Land Capability Studies of the Garladinne Mandal, Anantapur District, Andhra Pradesh, India, Using Remote Sensing & GIS Techniques.

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Abstract

The Garladinne mandal covering an area about 304.97 km² is studied with the help of SoI topographic sheets, IRS IB Geocoded data and LISS-IV data on scale 1:50,000 with a view to map the relief, slope, drainage, landforms, soils, erosion susceptibility and hydro geomorphology. Based on the above said physical characteristics the land capability of the Garladinne mandal has been brought out. The characteristics and limitations of each class of land are dealt in detail.

Introduction

Land embraces the atmosphere, the soils and underlying geology, the hydrology and the plants above and below a specific area of Earth surface. It also includes the results of past and present human activities as well as animals with in the area, in so far as they exert a significant influence on the present and future uses by man. The planning of land development and readjustment is usually carried out in a number of successive phases, namely land evaluation, socio-economic analysis, classification and programme effectuation. Land evaluation includes both qualitative and quantitative classification. In developing countries like India where agriculture is main economic activity, the basic resources namely the land water has to be properly augmented for better planning. Appraisal of resources and diagnosis of problems involved in management of the resource availability is particularly important in the areas of scarce resources. It has assumed much greater importance in India now with the acceptance of multi-level regional planning. Drainage basins or watersheds form most convenient, as well as most appropriate spatial units for the study of natural resources particularly the basic resources like land and water. Shafi (1969) has given a good account on the methods and techniques of land use planning, land classification and land capability. Ali Mohammad (1978) stated that the land capability classification is related to characteristics of land such as slope, erosion, stoniness, alkalinity, salinity, presence of high water table, land use, soil texture, soil moisture and the fertility of the soils. Raju and Vidyanadhan (1978) studied the geomorphology of Visakhapatnam and prepared the hazards map of Vishakapatnam town. Raghavswamy and Vidyanadhan (1980) mapped the morphological features and land systems of part of Vishakapatnam district using air photo studies. Nageswararao and Vidyanadhan (1981) brought out the land capability of Krishna delta based on studies from aerial photo interpretation. Suryanarayanan (1982) has mapped the landforms and brought out the land evaluation

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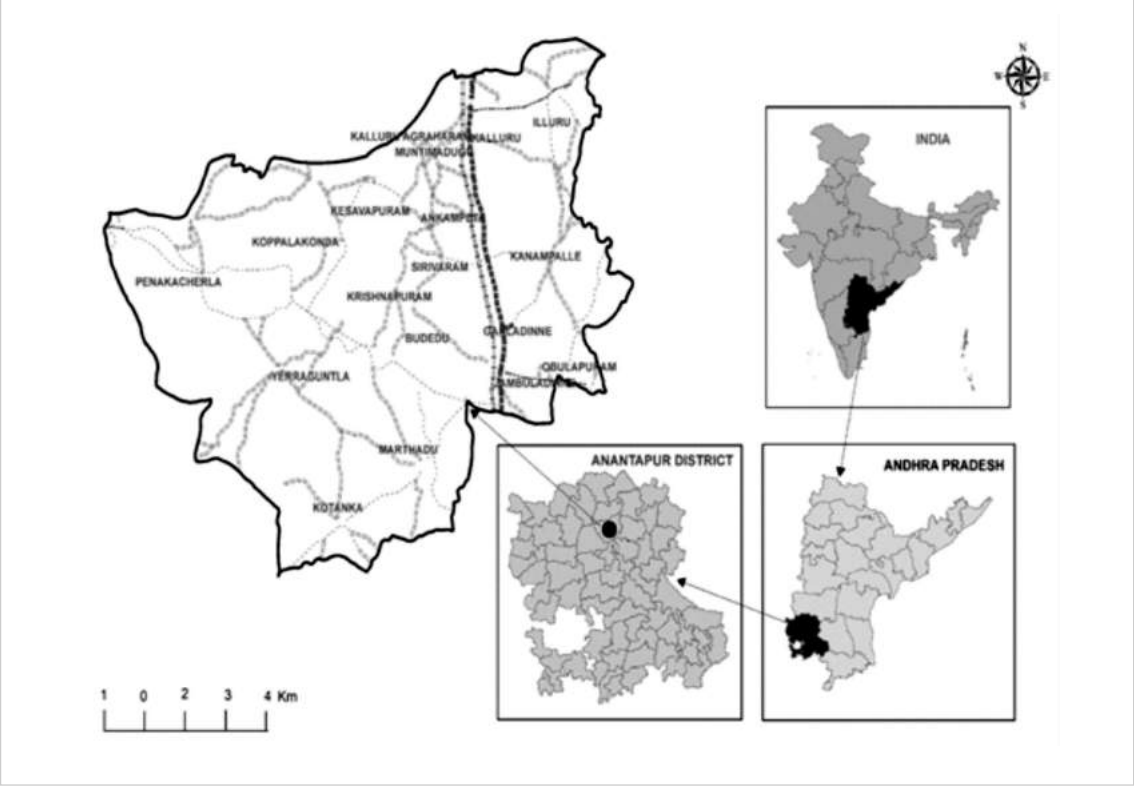

