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ANALYSIS OF THE SOIL SYSTEM AND THE SOIL MANAGEMENT IN THE STUDY AREA OF KALYANDURG, BRAHMASAMUDRAM AND SETTURU MANDALS OF ANANTAPUR DISTRICT, AP, INDIA: USING REMOTE SENSING AND GIS TECHNIQUES

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ABSTRACT

The present paper Examine the soil system and Soil Management in the study area of Kalyandurg, Brahmasamudram and Setturu mandals of Anantapur District, A.P. India. It is located in the middle of the peninsular region and it is confined to southwestern part of Andhra Pradesh and it is located in the drought prone area of Rayalaseema region; the total geographical area of the study area is 1101.25 Sq Km. In this study identify the Soil Classes, Soil depth, Soil slope, Surface soil texture, Soil Gravellines, Soil Calcareousness, Potential Soil Loss, Soil Degradation, Soil Fertility status, Salinity of the soils and Soil Erosion in the study area. Total 8 Soil Classes identified namely 1. Alluvio-colluvial clayey soils covering 3261.71 ha. (2.96%), 2. Medium calcareous black soils covering 582.24 ha (0.53%), 3 Red gravelly clay soils covering 42175.00 ha. (38.30%), 4. Red gravelly loamy soils 8432.76 ha (7.66%), 5.Red shallow gravelly clay soils covering 29789.48 ha. (27.05 %), 6. Red shallow gravelly loamy soils covering 8276.73 ha. (7.52%), 7. Red shallow loamy soils covering 4399.32 ha. (3.99%), 8. Saline-sodic soils covering 13209.01 ha (11.99 %). The study area covered with Red soils with 95 percent and Black soils over the rest of the area. For this study LISS-IV Satellite Data collected from NRSC (National Remote Sensing Centre), Topographical Maps collected from Survey of India (SOI) and Soil Maps and other data collected from Agriculture and Soil Department.

Keywords: Soil Classes, Soil Depth, Soil Degradation, Soil Management, Study Area, Remote Sensing and GIS.

INTRODUCTION

Soil is a natural part of earth's surface resulting from the modification of parent material by physical, chemical and biological processes operating under varying conditions during varying periods of time (Bushnell, 1944 in Thornberry). Soil is the non-renewable natural resources and is one of the basic components of ecosystem. Therefore, for planning and execution of any region, the information on soils with regard to their nature, extent and physic-chemical characteristics is a prerequisite.

'Soil' according to the pedagogical concept, is defined as "the upper, weather and biologically moulded part of the earth" (Lyon, 1949, p.4). Edaphically, soil is defined as a natural body engendered from a variable mixture of broken and weathered minerals and decaying organic matter which covers the earth in a thin layer and which may supply, when containing the proper amounts of air and water, mechanical support and in part sustenance for plants (Lyon,1949, p.4). From the genetic point of view, soils are the function of parent materials, relief soil biota, climate and time. In a micro-region the variations in physical and chemical properties relevant to plant growth are the result of the combined influence of morphology and drainage.

Agriculture, which literally means, the cultivation of the field "epitomizes the critical role of the soil in agriculture". Carefully husbanded and worked, soil is an asset that can be passed to countless generations almost intact forming the most precious and all important legacy. The present study of soils is mainly based on the LISS-IV satellite with limited field checks, soil maps and soil information available from other sources were also consulted (Soil Testing Laboratory, Anantapur). The various soil categories identified and presented in the map (Fig.1)

STUDY AREA

The present Study Area of Kalyandurg consisting of Kalyandurg, Brahmasamudram and Setturu Mandals of Ananthapur district, Andhra Pradesh. It Lies between 14^0 17' and 14^0 40' north latitude and 76^0 50' and 77^0 24' east longitude. It is located in the middle of the peninsular region and is confined to southwestern part of Andhra Pradesh. It is

bounded by Gummagatta, Beluguppa, Atmakur, Kanaganapalli and Kambadur Kundurphi mandals of the same district and western side bounded by Karnataka state. The total geographical area of the study area is 1101.25 Sq Km., According to 2011 census the total population is 1, 76,297 of which urban population is 32,335 (18 %), with literacy rate of 60.92 % and the sex ratio of total population is 964.

