International Journal of Engineering Research and General Science Volume 4, Issue 3, May-June, 2016
ISSN 2091-2730

Mapping and Analysis of Soil Fertility Using Remote Sensing and GIS; A Case Study of Tharangambadi Taluk, Nagappatinam District

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Abstract: Soil is the basic requirement of all life on earth. The origin of life has been attributed is soil along with other basic elements. Soil nutrients are the major source of soil fertility that helps for the plant growth. Soil nutrients has become a necessary resource to be enhanced further over the past years due to the increase in usage of inorganic fertilizers, disposal of waste water from domestic and industrial sector etc. soil resource is now facing threats due to various soil nutrients deficiency. The soil quality is equally important as that of crop production. Mapping of spatial variability of soil nutrients and its quality is vital important and it is particularly significant, where soil fertility is primary source of agriculture. The present study focus on spatial variability and temporal variability of soil quality. This variation maps of soil nutrients were prepared using GIS technology and other related maps were prepared from remote sensing data in ArcGIS 10.1. The soil nutrient index is determined to identify the nutrient status in the study area. From the soil nutrient index, the crops response to the nutrient, causes for the nutrient deficiency and consequences of such nutrient deficiency are analyzed. Samples were collected from twenty five locations in the study area. Soil nutrient analysis of the collected samples are done for 2015.The results were shown in spatial format using remote sensing and GIS. Suggestions to overcome such nutrient deficiency is also discussed in order to improve the crop productivity in the study area.

Keywords: soil nutrients, spatial variability, remote sensing, GIS, Macro and micro nutrients, soil nutrient index (SNI),

I.INTRODUCTION

Soil is the basic requirement of all life on earth. The origin of life has been attributed is soil along with other basic elements. Soil the source of life is passionate. It must be remembered that any natural or manmade activity on the surface of the earth will have its own impact on the quantity and quality of soil this will be taken into the biosphere systems and ultimately lead to hazardous extremes. The increase in population and urbanization and its necessities in growth of agricultural practices which leads to exploitation of soil nutrients. The dependability on inorganic fertilizers has reached high in recent decades due to reasons such vagaries of monsoon, increasing the crop yield, making money at short duration. This has resulted in over exploitation all over the country and in certain places it has reached critical levels like deficient soil nutrients. Soil nutrients (generally NPK) being one of the basic necessities for plant life. The source of life in its natural state is free from pollution but when man tampers the soil nutrients it loses its natural

conditions. Soil nutrient has become an essential resource over the past few decades. Remote sensing and GIS are effective tools for soil quality mapping. Hence this technique is adapted to analyze the soil quality based on soil nutrient parameters

II.STUDY AREA

The study area located in the South east coast of India Tamilnadu state which falls in between north latitudes 10° 15’ and 11° 00’and east longitudes 79° 30’ and 80° 00’ . The study area (topographic sheet no. 58N/11, 58N/13, 58N/14, and 58N/15) comprises south-eastern part of the Nagapattinam district the length of total coastal stretch around 55 km and total extent 1381 sq.km. The Nagapattinam district lies along the east coast of India, located to the south of Cuddalore district and another part of the Nagapattinam district lies to the south of Karaikal and Thiruvarur districts. The major soil types in this taluk are Sandy coastal alluvium soil and Clay soil. Sandy coastal alluvium soils are prevalent in coastal areas of tharangambadi taluk and some interior areas like Memathur, Seridiyur, Kulichar, Nangur etc..,while clay soil are found in south-west part of tharangambadi taluk.

Climate and Rainfall:

- Average maximum temperature is about 32° C
- Average minimum temperature is about 24.60°C