Fig.1- Location Map of Garladinne Mandal - Anantapur district

of Dharmapuri district in Tamilanadu. The studies on flood intensity and land evaluation in the Cauveri delta using remote sensing data has been carried out by Sambasiva Rao (1982).The evaluation of land and water resources of the Cumbam valley in Madurai district are studied by Sambasiva Rao and Nageswari (1983). Sambasiva Rao (1983) has mapped the land resources of the Madurai district of Tamila Nadu using remote sensing data. Sambasiva Rao (1986) has studied the morphological evaluation of land and water resources Tambrapani river basin in Tamila Nadu state. Sambasiva Rao (1987) has studied the environmental hazards and landscape management of Southwestern Ghats. The studies on land resources of the Anantapur district are carried out by Suresh babu. Sambasiva Rao (1996) has studied the water balance of and development of land, water and agriculture resources of Tamila Nadu state. Sambasiva Rao (1997) has given a good account of eco climatology, water balance, ecological degradation and ecodevelopment of Nallamalai and Yerramalai hills of Eastern Ghats. Narendra kumar (1999) has studied the integrated land and water resources development for sustainable land use of Chitravathi river basin with special reference to Gutturu watershed. The land resources of the Pennar river basin have been described by Sambasiva Rao (2002). Manjunath (2004) has studied the land and water resources and water resources development of Pandameru and Tadakaleru river basin of Pennar river system using remote sensing and GIS techniques.

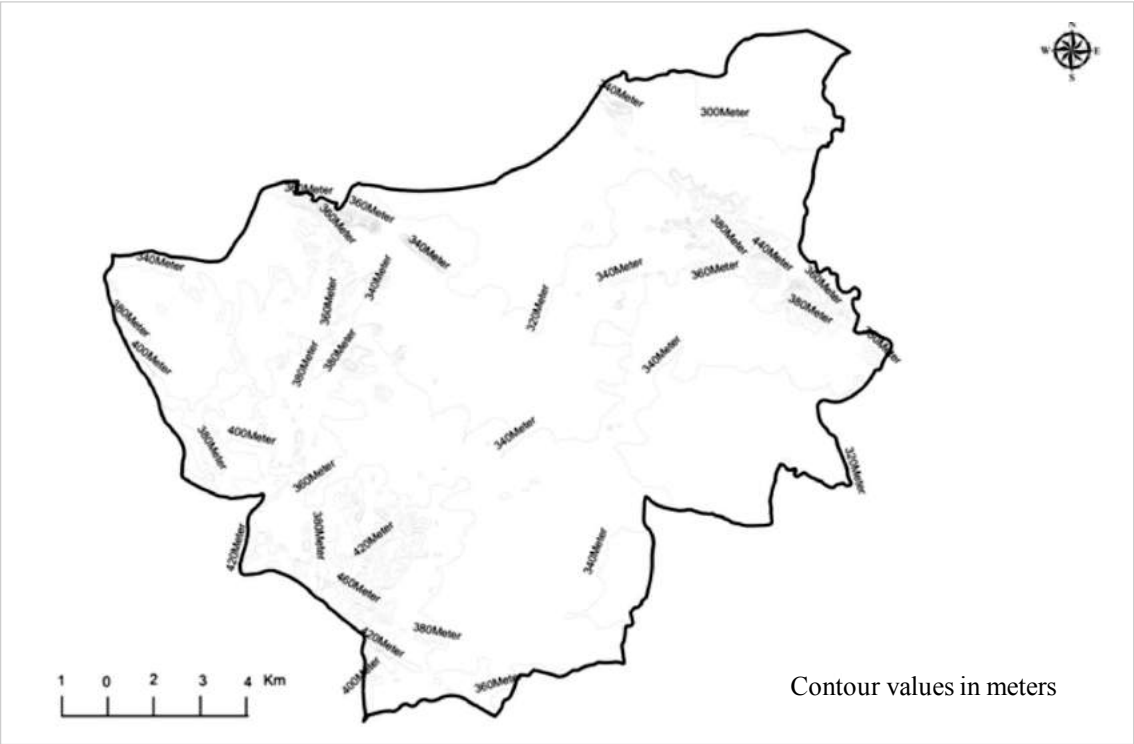

Fig.2.-Relief Map of Garladinne Mandal - Anantapur District

An integrated study of geo-ecology, geo-hydrology and watershed development of the Papagni river basin has been studied by Sambasiva Rao (2005). The geomorphic evolution and development of land and water resources of the Kunderu basin using remote sensing techniques has been carried out by Sambasiva Rao (2012).

Study area

Garladinne mandal covers an area of about 304.97 sq km and lies in the Anantapur district of Andhra Pradesh in between 14^0 49" 14' to 14^0 57"20' North latitudes and 77^0 35" 48' to 77^0 43" 43' East longitudes (Fig.1). There are 18 revenue villages in Garladinne mandal. The total population of Garladinne mandal is about 53,882 (2011 census). Geologically, it is mainly comprised of Archean rocks consisting of granitic gneisses with dolerite and quartzite intrusions. The annual rainfall is about 568 mm.The annual minimum temperature of 14^0c is noticed in January and the annual maximum temperature of 42^o c is noticed in the month of April. Climatologically the mandal is located in dry sub-humid type of climate. The NH-44 is major a North-South National Highway in India and it is connecting Varanasi-Kanyakumari and the Broad gauge Railway line connecting Bangalore - Mumbai and Bangalore - Hyderabad pass through the centre of the Garladinne mandal of Anantapur district.

