Geo-Spatial Soil Mapping and Environmental Health Risk Assessment Along Bheemunipatnam (Bheemili) Beach Road, Visakhapatnam District Using Remote Sensing and GIS Techniques

Dr. Ravi Kumar[1]*
Prof. Daniel Okafor[2]
Dr. Sofia Marinova[3]
[1] Andhra Medical College, Department of Community Medicine and Environmental Health, Visakhapatnam, India
[2] University of Lagos, Institute of Environmental Epidemiology and Geospatial Health Analytics, Lagos, Nigeria
[3] University of Athens, Department of Public Health Informatics and Environmental Medicine, Athens, Greece

ABSTRACT

Soil survey is an integral part of an effective agricultural research and advisory program. It provides complete information about soils and is an inventory of the soil resource of the area. It gives the information needed for planning land use and soil management programs. The study area covers 236 sq.km with nine varieties of soilsin the area. These include the Black Clay Soil with high AWC, Brown Gravelly Clay Soil, Red Clay Soil,Red Clay Soil with high AWC, Red Clay Soil with Medium AWC, Red Coastal Clay, Red Gravelly Loam Soil, Red Gravelly Clay Soil and Red Loamy Soil. This study aims to use Remote Sensing and Geographic Information Systems (GIS) to produce the soil map and estimate the bearing values of different soils. All types of soils of the area have been considered in to GIS analysis.

Keywords: *Soil survey*, *Agricultural research, Remote Sensing, Geographic Information Systems.*

I. INTRODUCTION

Soil is the upper most layer of Earth's surface and is composed of unconsolidated earth material which is prone to erosion. Besides its natural conditions, soil erosion is triggered by anthropogenic activities. Soil is a renewable natural resource, which covers a major portion of the earth's surface. It is an important natural resource that either directly or indirectly supports most of the planet's life. It is a mixture of mineral and organic constituents that are in solid, gaseous and aqueous states. The fabric of soil particles pack loosely, forming a soil structure filled with pore spaces and these pores contain liquid and air. Soil classification is typically made based on the relative proportions of silt, sand and clay. The ability of a soil to support a load without failing in shear is known as its bearing capacity**.** It may be defined as the largest intensity of pressure which may be applied by a structure to the soil without causing failure of soil in shear or excessive settlement.

Detailed spatial and attribute information of soil is required for many environmental modeling and land management applications (Beven and Kirkby, 1979; Burrough, 1996; Corwin et al., 1997; and Jury, Model and Process Limitations 1985).The abrupt development in the field of Remote Sensing and Geographical Information System (GIS), mainly in 1990s helped to devise new and advanced methods for soil mapping. Remote sensing techniques have significantly contributed to speeding up conventional soil surveys by reducing field work to a considerable extent. There are different types of soils on the Earth. Hence, mapping of various properties of soil is essential. Soil mapping provides us an insight of the various properties of soil which are required to analyse the various potentialities and limitations of soil. There are various methods of soil mapping. Remote sensing has proved to be an important part of soil survey and mapping. Various properties of soil can be mapped with its assistance. Visual image interpretation technique helps in the identification and mapping of soil elements like land type, vegetation, land use, slope and relief. Interpretation of aerial photographs and/or satellite imagery have also been used in soil salinity mapping, especially colour-infrared photographs in which barren saline soils (in white) and salt-stressed crops (in reddish brown) can be easily discriminated from other soil surface and vegetation features (Rao and Venkataratnam, 1991; Wiegand, Rhoades, et al., 1994).

II. STUDY AREA

The area of investigation is located in between $17^{0}73^{1}$- $17^{0}80^{1}$ Northern latitude and $83^{0}32^{1}$-$83^{0}45^{1}$ Eastern longitudes(Figure 1). Geographically, the area is covering about 236 km^{2}, out of which approximately half of the area cover is under the jurisdiction of GVMC and rest comes under the Bheemili municipality. Bheemili is a town and mandal headquarters in Visakhapatnam district, Andhra Pradesh. The study is confined to recent expansion of four lane roads connecting Visakhapatnam and Bheemili. The road lying adjacent to the sea coast of Bay of Bengal is under the natural vagaries of sea coast on one side whereas land and its natural activities on the other side render the road vulnerable. The anthropogenic activities have altered the topography along the road system. In view of the traffic load, recent road expansion has been taken up in place of old road network. Hence, this study has been taken up to investigate various soils spread in the area in order to access the recent and further developments of the region.