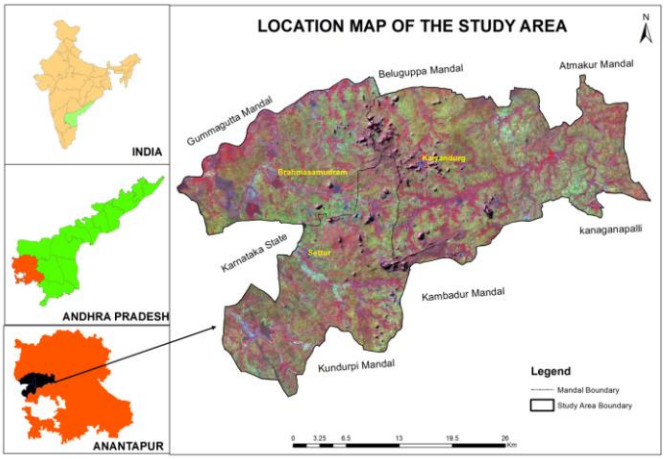

Fig 1. Location Map of the Study Area of Kalyandurg

RESULTS AND DISCUSSIONS

THE SOIL FORMING ENVIRONMENT IN THE STUDY AREA

In any region, the properties of the soils are determined by the soil-forming environment. Penologists often compare soil with an organism. According to them, soil is a natural phenomenon with its own independent organization, and is formed by the interaction of other natural elements. Modern pedologists express soil as a function of various factors as follows.

$S = f(c, v, o, p, r)\ t^o$

Where S = Soil, C= Climate, V = Vegetation, O = other organisms

P = Parent material, r = Relief and t^o = Time.

For proper management of the soil-resources, it is necessary to understand the soil forming environment of a region.

PARENT MATERIALS: Most of the soils in the study area are formed in situ from the regolith derived on weathering the underlying rocks. Soils derived from the transported parent materials are confined only to narrow belts of low lying stream courses. These transported parent materials belong to the quaternary period and comprises two types viz. (1) Coarse colluvial material along the valley plains of small ephemeral streams and (2) alluvial material along the valley plains of the large streams.

The parent materials of the region are derived mostly from the old group of Archean rocks which cover about 85 per cent of the area and the younger group of Precambrian sedimentary rocks. The older groups of rocks include granites, granitic gneisses, hyalites and schist's. Most of the study area covered in gneissic rocks. Granites and Dharwar super group, mainly consisting of schist's covered narrow area of the study region. Granites and gneisses are acidic rocks with the dominance of silicate minerals and on weathering give rise to red soils in semi arid climates. Schist's and dolomites are basic rocks with the dominance of dark colored Ferro-magnesium minerals and along with shale's give rise to black soils.

SOIL CLIMATE: The properties and ultimate use of soils are affected to a great extent by climatic parameters. In addition, these parameters govern the crop growth also. The soil moisture and soil temperature have been included as soil properties at various categorical levels in soil taxonomy (USDA, 1975). The soil moisture and temperature regimes of the area vary largely with altitude. The study area has a semi-arid to arid type of climate with a thronthwaite's moisture index of -71.3, It receive very low rainfall (544mm). The total rainfall occurs in a short span of four months with less than 50 rainy days. It has fairly hot climate with mean monthly maximum temperatures ranging from hot climate with mean monthly maximum temperatures ranging from 29.1ºc in December to 42.5ºc in May. Relative humidity ranges from about 40 percent in the dry month to about 90 percent in the humid months. The prevailing climate promotes fairly quick chemical weathering and decay of organic matter. The short rainy period also causes intensive normal erosion in the form of gull eying and dry period witnesses wind erosion to some extent.