Objectives

1. to study the relief, slope and drainage and slope of the Garladinne mandal,
2. to map the landforms and soils of the Garladinne mandal,

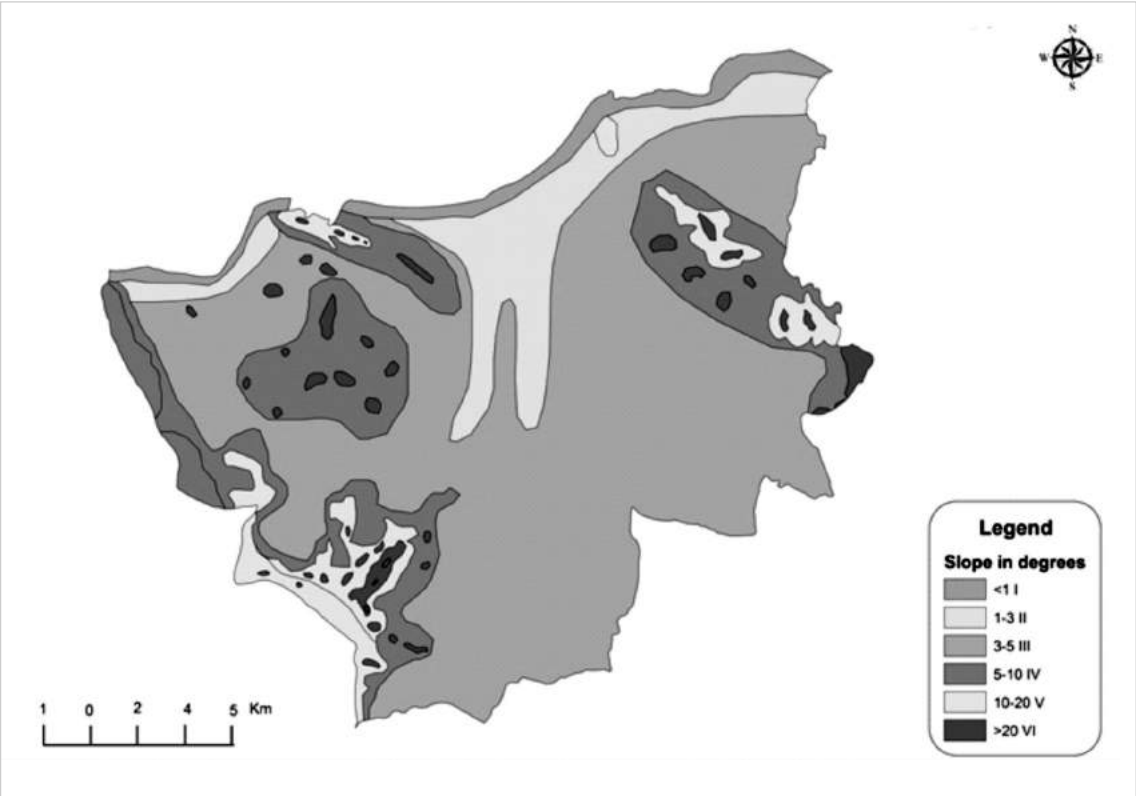

Fig.3 -Slope Map of Garladinne Mandal - Anantapur District

3. to study the land use, erosion intensity and hydro geomorphology of the Garladinne mandal and
4. to bring out the land capability of the Garladinne mandal.

Methodology

IRS 1B Geocoded data and LISS-IV data on scale 1:50,000 is used in this main study . The relief and drainage has been traced from SOI topographic sheet 57 F/5, 57F/9 on scale 1:50,000. The slope is worked out adopting Wentworth (1930) method. The landform, soils and land use has been mapped using SOI topographic sheets and IRS IB Geocoded data and LISS-IV data. The erosion susceptibility zones are mapped basing on texture, drainage and amount of soil removal adopting Flaxman (1971) method. The land capability map of the Garladinne mandal is brought out using physical characteristics. The Arc GIS is used for preparation of various physical thematic maps of Garladinne mandal.

Physical aspects of Garladinne Mandal

Relief

Physiographically the Garladinne mandal varies in altitude from 300 meters to a maximum of 460 meters above MSL (Fig 2). There are two prominent hilly terrains passing through Garladinne mandal in northwest and southeast direction. The hills are located in Kanampalle reserve forest in northeastern part of the Garladinne mandal. They range in altitude from