➢ During south west monsoon

- Normal rainfall is 265.2mm
- Actual rainfall is 250.6mm

➢ During north east monsoon

- Normal rainfall is 908.8mm
- Actual rainfall is 969.2mm

Fig 1. Study Area

III.METHODOLOGY

It is important to use the proper equipment for sampling soils. A soil probe can be used to collect soil samples and a small wooden rod can be used to remove the soil core from the tube. Here in tharangambadi taluk, the soil samples are collected by using a spade by digging a V-shaped hole to sample depth and then a thin slice of soil is taken from one side of the hole. The field, where the soil sample is collected is divided into four quadrants and then the soil sample is taken by above method. The samples collected from each quadrants is mixed and labeled as sample no.1. In similar manner 25 random locations are sampled and labeled. Then the soil samples are dried and sieved in order to remove other particles. Then 1 to 1 1/2 cups of soil sample (each in 25 samples) is sent to the laboratory for analysis. Samples were analyzed for macro nutrients and micro nutrients by using the standard procedures. Detailed macro and micro nutrients like Calcium carbonate ($caco_3$), EC (dsm^{-1}), P^H,organic carbon (%), nitrate, phosphorus, potassium, iron, manganese, zinc, copper were measured by Orion ion electrodes using standard procedure to understand the soil nutrients behavior. The Tharangambadi taluk map is scanned and georeferenced using ArcGIS software. Ground Co-ordinates are gained from Google map. Using these co-ordinates pixel co-ordinates of scanned image are

converted into ground co-ordinates. The georeferenced map is digitized by creating personal geodatabase and feature classes (point, line, and polygon). The map is digitized and it is projected for accurate information. The layout of the map is prepared with latitude and longitude for better understanding and more informative.

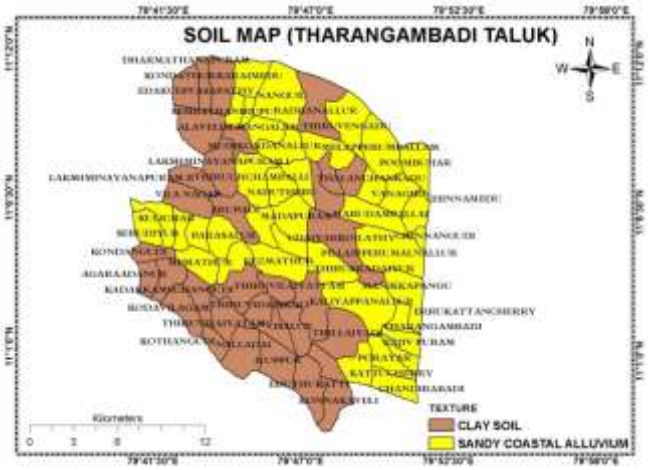


Fig 2: Soil map of the study area

Fig 3. Methodology

IV. RESULTS & DISCUSSIONS

1. SATELLITE MAPS

Raw satellite images of the given area is pre-processed using ENVI software. Satellite images are usually downloaded from USGS website. Geometric and Radiometric correction are applied to correct for these distortions and produce an image with geometric integrity of the map. Here the red band shows the vegetation areas, blue band shows water bodies where green band shows built up and barren lands. The satellite images of 1993, 2014 and 2015 is given below to understand the land cover variation

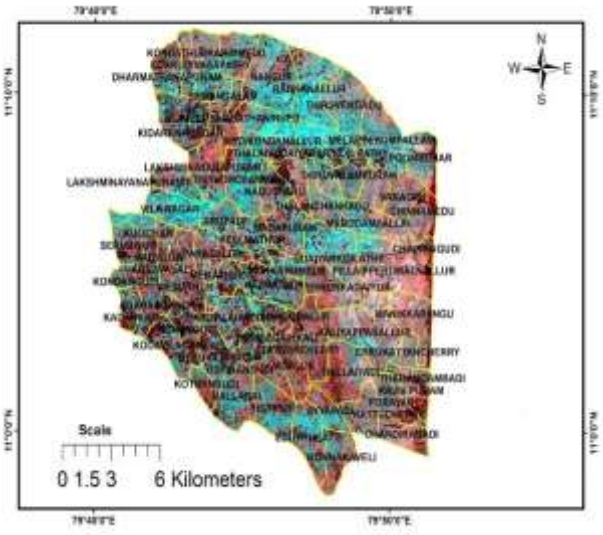


Fig 4: Satellite map of the study area (1993)

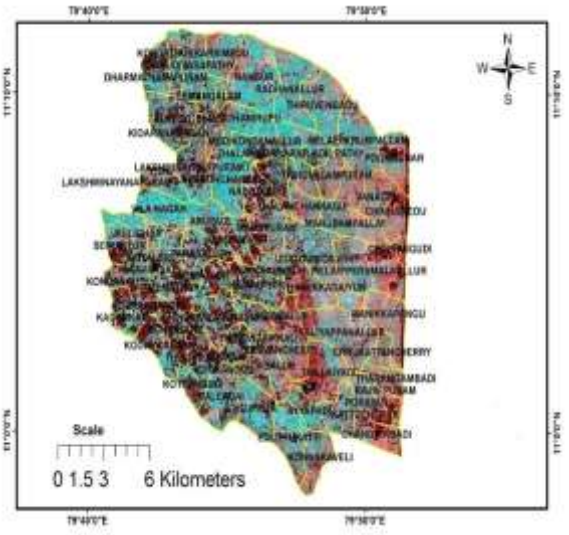


Fig 5: Satellite map of the study area (2014)