RELIEF: A major portion of the study area is a pediplain ranging in elevation from 300 to 600 mts with hill ranges and hillocks of relatively low relief scattered all over especially in the eastern, southern ad south-western parts of the district. The pediplain is characterized by gently sloping concave inter stream areas, usually with rocky flat out crops in the middle. Nearly 85 per cent of the area of the district has less than 2 of slope. This has led to the formation of a distinct relief associated soil catena in the order of clayey, loamy, sandy and rock soils occurring in that order from valley flats to the inter stream areas.

VEGETATION: Vegetation is the main source of soil organic matter which is a vital soil ingredient controlling a host of activities in the soil and also properties.

The study area has about 6.5 % of the area under forests; the net sown area is about 75 % of the total geographical area of the study area. Only 10 % of the area is under multiple cropping with irrigation facilities, nearly 65 % of the

geographical area of the study area is devoted to rain fed single crop of 3 to 4 months duration and the rest of the period is left open without any vegetation cover. Most of the hill ranges are barren or have thin veneer of vegetative over of scrubs and coarse grasses. The Normalized Differential Vegetation Index (NDVI) map (Fig.2) indicates, that high vegetation is observed in along the Hagiri or Vedavathi River and other rivers, streams and Tank catchment areas. Medium to low vegetation is observed in forest and other areas.

SOIL BIOTA: The population and activities of the soil biota is at the minimum in the upland tracts due to low moisture and organic matter required for their sustenance and multiplication.

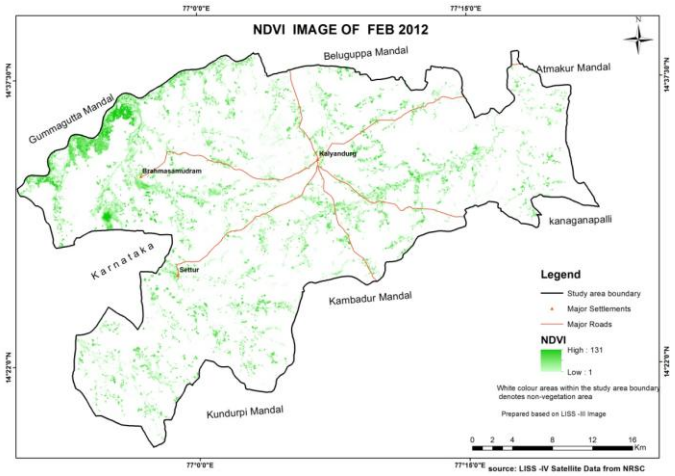

Fig 2 NDVI (Normalized Differential Vegetation Index) Map of the Study Area of Kalyandurg

TIME: Most of the soils in the uplands show rocky soils or soils with (A) C- profiles or AC-profiles indicating lack of stability and time in their development. But most of the soils, in the low lying areas, show the standard ABC profiles.

SOILS OF THE STUDY AREA: Approximately 95% of the soils in the study are alfisols with the remaining area covered by black clayey soils (AP GWD, 1999a).The relatively short growing period in Anantapur gives an indication of the risk involved in rain fed cropping in this district. The inherent advantages of the vertisols, in terms of soil water availability, can also be seen. Shallow and very shallow gravelly soils occur at the base of foothills with 4-8% slope in the study area. The percentage river bed areas and groundnut fields, both the soils are universally deficient in nitrogen. Red and black soils are poor in phosphorus, while potassium may become a limiting factor in light soils dominated by the clay mineral kaolonite. Deficiency of zinc, sulphur and calcium is widespread in the case of red soils that are under continuous groundnut cropping,. Similarly in black soils, zinc deficiency is a major limitation for crop production under intensive farming. Boron toxicity is also reported to inhibit crop growth in the study area. gravelliness of these soils ranges from 50 to 85% and is a major limitation on arable cultivation. Moderately deep soils occur in gently sloping lands and deep to very deep soils occur in valleys. As a result of erosion, clays are transported to valleys where they form calcareous clayey soils which are at times saline. Red soils suffer from the physical limitations of crusting and compact sub soils, while black soils suffer from crusting and low infiltration rates due to high exchangeable sodium percentage (>7.0). Soil salinity is a serious problem in the case of black soils and in red soils when irrigated with saline waters. Soil depths vary as a result of differential erosion. High levels of erosion continue to occur on many of the steeper slopes with soil losses range from 4 to 10 t/ha/annum. Wind erosion is also common in the study area particularly from river bed areas and groundnut fields. Both the soils are universally deficient in nitrogen. Red and black soils are poor in phosphorus, while potassium may become a limiting factor in light soils dominated by the clay mineral kaolonite. Deficiency of zinc, sulphur and calcium is widespread in the case of red soils that are under continuous groundnut cropping. Similarly in black soils, zinc deficiency is a major limitation for crop production under intensive farming.