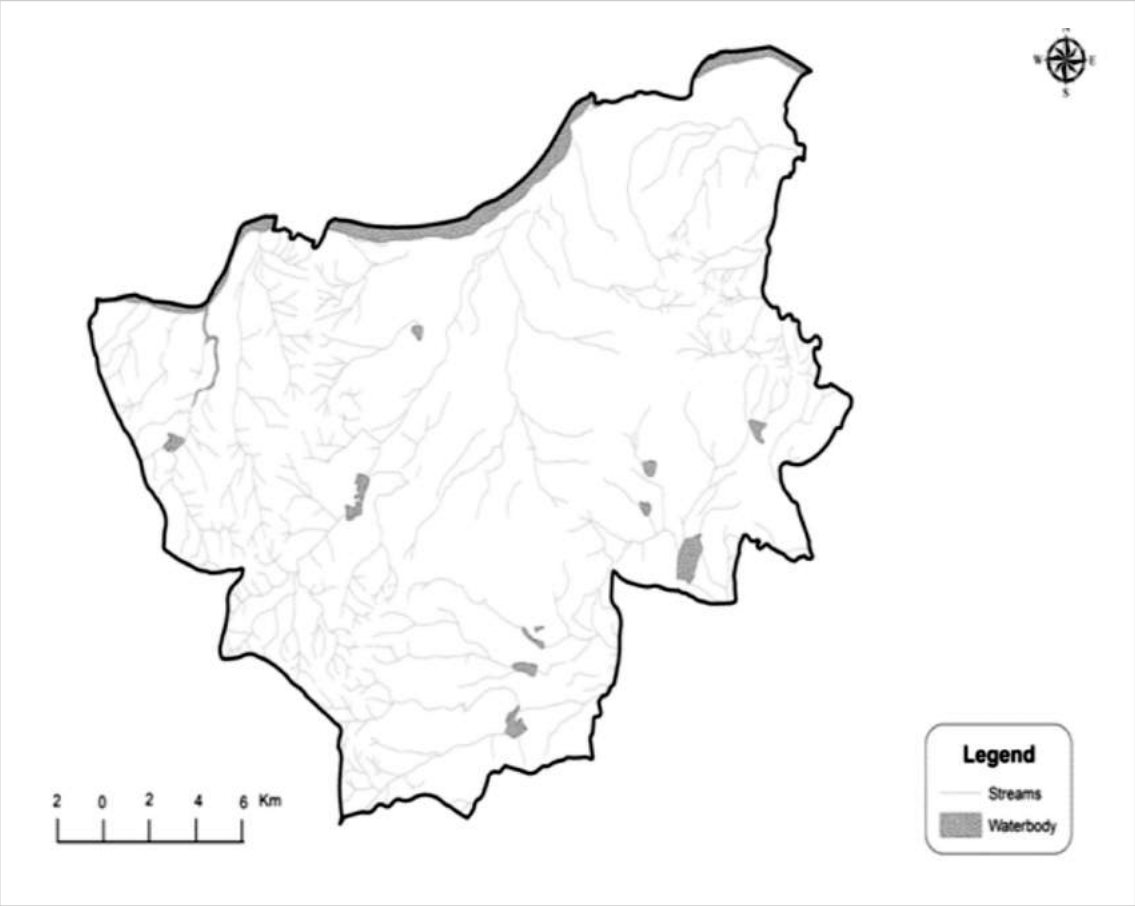

Fig.5 - Drainage Map of Garladinne Mandal - Anantapur District

360 meters to 440 meters above MSL. They align towards northwest and southeast direction. In northern part of the Garladinne mandal a few isolated hills align east northeast, west southwest direction. The western part of the Garladinne mandal is boarded by Marutla reserved forest hills which aligned in northeast and southwest direction. The altitudes in these hills vary from 360 meters to 460 meters above MSL. In northwestern direction of the Garladinne mandal there are Penakacherla hills which vary in altitude from 380 meters to 420 meters above MSL.There are a few isolated hills in the northwestern part of the Garladinne mandal which range in altitude from 340 meters to 440 meters above MSL. The central part of the Garladinne mandal is an undulating plain which varies in altitude from 320 meters to 380 meters above MSL.

Slope

The slope of the Garladinne mandal has been worked out using Wentworth (1930) method. The slope has been categorized into very gently sloping (less than 1^0) gently sloping (1^0 to 3^0) moderately sloping (3^0 to 5^0) strongly sloping (5^0 to 10^0) very strongly sloping (10^0 to 20^0) and steeply sloping (more than 20^0). The fluvial plains

Table 1- Order of streams in major stream sub basins of Garladinne mandal

Stream Sub basins	Number of streams in first order	Number of streams in second order	Number of streams in third order	Number of streams in fourth order	Number of streams in fifth order
I	41	8	1	-	-
II	42	8	2	-	-
III	112	29	9	2	1
IV	41	12	2	1	-
V	21	5	2	1	-
VI	23	6	1	-	-
VII	43	11	4	-	-
VIII	14	5	1	-	-
Total	337	84	22	4	1

of the Pennar River are categorized under very gently sloping with the less than 1^0 slope (Fig.3). The wash plains are grouped under gently sloping which vary in slope from 1^0 to 3^0. The undulating plains consisting of pediplains are categorized under moderately sloping zones with slope varying from 3^0 to 5^0. The undulating plains consisting of pediment inselberg complex fall under category of strongly sloping which vary in slope from 5^0 to 10^0 .The debris slopes of the hilly terrain are grouped under very strongly sloping which vary in slope from 10^0 to 20^0 . The steep areas of hills terrain are categorized under steep slopes with more than 20^0 slope.