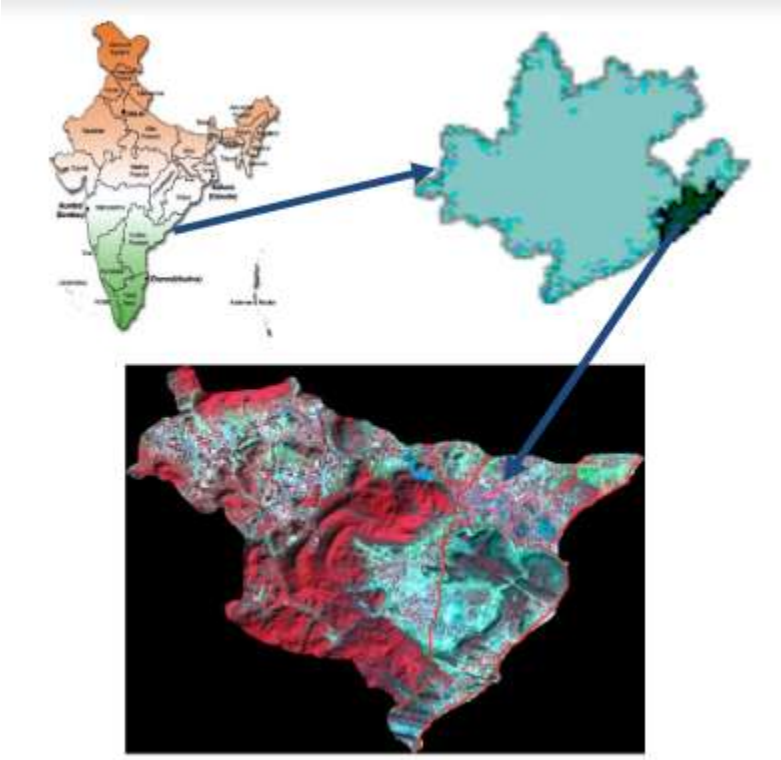

Figure1. Location Map of the study area as viewed on IRS 1D LISS III, 2004

III. METHOD & MATERIAL

The study area covers 2 sequences of the Survey of India (SOI) top sheets, they are 65 O/5 and 65 O/2 on 1: 50000 scale. These top sheets are geo-rectified and set to polyconic projection using ERDAS IMAGINE 9.1 software. The study area boundary is digitized and overlaid on mosaic; later verified by ground truthing. Image processing was carried out for IRS – ID LISS –III (23.5m resolution) - dated April, 2004. In this study, soil is studied in terms of geological origin and as a material in the construction. Therefore, attempts have been made to ascertain civil engineering parameters in order to relate its value for road construction. Soil samples are collected at different places along the recent road expansion and analyzed for California Bearing Ratio test to measure the safe bearing capacity of the soil. While collecting the samples, priority has been given due to coastal landforms along the road from MVP to Bheemili. The soil map of the area is shown in Figure. 2.

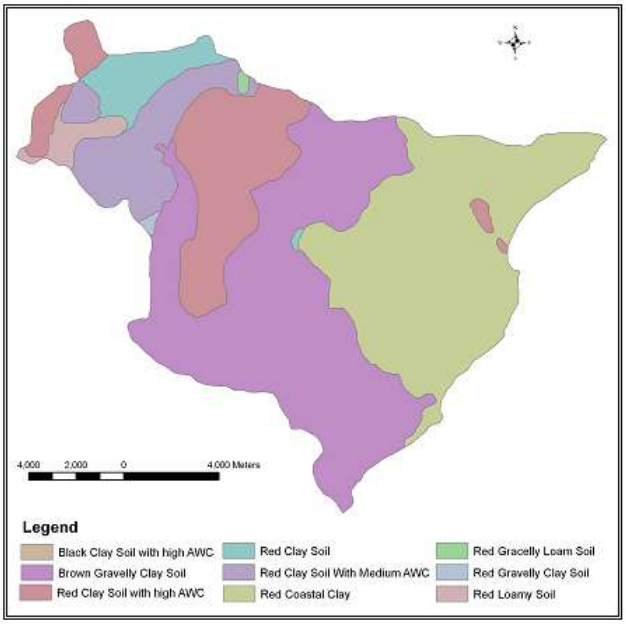

Figure 2. Soil map of study area

IV. RESULT & DISCUSSION

The study area covers 236 sq.km and nine varieties of soils have been observed in the area (Table 1). The road passes over brown gravelly clay and red coastal clay types of soil and these are exposed in the vicinity of Rendugullapalem, PeddaUppada villages. Different types of soils have different load bearing capacity. General presumed value of bearing capacity is given in Table 2.