Broad soil classes and distribution are shown in fig 3 and 4 and table 1 as followed:

1. ALLUVIO-COLLUVIAL CLAYEY SOILS

This type of soils distributed only south western (SW) part of the study area of setturu mandal at Mulakaledu Village, small streams are flowing in this area and Mulakaledu Cheruvu is the Big Tank in this area and Paddy, Ground nut, Jower, Ragi is dominant crops in this soil of the area and 3261.71 ha of the area (2.96%) covered in this type of soil in the study area.

2. MEDIUM CALCAREOUS BLACK SOILS

Very small portion of the study area of Kalyandurg mandal covered in this type of soils, 121.6 ha covered in the study area. This area is Located near Golla village, and part of the Hagiri or Vedavathi River basin area. Paddy is the dominant crop in this soil of the area.

3. RED GRAVELLY CLAY SOILS

This type of soils distributed all over the study area, most of the Kalyandurg mandal area and eastern part of the Brahmasamudram mandal in Hagiri River basin and small

portion of the southern part of the Setturu mandal near Anumapalle village covered in this type of soil. About 42175 ha. (38.30 %) of the area covered Red gravelly clay soils in the study area. Groundnut, Jower, sunflower crops dominant in this area and Agriculture Plantation like citrus, pomegranate, Banana and Jasmine are also observed in this area where the irrigated facilities are available.

Table.1 Distribution of Soils in the study area

S.No	SOIL TYPE	Area in hectares	Percentage %
1	Alluvio-colluvial clayey soils	3261.71	2.96
2	Medium calcareous black soils	582.24	0.53
3	Red gravelly clay soils	42175.00	38.30
4	Red gravelly loamy soils	8432.76	7.66
5	Red shallow gravelly clay soils	29789.48	27.05
6	Red shallow gravelly loamy soils	8276.73	7.52
7	Red shallow loamy soils	4399.32	3.99
8	Saline-sodic soils	13209.01	11.99
	Total	**110126.24**	**100.00**

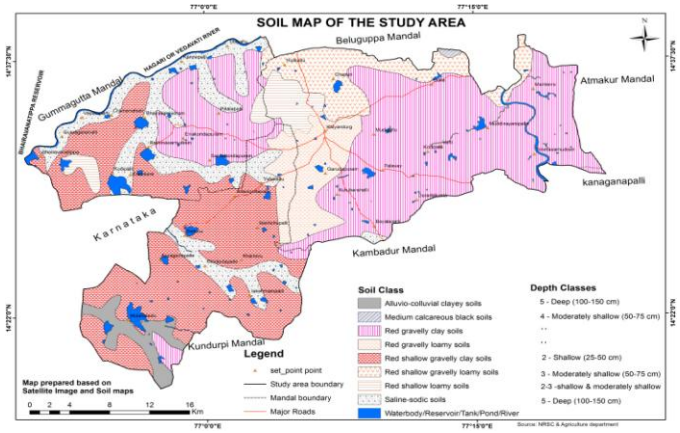

Fig 3. Map showing the Soil Classes and Soil Depth in the Study Area of Kalyandurg

Plate1. A view of the Red soil covers which is predominant soil type in all over the study area

4. RED GRAVELLY LOAMY SOILS

These soils situated at middle portion of the study area and 8432.76 ha. (7.66%) covered in Kalyandurg and Setturu mandals. Majority of the area covered in Kalyandurg mandal surrounded by Kalyandurg town and Penneru Drainage basin area. Paddy and Groundnut is dominant crops in this soils of the area.