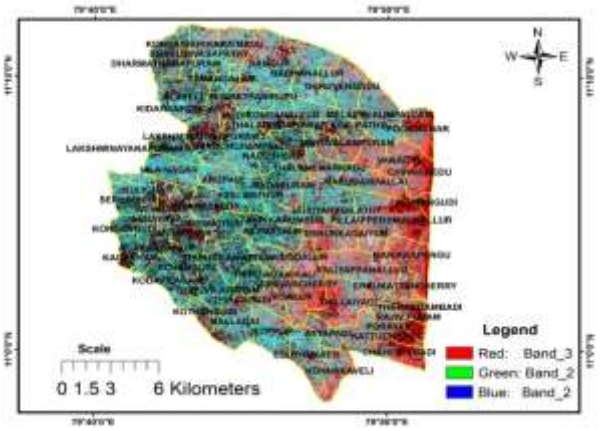
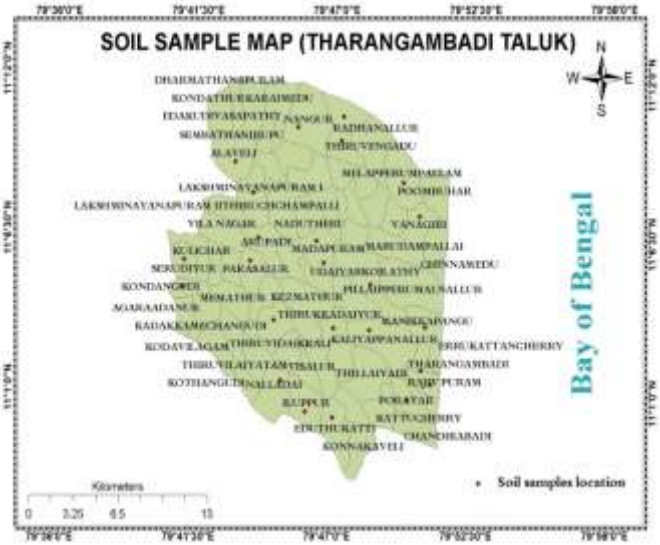


Fig 6: Satellite map of the study area (2015)



LOCATION	N in kg/acre	P in kg/acre	K in kg/acre	Fe in ppm	Mn in ppm	Zn in ppm	Cu in ppm
RAJIVPURAM	12.6	26	54	15.23	7.92	0.21	0.37
PORAYAR	53.2	25	76	14.62	4.31	0.33	0.29
EDUTHUKKATI	133	25	128	15.33	6.91	0.28	0.38
ILLUPUR	32.2	8	92	13.28	4.2	0.64	0.63
KOTHANGUDI	50.4	6.5	56	13.91	2.81	0.61	0.71
PERAMBUR	91	21	148	13.41	3.91	0.38	1.31
KADAKKAM	15.4	13	52	15.43	6.79	0.39	1.04
OZHUGAIMANGALAM	23.8	18	60	16.71	6.81	1.01	0.79
THIRUVIDAKAZHI	117.6	9	52	12.87	5.43	0.79	0.81
ECHANGUDI	121.8	11	76	12.79	6.38	1.28	0.96
MANIKKAPANGU	50.4	16	54	12.41	4.31	0.39	0.91
KAZHIYAPPANALLUR	39.2	10	48	15.42	7.41	0.71	0.55
PILLAIPERUMANALLUR	15.4	13.5	50	15.42	7.41	0.71	0.55
MANNAMPANDAL	35	13	52	13.39	3.92	0.53	0.31
PARASALUR	19.6	6.5	56	12.45	4.56	0.59	0.39
SERIDIYUR	40.6	25	124	16.12	3.94	0.86	1.03
VANAGIRI	7	15	50	14.39	5.38	1.21	1.09