Table 1: Type of Soils in the study area

Type of Soil	Area in Sq. Km
Black Clay Soil with high AWC	0.001
Brown Gravelly Clay Soil	89.354
Red Clay Soil	9.891
Red Clay Soil with high AWC	36.491
Red Clay Soil with Medium AWC	20.629
Red Coastal Clay	74.785
Red Gravelly Loam Soil	0.391
Red Gravelly Clay Soil	0.419
Red Loamy Soil	3.996
Total Study Area in sq. km	235.956

Black clay soil with high AWC: Exposed in the area around 0.001 sq. km, this soil appears black in colour enriched with clay content. Due to lime pours, the soil holds water and it will not easily drip as in the case of other soils. If this soil happen to saturate with water and exceeds its threshold limit it may be liable to creep on to the existing road.

Brown gravely clay soil: This soil covers an area of about 89.345 sq. km which is the highest type in the area and occurs in the villages of Chemudupalem, Gollapalem, Gudilove, etc. The physical properties of the soil are observed as given as colour: brown to brownish red, texture: gravely clay, structure: massive and irregular, humus content: partially high, water holding capacity: high, permeability: permeable. This soil is formed from the parent khondalite rock with the admixture of gravel, in high proportion than other constituents of the soil. The gravel in the soil has been derived from the hill tops and subsequently became a part in the soil. It supports vegetation and agriculture.

This soil area is exposed along the road network. It is excavated in the recent road expansions and left as a cliff like massif at places. If these are saturated with water, it may slide as a slump.

Red coastal clay: This soil is confined along the sea coast of the area. It covers an area about 75 sq. km and occurs in the vicinity of Timmapuram, Somannapalem, Gambhiram, etc. This is composed of marine sand dunes and river deposited clay materials in the vicinity of river systems in the area. This is a younger soil and liable to creep and settle if the load is applied on it.

Red clay soil: It is the second highest type of soil in the area and available in the areas of Kambalakonda and it is formed from the parent khondalite rock under the process of weathering and land mass denudation. However, red soils are formed exclusively by in-situ process at places. The soil is enriched with iron and therefore it appears red colour and the major type of clay mineral present in the soil is a kaolinite type. This soil occurs as small mounds at different places and formed as waste land topography. This topography is famous in this area and attracts cinema shooting and became as center for tourist attraction. This area has calcarious nodules and sparse vegetation are the characteristics feature. The calcarious material acts as a nucleus on which the red soil particles are formed as an outer layer and occurs as a residual material. This topography is characteristically exposed along the road near INS Kalinga and it is famously known as Eramitidebalu. Gullied topography with quick sand is the characteristic feature in this area. The eroded sand material settles on road adjacent which causes sliding of the vehicles.

The soil content available in the area is 9.891 sq. km, it means 15% of the study area is covered with this type of soil. It is generally available in deep to moderate sloppy areas and gently sloping lands. These types of soils are formed by quartzite where they are exposed in the area.

Red Clay Soil with high AWC*:* This soil covers about 36.491 sq. km (15%) of the study area cover in the villages of Mannipalem, Relli, Dibbadipalem, etc. It has slightly higher moisture content than the other red soils in the area. If this soil is saturate with water, it may be liable to soil flow, creep / solifluction etc.

Red clay soil with medium AWC: This soil covers about 20.629 sq. km in the vicinity of Mavaram, Gorinta, Pappulavampalem, etc.

Red gravelly loam soil: This soil covers about 0.391 sq. km of the study area near the villages of Erravanipalem, Kolavanipalem, etc.

Red gravelly clay soil*:* This soil covers about 9.891 sq. km (4%) of the study area cover this type of soil and available in the village Satram.

Red loamy soil*:* This soil covers about 3.996 sq. km it (2%) of the study area cover this type of soil available in the village Uppada.

Table 2: Presumed bearing values for soils.

