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ASSESSMENT AND MAPPING OF SOIL QUALITY OF GANNAVARAM MANDAL, KRISHNA DISTRICT USING GIS

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Abstract:* Soil is an important natural resource and essential for agricultural purpose. Protection of the soil quality under intense land use and fast economic development is a major challenge for sustainable resource use in the developing world. The assessment of soil quality is necessary to evaluate the degradation status and to adopt suitable management practices. Soil quality is simply defined as the capacity of a specific kind of soil to function, i.e. mainly to provide nutrition to plants and absorb and drain water. Soil quality index (SQI) describes the goodness of a soil to have higher crop production, better fertilizer response rate and maintenance of good soil environment. In this work experimental investigation is made on the soil quality of Gannavaram mandal of Krishna district. The place has been chosen for case study because of its very little used net sown area. All the tests have been done to analyze the area's soil quality and to assess the problem causing low fertility in the area. Total 100 soil samples have been collected from 20 villages of Gannavaram mandal. Soil quality tests were performed using multi parameter field soil test kit to assess pH, Organic Carbon, Nitrogen, Phosphorous and Potassium. From the soil quality parameters, SQI has been calculated. Using interpolation techniques available in GIS thematic maps were developed showing the spatial distribution of these parameters. The thematic maps describe the variation of SQI in the area. These output maps serve as a basis for soil conservation practices.

***Key words:* Soil Quality, Soil Quality Index, Thematic maps, GIS**

I. INTRODUCTION

Soil quality is a measure of the condition of soil relative to the requirements of one or more biotic species and or to any human need or purpose. According to the United States Department of Agriculture Natural Resources Conservation Service, Soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. The European Commission's Joint Research Centre proposed a definition, stating that Soil quality is an account of the soil's ability to provide ecosystem and social services through its capacities to perform its functions under changing conditions. Soil quality reflects how well a soil performs the functions of maintaining biodiversity and productivity, partitioning water and solute flow, filtering and buffering, nutrient cycling, and providing support for plants and other structures. Soil management has a major impact on soil quality. Soil testing, as mentioned above in the abstract, means its analysis for the evaluation of fertility status and for the nutrients needed for the plants, like Sodium, Potassium, Organic carbon etc. The main purpose of soil testing is to identify the problematic areas which are unfertile, and arrive at a solution for this and to suggest alternative practices. A secondary purpose is also to find the impact of the pollutants present in soil on groundwater. Based on this current situation, soil quality management has become an important tool to guarantee the required amount of agricultural production for current needs and to maintain the sustainability of the land for future generations. Motivated by this necessity decision makers have asked the experts to provide non-technical tools to help them come up with better decisions. To this end, the development of maps showing the spatial distribution of soil quality is found to be useful.

SOIL QUALITY INDEX (SQI)

Soil quality Index in the agricultural and environmental context describes the goodness of a soil to have higher crop productivity, better fertilizer response rate, stabilized crop production and maintenance of good soil environment. The Soil Quality Index (SQI) integrates the measured physical and chemical properties of soil into a single parameter that could be used as an indicator of overall soil quality for agriculture. Soil quality cannot be measured directly, but soil properties that are sensitive to changes in management can be used as indicators. The soil quality is dynamic in nature and can affect the sustainability and productivity of land use. The soil quality is the end product of soil degradation or conserving processes and is controlled by chemical, physical and biological components of soil and their interactions. It is not possible to develop a single list of quality indicators which is suitable for all purposes. It is emphasized to use a range of likely indicators of soilquality rather than the use of a single indicator. The main objectives of the present work are as follows:

- To determine the soil quality parameters from the field
- To develop Soil Quality Index
- To develop maps showing the spatial distribution of soil quality index.

II. STUDY AREA

Gannavaram mandal is one of the 50 mandals in Krishna district of the Indian state of Andhra Pradesh. It is under the administration of Nuzvid revenue division and the headquarters are located at Gannavaram. The mandal is bounded by Agiripalle, Bapulapadu, Unguturu, Vijayawada (rural) and Kankipadu mandals. The mandal is also a part of the Andhra Pradesh Capital Region under the jurisdiction of APCRDA. As of 2011 census, the mandal had a population of 87,027. The total population constitute, 43,172 males and 43,855 females —a sex ratio of 1016 females per 1000 males. 8,098 children are in the age group of 0–6 years, of which 4,147 are boys and 3,951 are girls. The average literacy rate stands at 73.96% with 58,379 literates