ARUPATHY	85.4	15.5	68	14.32	3.56	0.91	0.86
THIRUCHAMPALLI	39.2	11	50	16.71	6.13	0.87	0.93
RADHANALLUR	99.4	14	176	15.91	2.91	1.25	0.39
NANGUR	71.4	18.5	96	12.68	3.56	0.38	0.64
ALAVELI	89.6	20	92	12.73	2.58	0.47	0.39
UMAYALPURAM	72.3	2.5	58	13.34	3.91	0.38	0.28
POMPUHAR	33.6	1.5	56	17.47	4.97	0.49	0.35
THIRUVENGADU	78.4	2.5	144	13.28	3.95	0.31	0.33

Table-1: Macro and micro nutrients of the samples collected

Fig 8: Soil sample collection, labelling, Drying, Sieving and removing other particles from sand

Macronutrients

Soil Test Category	Phosphorus (P) in Kg/acre	Potassium (K) in Kg/acre	Nitrate (N) in Kg/acre
Deficient (low)	0-5	0-40	0-50
Optimum (high)	6-10	41-100	51-100
Exceeds Crop Needs (very high)	>10	>100	>100

Micronutrients

Soil Test Category	Iron (Fe) in ppm	Manganese (Mg) in ppm	Copper (Cu) in ppm	Zinc (Zn) ppm
Deficient (low)	0-10	0-1	0-1.2	0-10
Optimum (high)	11-20	1.1-10	1.3-10	11-20
Exceeds Crop Needs (very high)	>20	>10	>10	>20

Table-2: Soil Test Categories for Nutrients

NITRATE:

Nitrogen is the basic nutrient helps in seed formation and increases the food and feed value of crops. The nitrogen-deficient plants are light green in colour. The lower leaves turn yellow and in some crops they quickly start drying up as if suffering from shortage of water. The analyzed sample varies from 7 – 135 kg/acre in the study area.

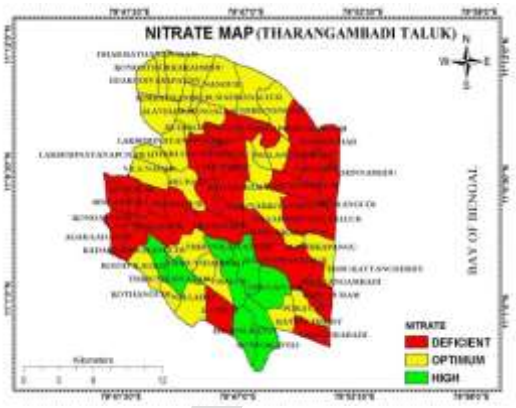


Fig 9: NITRATE MAP

PHOSPHORUS:

Phosphorus is particularly helpful in the production of legumes, as it increases the activity of nodular bacteria which fix nitrogen in the soil. Generally phosphorous deficiency causes the plant is dark-green but the lower leaves may turn yellow and dry up. Growth is stunted and leaves become smaller in size. The analyzed sample varies from 1.5 – 26 kg/acre in the study area.

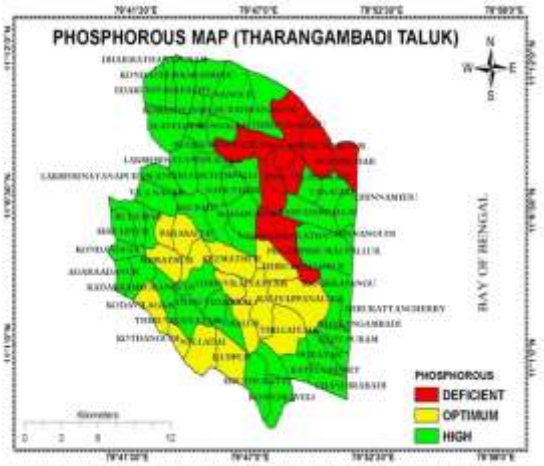


Fig 10: PHOSPHOROUS MAP

POTASSIUM:

Unlike nitrogen and phosphorus, potassium is not a constituent of the carbohydrates, oils, fats and proteins, the substances which form the fabric of the plants. But it plays a vital role in the formation or synthesis of amino acids and proteins from ammonium ions which are absorbed from the soil. Deficiency of potassium causes the margins of leaves turn brownish and dry up. The stem remains slender. The analyzed sample varies from 48 – 176 kg/acre in the study area.