Drainage

Based on direction of flow of major streams in the Garladinne mandal eight stream sub basins are identified. (Fig.4) The first and second order streams flow in north-south direction. The origin of these streams is in cuesta hills of the Penakacherla. There are 41 first order streams, eight second order streams and one third order stream in the first major stream Penakacherla. The type of drainage is dendritic to sub-dendritic. The second major stream has its origin in cuesta hills near Penakacherla. There are 42 first order streams, eight second order streams and two third order streams in the second major stream. The type of drainage is dendritic to sub-dendritic. The third order stream has its origin in cuesta hills near Mukundapuram. There are 112 first order streams, 29 second order streams, 9 third order streams, two fourth order streams and one fifth order stream. The direction of flow of this major stream is NE-SW. The type of drainage is dendritic, sub-dendritic and intermittent streams. The fourth major stream flows ENE-WSW direction and has its origin in cuesta hills of Kotanka. There are 41 first order streams, twelve second order streams, two third order streams and one fourth order stream. The type of drainage is dendritic, sub-dendritic and intermittent. The fifth major streams flows from WNW to ESE direction. The number of first order streams is 21, second order streams are five, third order streams two and one fourth order stream. The type of drainage is sub-dendritic and intermittent. The sixth major stream has its origin in pediment plains of Garladinne. There are 23 first order streams, six second order streams and one third order stream. The direction of flow is NW-SW. The seventh major stream flows NW-SE, NE-SW and ENE-WSW direction. The origin of this major stream in structural hills is in structural hills of Kannampalli. There are 43 first order streams, 11 second order streams and four third order streams. The type of drainage is dendritic, parallel, sub-dendritic and intermittent. The eight major stream has its origin in structural hills near Illuru. The direction flow is NNW-SSE, NE-SW, EW and ENE-WSW direction. There are fourteen first order streams, five second order and onethird order stream. The type of drainage is dendritic and sub-dendritic. In total there are 337 first order streams, 84 second order streams, 22 third order

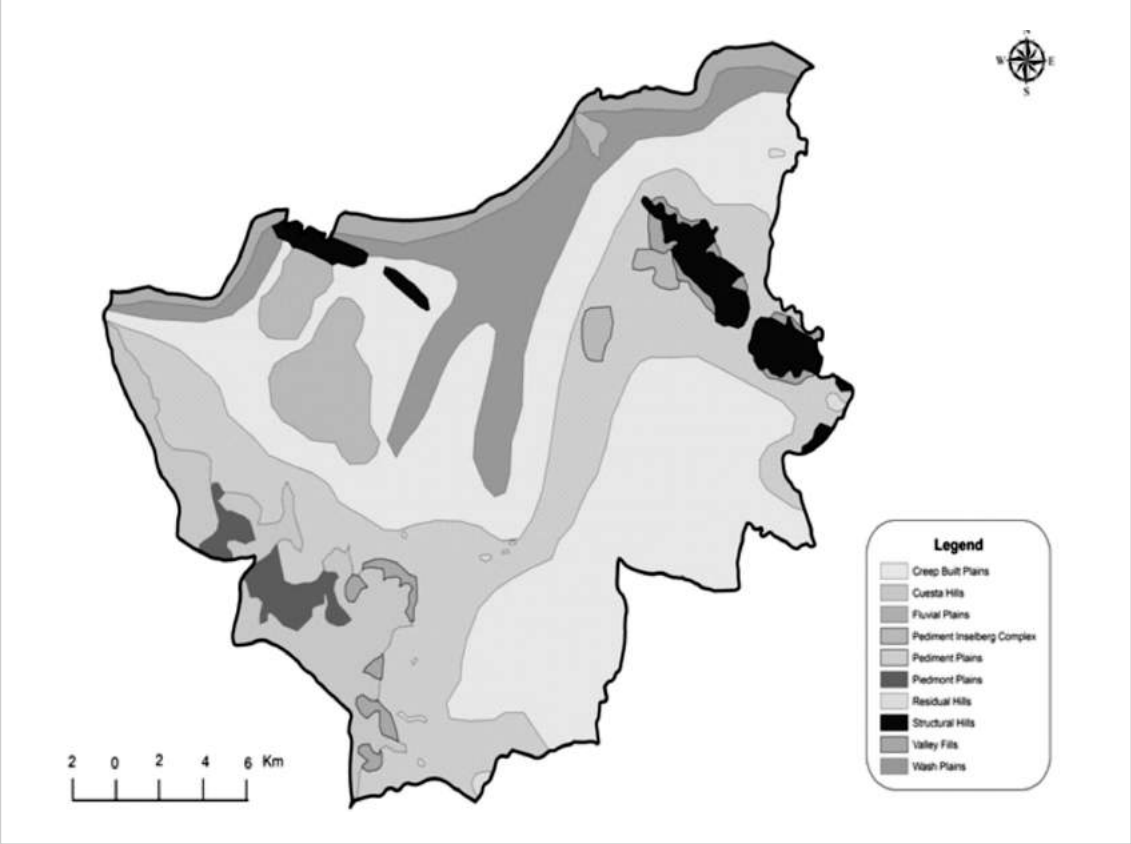

Fig.5 - Landforms Map of Garladinne Mandal - Anantapur District

streams, 4 fourth order streams and one fifth order stream. The bifurcation ratio is 4.01 for first order streams, 3.82 for second order streams, 5.5 for third order streams and 4 for fourth order streams. The average bifurcation ratio is 4.33.