5. RED SHALLOW GRAVELLY CLAY SOILS

Covered in western part of the study area, about 29789.48 ha (27.05%) area covered in Setturu and Brahmasamudram mandals. predominantly Hagiri River basin area of Brahmasamudram and Setturu mandals covered in this type of soil. Paddy, Groundnut, jower, Ragi and other rainfed crops are observed in this soil of the area.

6. RED SHALLOW GRAVELLY LOAMY SOILS

Northern part of the study area covered in this type of soils, predominantly in kalyandurg mandal and small portion of the North Eastern part of the Brahmasamudram mandal covered about 8276.73 ha (7.52 %). Hagiri or Vedavathi River basin covered and Paddy, Groundnut, Jower and other rainfed crops are observed in this soil of the area.

7. RED SHALLOW LOAMY SOILS

North and North Western portion (NW) of the study area covered in this type of soils covered in Brahmasamudram and Kalyandurg mandals about 4399.32 ha (3.99 %). Reserved Forest area of Kalyandurg mandal covered in this type of soils. Paddy and Groundnut are dominant crops of the Hagiri drainage basin near Bhairavanitippa Reservoir of Brahmasamudram mandal.

8. SALINE-SODIC SOILS

This type of soils covered along the Hagiri or Vedavathi River of Brahmasamudram mandal and Nomagadda vanka area of the setturu mandals covered in this type of soils. Paddy and Groundnut are dominant crops and jower, Ragi other rain fed crops are also observed in this area.

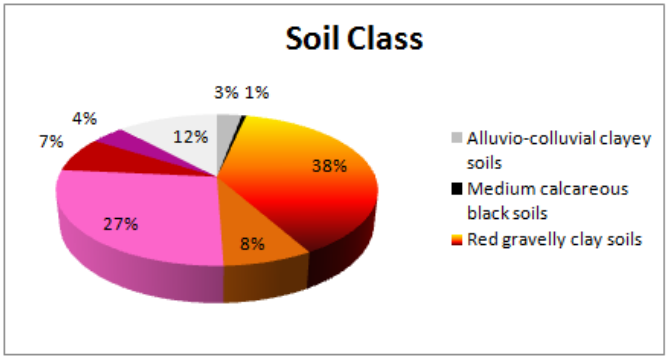

Fig.4 Distribution of the Soils in the study area

SOIL DEPTH: Soil depth indicates effective rooting depth available for the plants, which influence the soil water holding capacity and supply of plant nutrients, based on the volume of soil. Medium deep soils occupy large area followed by equal proportion of shallow and deep soils in the study area as shown in the fig.3 Medium shallow soils followed by deep soils are dominant in Kalyandurg and Brahamasamudram mandals, shallow followed by deep soils in Setturu mandal.

SOIL SLOPE: Slope refers to inclination of the land surface. It is defined by the gradient, shape and length, which from integral part of soil as a natural body. The length and gradient of slope influence soil formation, depth, proneness to erosion and affect land use and development.Fig.5 shown Soil slope in the study area. Gently sloping lands in large area followed by very gently sloping lands in the study area as shown in the Fig.5 and also in Kalyandurg and Setturu mandals. Nearly equal proportions of nearly level, very gently and gently sloping land occur in Brahmasamudram mandal. Different soil slope classes, area and percentagewise for the study area are given in table 2 and also the data is shown in pie diagram (figure 6).

Table.2 Soil slope categories in the study area

SOIL SLOPE CLASSES	Area in Hectares	Percentage (%)
A - Level to nearly level (0 to 1 %)	13667.29	12.41
B - Very gently sloping - 1 to 3 %	17229.39	15.65
C - Gently sloping - 3 to 8 %	64331.41	58.42
B-C	10205.91	9.27
D - Moderately sloping - 8 to 15 %	4692.24	4.26
Total	**110126.24**	**100**

