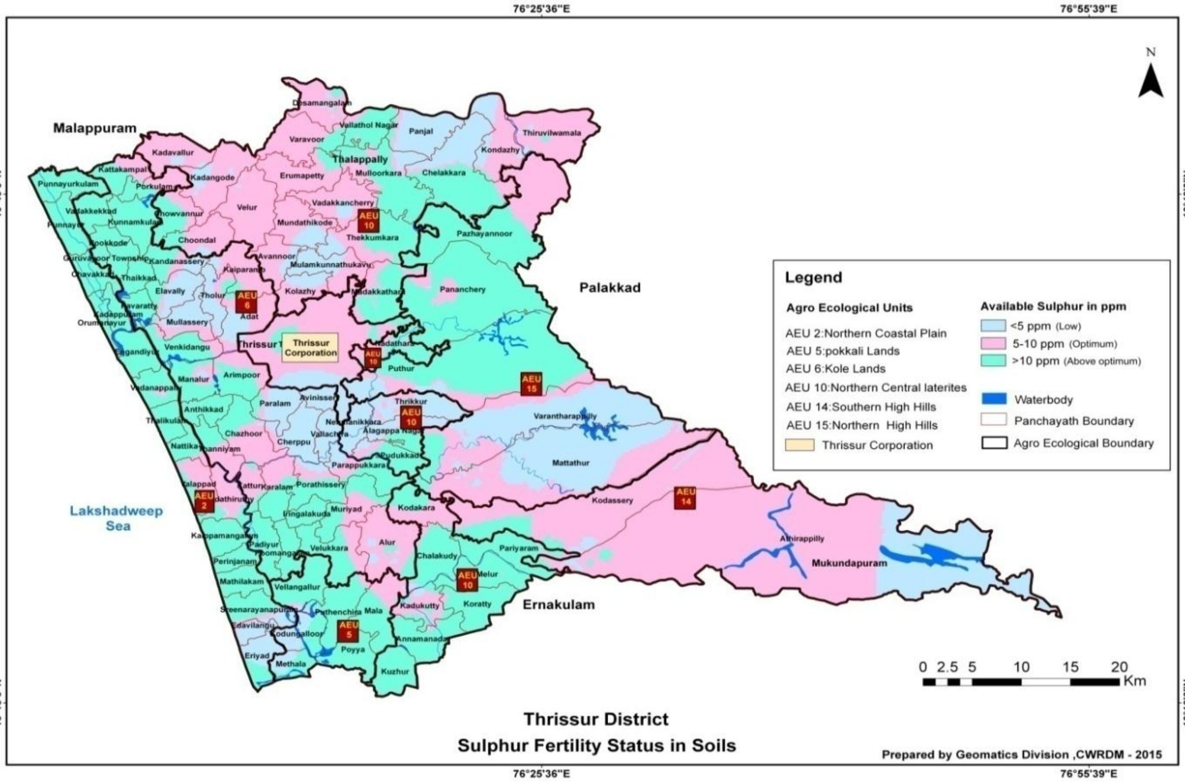

Figure-11: Status of S in the soils of various AEUs in Thrissur district.

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