Landforms

The landforms of the Garladinne mandal are classified into denudational, fluvio-denudational and fluvial based on geomorphic processes and agents involved in their formations (Fig.5). The denudational landforms are associated with hill terrain. They consist of structural hills, cuesta hills, pediment inselberg complex and residual hills. The structural hills are found in northeastern and northern part of the Garladinne mandal. They range in altitude form 360 meters to 440 meters above MSL. The cuesta hills are found in the western and southwestern part of the Garladinne mandal. They range in altitude from 380 meters to 460 meters above MSL. They are covered with shrubs and bushes. The pediment inselberg complex is noticed in the northwestern part of the Garladinne mandal and ranges in altitude from 340 meters to 400 meters above MSL .They are covered with bushes. The isolated hills are scattered in the pediment plains which raised to about 30 meters to 40 meters above ground level. They are barren and represent the remnant hills of denudational hilly terrain which was weathered by back weathering. The fluvio-

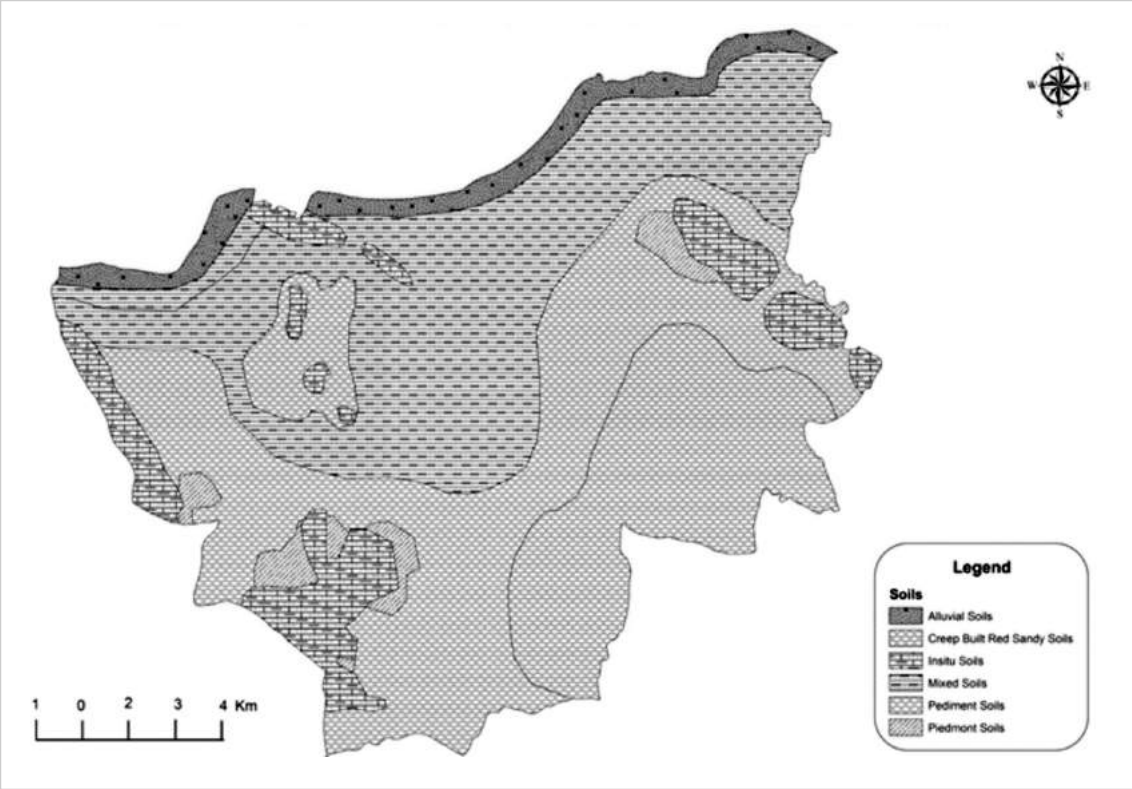

Fig. 6- Soil Map of Garladinne Mandal - Anantapur District

denudational landforms are valley fills, colluvial fans, creep built plains and wash plains. The pediment plains cover an about 160 sq km^2 which is about 52.63 % of the total area of Garladinne mandal. The pediment plains are formed by back weathering and lateral planation. The altitudes vary from 320 meters to 380 meters above MSL. The valley fills are found in the cuesta hills and structural hills. The colluvial fans are formed in the southwestern part of the Marutla reserve forest hills. They are derived from the boarding hilly terrain and are cone shaped. They are formed of small rocky stones with gravel and red sandy soils. The creep built plains are found on the pediment plains which vary in depth from 1 meter to 2 meters. They are formed by gravity and stream action. The wash plains are bordering the fluvial plains along the Pennar river course and are composed of mixed soils. They act as good recharge zones of the fluvial plains. The fluvial plains lie parallel to the Pennar River and are extended in length to about 30 km in east west direction. They vary in width from 500 meters to 1200 meters. They are composed of rich alluvial soils, and are formed by stream deposition in the Pennar river valley.

Soils

The soils of the Garladinne mandal are categorized into hilly soils, piedmont soils, pediment soils, creep built red sandy soils, wash plain soils or mixed soils and alluvial soils (Fig.6).