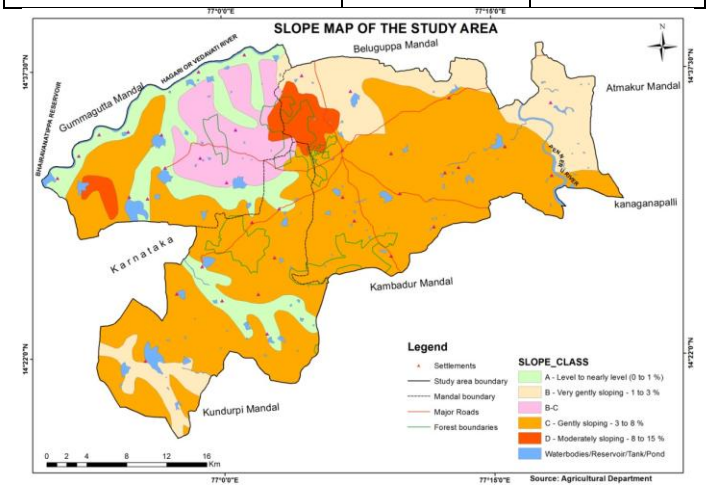

Fig.5 Soil Slope of the study area

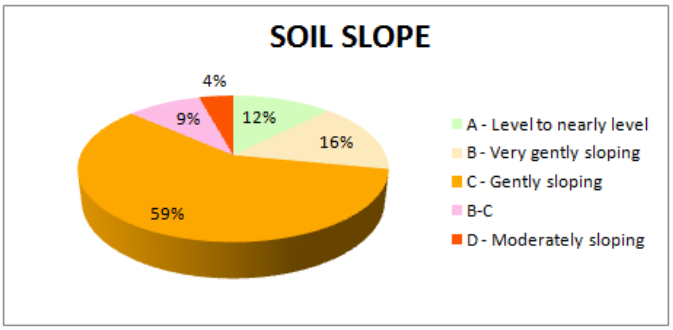

Fig.6 Distribution of the Soil Slope Categories in the study area

SURFACE SOIL TEXTURE: Soil surface texture indicates the relative proportion of primary particles of sand, silt and clay present in the top 25 cm soil depth. The surface soil textural class provides a guide to understand soil water retention and availability, workability, nutrient retention, infiltration, drainage, physical and chemical behavior, microbial activity and crop suitability. Sandy followed by loamy textured soils are predominant in the Study area and also in Kalyandur mandal. Loamy soils alone are extensive in Setturu and Brahmasamudram mandals.

SOIL GRAVELLINESS: Gravelliness indicates the presence of coarse fragments in the soil that affects moisture storage and infiltraton, which hinders plant growth by impeding root

growth, seedling emergence, intercultural operations and mechanization. Non gravelly and gravelly soils occur in equal proportion in the study area. Gravelly soils are predominant in area in Brahmasamudram and Setturu mandals while non gravelly soils are dominant in Kalyandurg mandal.

SOIL CALCAREOUSNESS: The term calcareousness is used to indicate the presence of calcium carbonate (CaCo3) in the soil either in powdery form of nodular form which hinders the availability of plant nutrients and induce nutrient disorder. It is assessed in the field by observation of effervescence from the soil when it is moistened with dilute HCL. The calcareousness is graded into three classes i.e. slight, moderate and strong. Non calcareous soils are most predominant in area as compared to calcareous soils in the study area.

POTENTIAL SOIL LOSS: Potential soil loss indicates the magnitude of detachment of finer particles from earth surface by the action of wind and water. In the study area vulnerable to different degrees of soil loss, which enable to assess the rate of sedimentation in water storage systems. Soil loss is moderate (5-10 t/ha/Yr) to strong (10-15 t/ha/Yr) in Kalyandurg and Setturu and strong to severe (15-20t/ha/yr) in Brahmasamudram mandal.

SOIL DEGRADATION: Soil degradation refers to the decline in productivity of soils due to natural or human induced processes such as floods, earth quackes, volcanic eruptions, excessive irrigation, deforestation, overgrazing, enhanced industrial growth, excessive use of chemical fertilizers and pesticides. All these processes reduce the productive capacity of the soils, affecting food security. The kind and degree of different degradation processes affecting the soils have been spatially represented in the map.