Gannavaram is a town and a mandal headquarter located in Krishna district of Andhra Pradesh, India. It is situated at a distance of 20 kilometers from the city of Vijayawada on National Highway no 5 connecting the Chennai and Kolkata. Gannavaram is known for its airport and weather reporting station. It is also the mandal headquarters of Gannavaram mandal, administered under Nuzvid revenue division. Gannavaram is a City in Gannavaram Mandal in Krishna District of Andhra Pradesh State, India. It belongs to Andhra region . It is located 64 KM towards North from District head quarters Machilipatnam. Gannavaram is surrounded by Unguturu Mandal towards East , Agiripalli Mandal towards North, Penamaluru Mandal towards South, Kankipadu Mandal towards west. Vijayawada , Hanuman Junction, Gudivada, and Nuzvid are the nearby Cities to Gannavaram. The place has been chosen for case study because of its very little used net sown area. Location of the study area is shown in the figure 1.

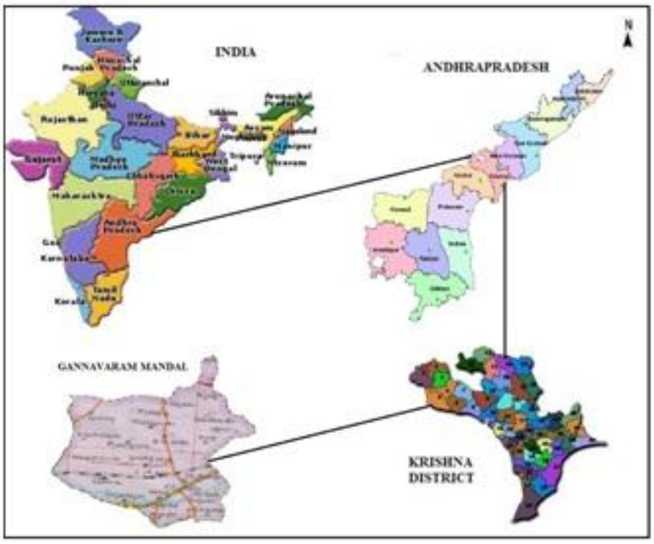

Figure.1 Study Area

III. METHODOLOGY

The area chosen for case study is Gannavaram mandal, which consists of 20 villages. The sampling process was carried out in all 20 villages, collecting 10 representative samples per village and combining them all together as a single sample per village. The samples were all put in plastic bags with labels according to their respective villages. Five tests for various elements presence, as mentioned above, have been done on each sample and tabulated. Each area is to be studied individually and analyzing them.

A field is treated as a single sampling unit. Variations in slope, texture, colour, crop growth are all taken into account. The soil samples are usually taken in a zigzag pattern. A representative composite soil sample is composed of 8-10 samples from a uniform field. For field crops, a sampling depth of 15 to 20 cm is desired. For a pasture crop, a depth of 10 cm depth is normally sufficient.

The methodology of the work is represented in the form of flow chart shown in the figure 2.

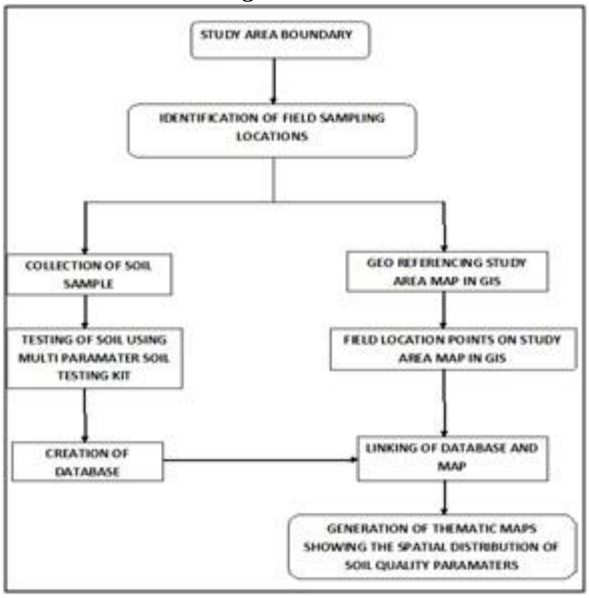

Figure.2 Flow chart representing the methodology

Assessment of Soil Quality Index (SQI):

In the present study, the Soil Quality Index (SQI) is developed based on the soil test ratings given in Hand book of Agriculture published by Indian Council of Agricultural Research (ICAR). These guide lines of ratings are given in Table.1 and are used in the development of Soil Quality Index. The Soil Quality Index (SQI) incorporates the pH, Electrical Conductivity, macronutrients and Organic Carbon, an indicator of Nitrogen (N), Phosphorus (P) and Potassium (K). In the methodology used to assess the Soil Quality Index, equal weight ages are assigned to the quality parameters of soil analysis results for pH, Electrical Conductivity, Organic Carbon, available Phosphorus and available Potassium. The SQI for cultivation is based on the linear combination of five chemical indicators of soil quality parameters which have potential impact on crop yield. The parameters used in the analysis are combined to form a single index value, which is then used to determine the suitability of soil for a crop. The SQI so obtained is integrated into Geographical Information System (GIS) platform, which provides a better platform for visualization and making comparative evaluation.