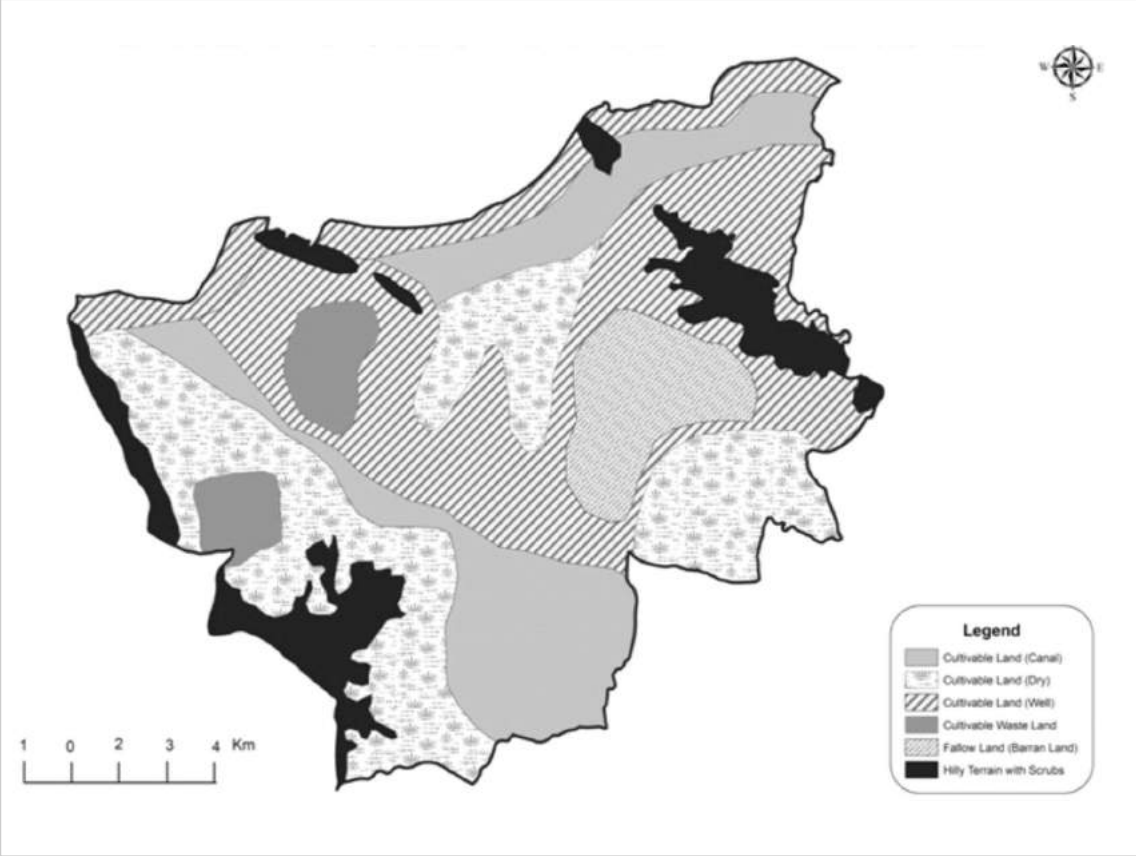

Fig. 7 - Landuse Map of Garladinne Mandal - Anantapur District

The insitu soils or hilly soils are found on the hills terrain located in northeastern and southwestern parts of the Garladinne mandal. They are formed of dead and decayed leaves of shrubby forests. They are rich in organic matter. The piedmont soils are deep red sandy soils mixed with rocky stones, gravel and red sands. They are found in valley fills and colluvial fans. The pediments soils are shallow stony red sandy soils. They are formed on the pediments and pediment inselberg soils. The depth of soil is less than I meter. The creep built red sandy soils are formed on the creep built sandy plains derived from the bordering hilly terrain and pediment plains by creep. The mixed soils consisting of clayey and red sandy soils. They are noticed in the wash plains bordering the fluvial plains. The alluvial soils are formed by stream deposition in the fluvial Pennar river valley.

Land use

The land use of the Garladinne mandal (2010) has been categorized into cultivable land, cultivable land under canal irrigation, and cultivable land under tube well and tank irrigation, cultivable land under dry conditions, cultivable waste lands, fallow lands, barren lands and hilly terrain with scrubby forests (Fig.7). The cultivable land under canal irrigation is found in western part of the bordering hilly terrain in