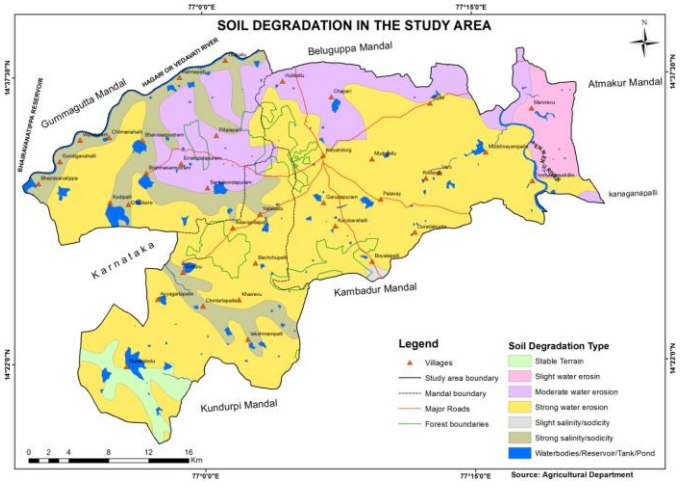

Fig.7 Soil Degradation in the study area

Moderate to strong water erosion followed by slight to strong salinity-sodicity processes are predominant in the study area. Slight to strong erosion is in Kalyandurg mandal, strong erosion followed by slight to strong salinity-Sodicity in Setturu mandal, moderate to strong water erosion followed by slight to strong salinity-sodicity processes are predominant in Brahmasamudram mandal. The distribution of soil degradation in the study area is given in table .3 and fig 7 and 8.

Table.3 Distribution of soil degradation in the study area

Soil Degradation Type	Area in hectares	Area in percentage (%)
Moderate water erosion	18896.4192	17.15887028
Slight salinity/ sodicity	822.4550096	0.746829263
Slight water erosion	5105.481306	4.636026038
Stable Terrain	3631.258943	3.297360229
Strong salinity/ sodicity	13553.25236	12.30701419
Strong water erosion	68117.3763	61.8539
Total	**110126.2431**	**100**

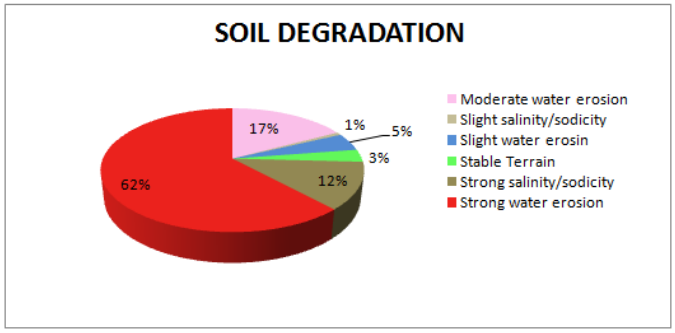

Fig.8 Distribution of Soil Degradation in the study area

SOIL FERTILITY STATUS: Soil fertility refers to the inherent status of plant-available nutrients in respect of nitrogen, phosphorus, potassium and micronutrients, which can guide the users on the amount of fertilizers to be applied for different crops in different areas. Soils are low in available nitrogen and high in available Phosphorus and potassium in all the mandals in the study area.

SALINITY OF THE SOILS: The excess of salts that the soils contain is termed as the salinity of the soils. Saline soils usually have a surface crust of white salts, especially in the dry season when the net movement of soil moisture is upward. Salts dissolved in the soil water move to the surface where

they are left as a crust when the water evaporates. These white salts are mostly chlorides, sulphates and carbonates of calcium, magnesium and sodium.

Soluble salt analysis for soils aims to find out whether enough salt is present to cause interference with normal seed germination, plant growth or plant intake of water, Salinity of the sols is determined by electrical conductivity method and the E.C is expressed in mmhos/cm (milli mhos). Virtually the entire study area has normal soils, 97 % of the soils in the study area is <1.0 mmhos (normal), only 3 % of the soils are 1-2 mmhos (critical to germination).