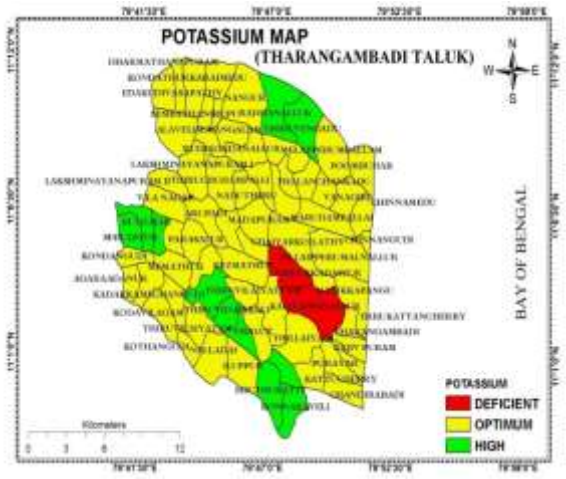


Fig 11: POTASSIUM MAP

IRON:

Although iron does not enter into the composition of chlorophyll, its deficiency manifests itself in chlorosis, yellowing or whitening of leaves. The concentration of iron ions plays and important part in the oxidation process in leaf cells. Sever deficiency results in chlorosis and leaves turn white and eventual leaf loss and the growth of plants is very much restricted. The analyzed sample varies from 12.41 – 17.46 ppm in the study area.

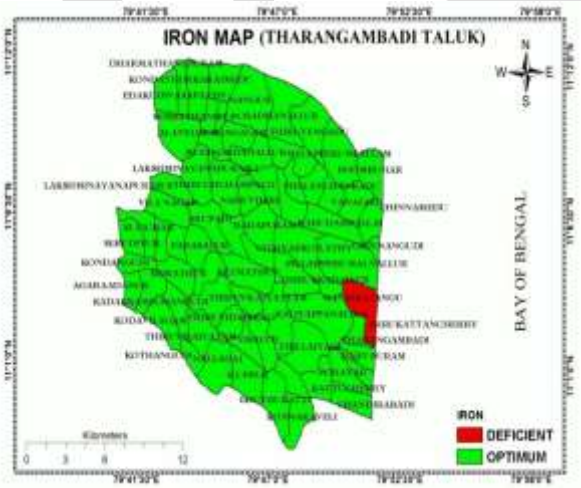


Fig 12: IRON MAP

MANGANESE:

Manganese is an essential element and appears to have a role in the formation or synthesis of chlorophyll. Due to deficiency of manganese the carbohydrate synthesis is disturbed, resulting in retarded growth, decrease in the content of ash and failure to reproduce. The analyzed sample varies from 2.58 – 7.92 ppm in the study area.

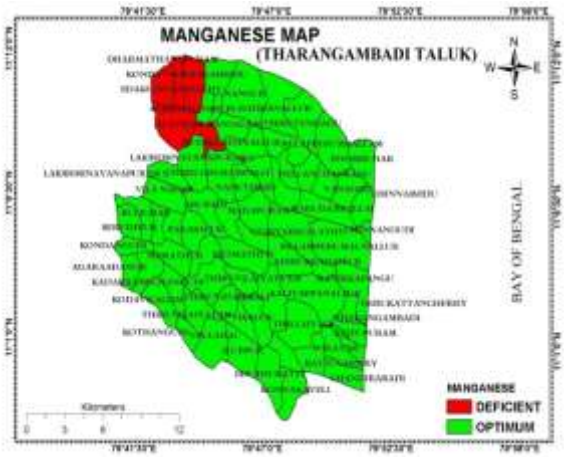


Fig 13: MANGANESE MAP

ZINC:

Zinc is associated with the development of chlorophyll in leaves and a high content of zinc is correlated with a high amount of chlorophyll. In its absence growth is less, buds fall off and seed development is limited. Extreme deficiency of zinc manifests in chlorotic conditions and in darker coloured veins of leaves the analyzed sample varies from 0.21-1.28 ppm in the study area.

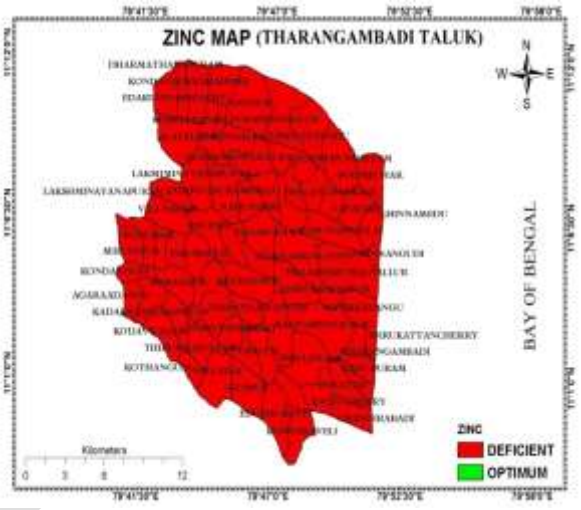


Fig 14: ZINC MAP

COPPER:

In the chloroplasts of leaves there is an enzyme which is concerned with the oxidation-reduction processes. The presence of copper is essential for this enzyme to function. Thus, copper plays an important role in the process of photosynthesis. In extreme deficiency there may occur excessive leaf shedding. The analyzed sample varies from 0.28 – 1.31 ppm in the study area.

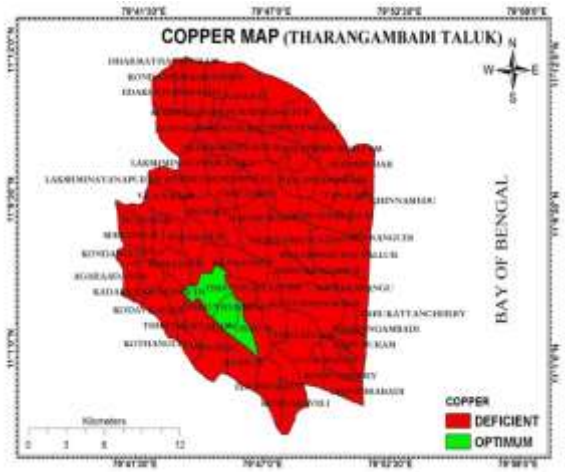


Fig 15: COPPER MAP

ESTIMATION OF SOIL NUTRIENT INDEX (SNI)

Parker's (1951) method of calculating Nutrient Index (NI) values to indicate fertility status of soils for the purpose of mapping. The following equation is used to calculate Nutrient Index Value:-

$$\text{Nutrient Index} = \frac{(Nl \times 1) + (Nm \times 2) + (Nh \times 3)}{Nt}$$

Nh = Number of samples falling in high category of nutrient Status.

Nt = Total number of samples analyzed for a nutrient in any given area.

Nl = Number of samples falling in low category of nutrient status.

Nm = Number of samples falling in medium category of nutrient status.

Separate indices are calculated for different nutrients like nitrogen, phosphorus and potassium. Based on the above WQI values, the soil nutrient index is rated for the study area (tharangambadi taluk).

Table 3: soil nutrient index standards

Parker's nutrient index standard	Description
<1.5	Low nutrient status
1.5-2.5	Optimum nutrients
>2.5	High nutrient status

Table 4: soil nutrient index for the study area

Nutrient	Soil nutrient index	Description
Nitrate (N)	1.6	Optimum nutrients
Potassium (K)	2.36	Optimum nutrients
Phosphorus (P)	2.62	High nutrient status
Iron (Fe)	2	Optimum nutrients
Manganese (Mg)	2	Optimum nutrients
Copper (Cu)	**1**	**Low nutrient status**
Zinc (Zn)	**1.02**	**Low nutrient status**

V.CONCLUSION

Soil nutrients are the prime requirement for the existence of life. Soil resources is a precious resource of finite extent. Over the years increasing population urbanization and expansion in agriculture has head in the scientific exploitation of soil nutrients by using inorganic manures in order to increase the yield creating soil quality contamination condition. Tharangambadi taluk area is under threat due to the critical issues of environmental pollution and salinity problem. The soil quality in tharangambadi taluk has been reduced due to pollution. Hence monitoring the soil quality is indispensable. The study was carried out in tharangambadi taluk in Nagappatinam district. GIS techniques can provide appropriate platform for convergent analysis of large volume of multi-disciplinary data. It helps in decision making for soil nutrient studies. The soil nutrient map will serve as a tool for the general public to identify the soil response to crops. The analysis of the results drawn at various stages of work revealed that integration of Remote Sensing and GIS are effective tools for the preparation of various thematic layers. From the various inference from the thematic maps we came to

conclusion that the soil quality in the study area should be enhanced further. Hence it is suggested that to enhance the soil fertility appropriate organic fertilizers should be used.

ACKNOWLEDGEMENT

I wish to thank my professors of Gnanamani College of Engineering, Namakkal Mr.P.Balaganesh and Dr.M.Bagyaraj for providing all their support to complete this study successfully. Above all my at most gratitude to the Almighty for being with me always.

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