The SQI index is calculated by

$$SQI\ Index = \sum W_i; \qquad i = 1 \text{ to } 5 \qquad [1]$$

Where “i” is an incremental index and W(weights) represents the contribution of each one of the five categories of chemical indicators that are important to assess the quality of soil. Hence for each parameter a weights factor will be obtained for a particular soil sample. Algebraic sum of all these weights will be the soil quality index.

Table.1 Weightages of Soil Parameters

SNO	CHEMICAL PARAMETERS	SUITABILITY OF SOIL TO GROW CROPS (CORRESPONDING WEIGHTS ARE GIVEN IN BRAKETS)		
		LOW (Wt: 1)	MEDIUM (Wt: 2)	HIGH (Wt: 3)
1	SOIL pH	< 4.0 & > 8.5	4.0 to 5.5 & 7.2 to 8.5	> 5.5 & <7.2
2	ORGANIC CARBON(OC)%	< 0.5%	0.5 - 0.75%	> 0.75
3	NITROGEN(N) Kg/ha	< 280	280 to 560	> 560
4	PHOSPHORUS (P) Kg/ha	< 10 > 25	10 to 25	> 25
5	POTASSIUM(K)Kg/ha	< 110	110 to 280	> 280

The desirable ranges of the different parameters are given higher rating of 3, moderate ranges with rating of 2 and undesirable ranges with rating as 1. The values of SQI of different soil samples is obtained by assigning different rating factors (i.e., 1, 2 and 3) to each parameter given in the Table.1 thus yielding three different index values (i.e., 15, 10 and 5). Ranges of Soil Quality Index are represented in the following table2.

Table. 2 Ranges of Soil Quality Index

SQI	SUITABILITY OF SOIL FOR CROPS
< 7	LOW
7 – 12	MEDIUM
> 12	HIGH

Testing of Soil Quality Parameters

The five important soil quality parameters were tested using multi-parameter field soil testing kit. While taking the soil sample the location of the sample was identified using GPS and the corresponding latitude and longitude were noted and tabulated.

IV. RESULTS AND DISCUSSION

The locations of the soil sample collected from 20 villages are given in the form of latitude and longitude in the table 3. The pH test’s result is on a pH scale ranging from 0 to 14. As mentioned above, the ideal pH range is 5 to 8. The organic carbon test’s results are rated on basis of percentages. Organic carbon content greater than 1 % is sufficient. The soil nitrogen, phosphorous and potassium test results are given in kg/hectare. The results of the 5 tests conducted on each representative soil sample from 20 villages in Gannavaram have been table 4.

Table.3 Locations of soil sample collection points

Sno	Village	Latitude	Longitude
1	Ajjampudi	16.52	80.81
2	Allapuram	16.54	80.84
3	Bahubalendrunigudem	16.56	80.80
4	Balliparru	16.55	80.73
5	Buddavaram	16.53	80.81
6	Buthumillipadu	16.52	80.81
7	Chikkavaram	16.60	80.79
8	China Avutapalle	16.56	80.83
9	Gannavaram	16.53	80.80
10	Gollanapalle	16.60	80.77
11	Gopavarapugudem	16.61	80.76
12	Jakkulanekkalam	16.54	80.75
13	Kesarapalle	16.52	80.78
14	Kondapavuluru	16.57	80.76
15	Metlapalle	16.63	80.82
16	Purushottapatnam	16.56	80.77
17	Ramachandrapuram	16.58	80.71
18	Savarigudem	16.59	80.71
19	Surampalle	16.59	80.72
20	Tempalle	16.59	80.83

Table.4 Soils Quality Parameters Estimated

S no	pH	OC(%)	N (Kg/Ha)	P (Kg/Ha)	K (Kg/Ha)
1	7.5	0.5	280	10	280
2	6.5	1	260	14	90
3	7.5	0.8	200	38	110
4	7.5	0.5	270	26	100
5	5	0.8	800	32	180
6	7.5	0.5	260	37	160
7	7.5	1	360	30	140
8	8	0.5	560	38	290
9	8	0.5	260	12	300
10	5	1.5	470	53	340
11	7.5	0.8	300	12	280
12	5	1	520	48	90
13	5.5	0.5	540	38	320
14	8	1	630	10	310
15	7.5	0.8	320	26	430
16	5	1	700	48	330
17	6	0.8	420	20	80
18	7.5	0.5	320	20	250
19	7.5	1	680	42	290
20	7.5	0.8	200	22	70