SOIL EROSION: The general aridity of the region, sparse vegetation cover, the ever-increasing population pressure on land and forest areas and livestock pressure on grazing areas have lead to severe soil erosion in this region. The soil forming system of a semi-arid region with high temperatures, low rainfall, and year round water deficiency and the resultant sparse vegetation are least suited for the development of fertile soil. More over a slight interference of man in this system in the form of removing the already sparse vegetation cover aggravates the problem at a rapid rate. These areas are affected both by wind and fluvial erosion. Though the average annual rainfall is low, it comes, sometimes, as cloud-bursts and causes severe soil erosion. The all important fine soil is depleted both by wind and normal erosion process.

The study area suffers from soil erosion caused more by rain than wind. A major portion of its surface soil is lost by runoff causing sheet and gully erosion and rendering extensive areas permanently unsuitable for cultivation. The problem is acute in almost all the mandals in the study area. So, suitable measures are to be taken to conserve the soil resources using Remote sensing and GIS Technology.

SOIL MANAGEMENT: The soil management programme in semi-arid region should be comprehensive and integrated one encompassing three different objectives-namely, (1) improvement of the soil forming environment and thereby fertility of the soil, (ii) improvement of the suitability of the soil with proper measures to prevent soil alkalinity and salinity and also reclamation of soils already affected, and (iii) prevention of soil erosion and reclamation of erosion affected areas.

The soil conservation measures of engineering and agronomic measures have been implemented by the agricultural Research Station, located in Anantapur District. In these programmes stress should also be laid on extension programmes for creating awareness in the farming community about the dangers of continued soil erosion and motivating them for implementation of the soil conservation measures.

The soil conservation measures consisting of agronomic and engineering measures should be implemented in complementary manner to achieve better results. Agronomic practices of soil and water conservation help to reduce the splash effect on soil, promote better intake of water rate by the soil by improving the content of the organic matter and soil structure, help to retard and reduce the overland runoff through the use of contour cultivation, ploughing against the slope, mulches, dense growing crops, strip cropping, mixed cropping and crop rotation. Mechanical measures play a vital role in controlling erosion. These measures include basin-listing, sub soiling, contour bounding, graded bounding and bench terracing on steep slopes. Rising rows of trees along the bunds act as wind-breaks; thus reducing the severity of wind erosion. They also help to add organic matter to the soil.

The soil forming environment could be improved by management of the stream catchments at micro level. Construction of check-dams on small catchments serves as a multipurpose scheme in this direction. The stored water is useful for short term irrigation, groundwater replenishments and improving the vegetative cover. The dams act as silt traps which can be respired over the catchment thus restoring the fine material to the soil. This scheme should be implemented in the piedmont areas of the district where sheet and gully erosion is most severe.

The alkalinity and salinity problems of the soils have to be solved with suitable measures like gypsum application and leaching of the excessive salts with suitable dosage of irrigation respectively.

Evaluation of quality of irrigation water and the suitability of the soil for heavy irrigation is to be done to prevent adverse effects like salinity and alkalinity problems in the soils.

Proper care should also be taken to minimize water seepage from the irrigation canals which will lead to the problems of salinity and alkalinity in the semi- arid areas. What is needed is an integrated approach for management of soil and water resources.

CONCLUSION

The study area is covered with red soils over 95 % of the area and black soils over the rest of the area. The black soils are comparatively more fertile and better suited for cultivation in this drought-prone area. The soil forming environment of the region with its low rainfall, high temperatures, sparse vegetation and the undulating relief promoting soil erosion, is not congenial for development of good fertile soils. The soils of the region are generally poor in and organic matter content but contain high amounts of phosphorus and potash. Most of the soils are neutral or weakly alkaline and only a few small pockets are having severe salinity or alkaline problems. But if the soils are not properly

managed, the soils are prone to become saline as well as alkaline in some micro-environments. The conditions in the region are causing both wind and river erosion of the soil and suitable integrated engineering and agronomic measures are to be implemented to prevent the soil erosion to reclaim the erosion affected areas and to improve the soil conditions.

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