Category	Types of rocks and soils	Presumed bearing value
Non-cohesive soils	Dense gravel or dense sand and gravel	>600 kN/m²
	Medium dense gravel, or medium dense sand and gravel	<200 to 600 kN/m²
	Loose gravel, or loose sand and gravel	<200 kN/m²
	Compact sand	>300 kN/m²
	Medium dense sand	100 to 300 kN/m²
	Loose sand	<100 kN/m² *depends on* degree of looseness
Cohesive soils	Very stiff bolder clays & hard clays	300 to 600 kN/m²
	Stiff clays	150 to 300 kN/m²
	Firm clay	75 to 150 kN/m²

	Soft clays and silts	< 75 kN/m²
	Very soft clay	Not applicable
Peat		Not applicable
Made ground		Not applicable

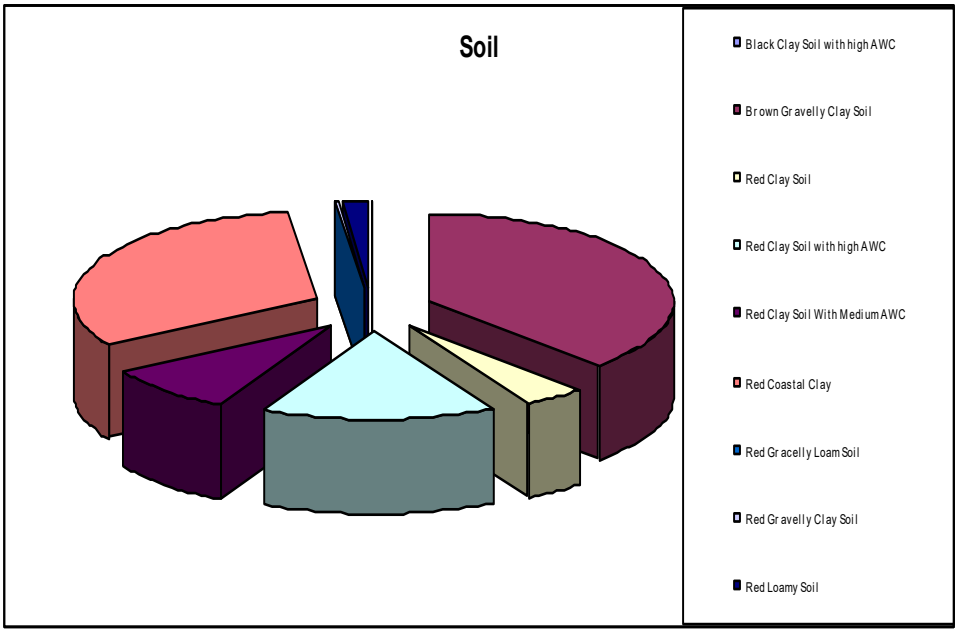

Figure 3: Percentage area of each soil

V. CONCLUSION

If the black clay soil with high AWC happens to saturate with water and exceeds its threshold limit, it may be liable to creep on to the existing road. The brown gravely clay soil is the highest type in the area occurring in the villages of Chemudupalem, Gollapalem, Gudilove, etc. The red coastal clay occurs in the vicinity of Timmapuram, Somannapalem, Gambhiram, etc. This is composed of marine sand dunes and river deposited clay materials in the vicinity of river systems in the area. The red clay soil available in the areas of Kambalakonda is formed from the parent khondalite rock under the process of weathering and land mass denudation. The red clay soil with high AWC covers the villages of Mannipalem, Relli, Dibbadipalem, etc. It has slightly higher moisture content than the other red soils in the area. The red clay soil with medium AWC is available in the vicinity of Mavaram, Gorinta, Pappulavampalem, etc. The red gravelly loam soil occurs near the villages of Erravanipalem, Kolavanipalem, etc. The red gravelly clay soil is available in the village Satram. The red loamy soil is available in the village Uppada.

VI. ACKNOWLEDGEMENTS

I express my profound gratitude and heartfelt thanks to my research guide, Prof. P. Jagadeeswara Rao, Andhra University for his constant support throughout the course of my research. I express my special thanks to Prof. G. Jai Sankar, Head of the Department, for all the cooperation, facilities provided in my course duration. I express my grateful thanks to Prof. K. Nageswara Rao and Prof. E. Amminedu, for their timely support and encouragement throughout the completion of my project. I express my sincere thanks to the retired Professors B. Surya Prakasa Rao, V. Venkateswara Rao and D. Markandeya Rao for their academic support.

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