The bar graph showing the variation of soil pH among the villages is shown in the figure.3. The boundary of the study area, locations of the soil sample collected points and corresponding soil quality parameters were fed to the

Geographical Information System (GIS). The sample points and the boundary of the Gannavaram mandal which are being processed by GIS is shown in the figure4.

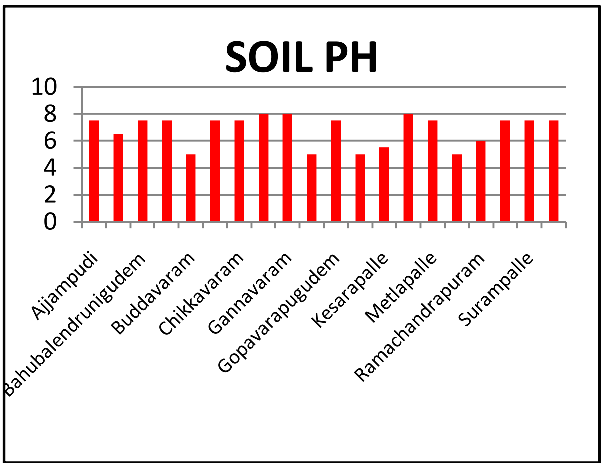

Figure.3 Variation of pH

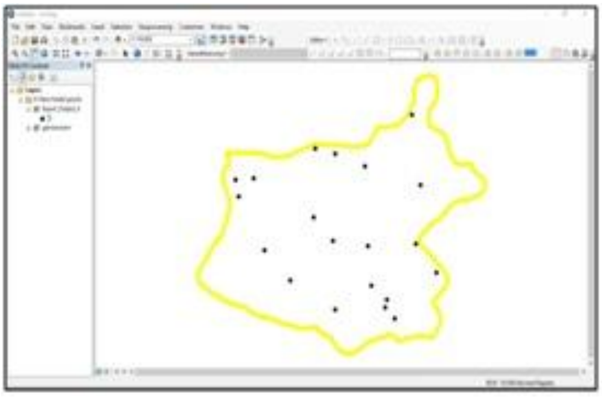

Figure.4 Sampling points and boundary in GIS

Figure.5 Sampling points and boundary on Google Earth

From the output of interpolation in GIS, the spatial distribution maps of the five parameters and the calculated soil quality index are given in the following figures 6-11.

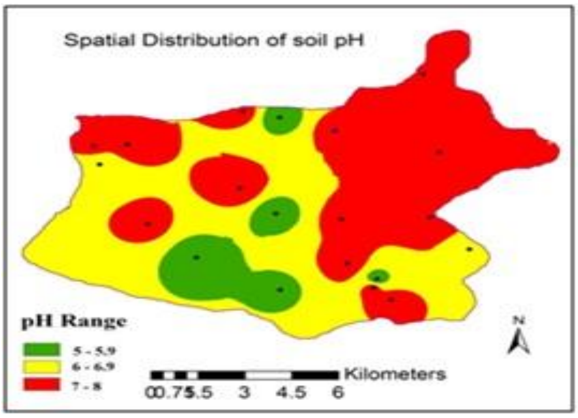

Figure.6 Spatial distribution of Soil pH

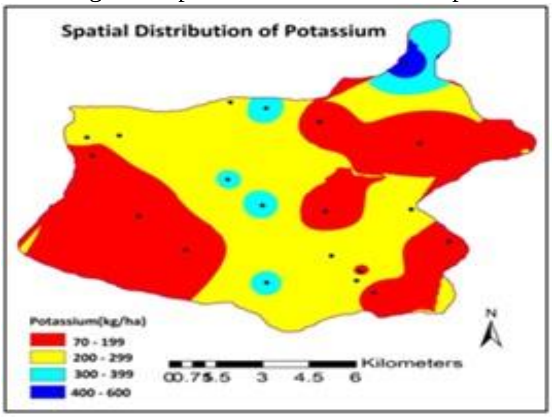

Figure.7 Spatial distribution of Soil Potassium

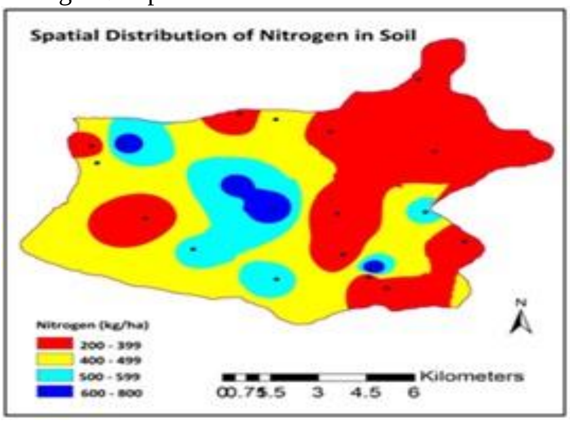

Figure.8 Spatial distribution of Soil Nitrogen

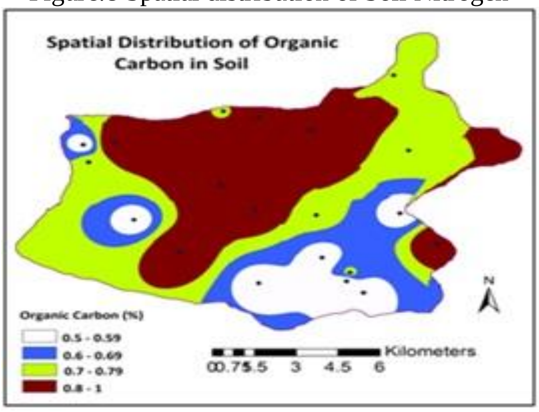

Figure.9 Spatial distribution of Soil Organic Carbon

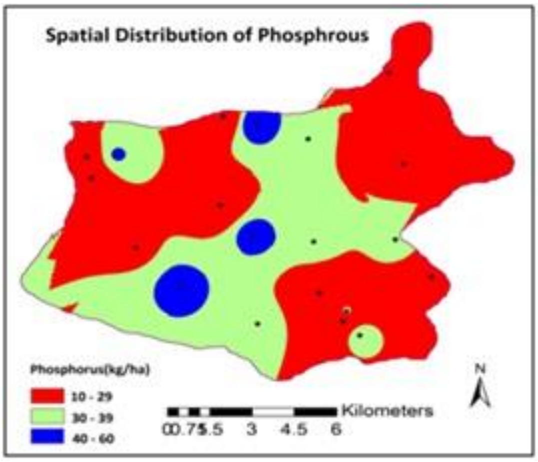

Figure.10 Spatial distribution of Soil Phosporous

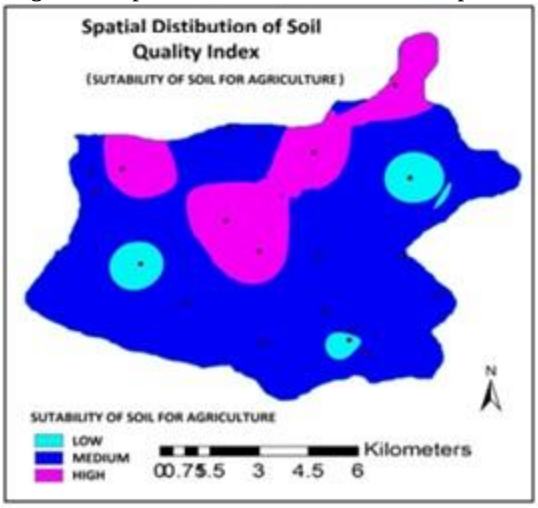

Figure.11 Spatial distribution of Soil Quality Index

V. CONCLUSION

In the present study, we have aimed at estimating the soil quality parameters of Gannavaram mandal and to map the same with GIS. For this, we have taken the Gannavaram mandal boundary as study area in which 20 villages are considered for carrying out experimental work.

- Soil samples were collected at five locations from each village. These samples were tested with multi parameter field soil test kit for estimating soil pH, organic carbon, nitrogen, phosphorous and potassium.
- Total hundred tests were performed. While taking the soil sample, location of the sampling stations were identified using GPS and latitude and longitude were noted and tabulated. From the soil quality parameters, soil quality index was calculated.
- The boundary of the study area was geo referenced using GIS. The points of sampling locations were placed in the study area map along with attributes like soil quality parameters and soil quality index.
- Now, using interpolation techniques available in GIS, thematic maps were developed showing the spatial distribution of the soil quality parameters and soil quality index.

The usefulness of soil for agriculture purpose can be identified easily with these maps. These maps also serve as basis for adopting suitable soil conservation measures that are required in the area.

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