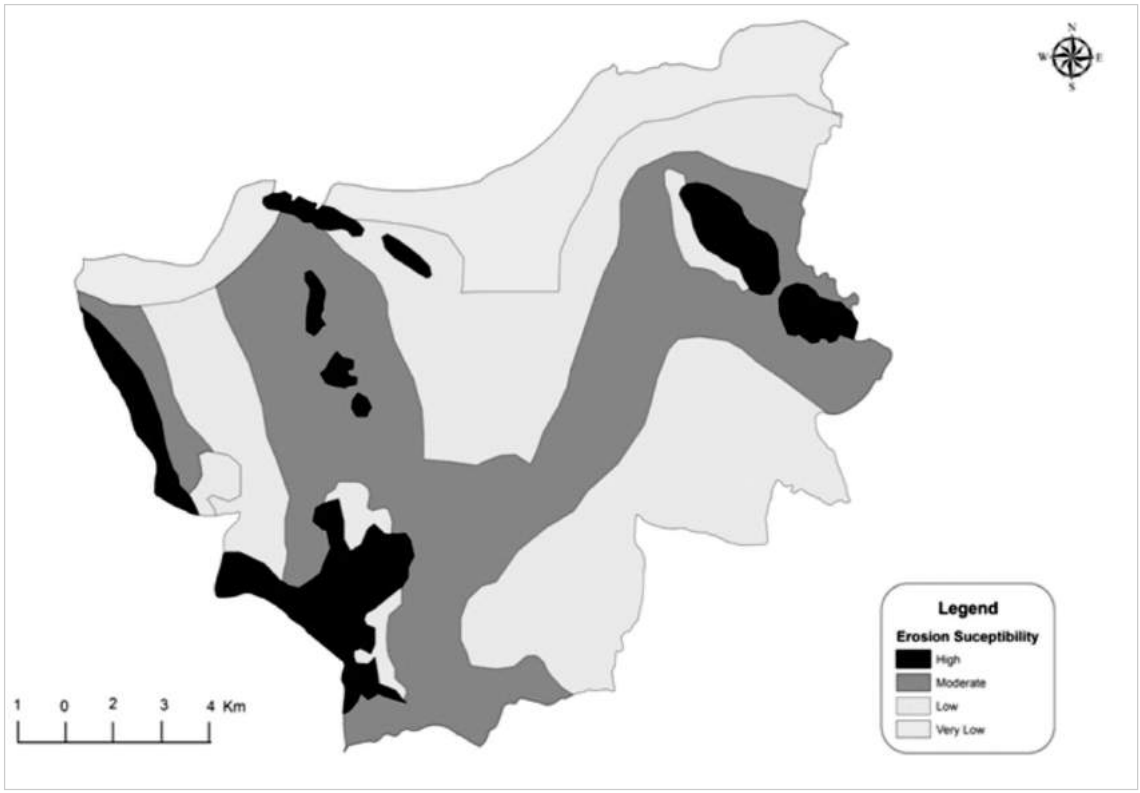

Fig. 8- Erosion Suceptibility Map of Garladinne Mandal - Anantapur District

northwest southeast direction. The Mid Pennar south canal of Mid Pennar dam passes through this area and supplies water during kharif season. Paddy is the predominant crop cultivated under canal irrigation.The cultivated land under wet condition is found along the river Pennar in fluvial and wash plains. The source of irrigation is tube well or dug well. The crops cultivated are paddy, banana, maize, jowar and groundnut. The cultivated land under dry conditions is found in the pediment plains .The predominant crop cultivated is groundnut followed by castor, sunflower, red gram and vegetables. The cultivable waste lands are associated with pediment inselberg complex. They are used for cultivating of groundnut and red gram. The fallow and barren lands are also found in the pediment plains. The hilly terrain is formed of scrub and bushy forests.

Erosion susceptibility

The intensity of erosion is high in the hills terrain due to steep slopes and poor vegetation cover (Fig. 8). The moderate intensity of erosion is found in the pediment plains. The low intensity of erosion is noticed in creep built plains. The very low intensity of erosion is found in fluvial and wash plains. The pediment inselberg complex is also subjected to high intensity of erosion. The amount of soil removel is less than 0.5 m^3/ha in fluvial and wash plains. It varies from 0.5 m^3/ha to 5 m^3/ha in crrep built plains. 5 m^3/ha to 10 m^3/ha in pediment plains and more than 15 m^3/ha in the slope regions with poor vegetation cover.

Hydrogeomorphology

The hydrogeomorphology of the Garladinne mandal has been studied with the help of spatial

Fig. 9 - Hydrogeomorphology of Garladinne Mandal - Anantapur District

distribution of landforms and hydro geological conditions of the Garladinne mandal (Fig. 9). Hydrogeologically Garladinne mandal is composed of hard rock terrain, consisting of unclassified granitic gneisses of Archean age. In the hard rock terrain ground water resources are restricted to weathered, fissured, faulted and fractured zones. The specific yield is less than 5%. The transmissibility and specific capacity are very low due to hard rock nature of the terrain. The yield of ground water is very low in granitic terrain and does not exceed 10,000 liters for a day for hour. The fluvial plains consisting of deep alluvial soils are categorized excellent water resources because of high yield, high recharge. The ground water is found in semi-confined and confined aquifers. The wash plains are categorized under good ground water potential zones because they are good recharge water zones .The valley fills and colluvial fans posses very fair ground water resources. The creep built plains are formed of fair ground water resources. The pediment plains and pediment inselberg complex are poor zones for excavation of ground water resources because of shallow depth of rock. However ground water resources are found in weathered, fissured, fractured and faulted zones in the pediment plains. The ground water yield is poor. The hilly terrain acts as run-off zones due to steep slopes and shallow soil formation.

Paddy cultivation on loamy soils near Sanjevapuram

Mid Pennar south canal near Yerraguntla

Land capability

Based on physical characteristics like relief, slope, lithogy, landforms, soils, land use, erosion susceptibility and hydro geomorphic potential the land capability of the Garladinne mandal has been evaluated and classified into seven classes of land (Fig. 10).

Class -1

The class 1 lands consist of fluvial plains bordering the Penna River for a length of about 30 km covering area about 25.5 sq km. They are rich soils with excellent ground water resources. The slope is very gentle. The paddy, banana, fruits and vegetables are cultivated in class 1 lands. The soil productivity is high. The intensity of soil erosion is very low. The soil and land irrigability are grouped under class A and class 1 respectively. The major land development activities that could be carried out are land mulching, land leveling and land grading.

Class-II

The class II land consists of irrigated plains other than fluvial plains. The slope is gentle. The ground water potential is good. The recharge is high. The soil fertility is moderate to good. The intensity of erosion is low. The soil and land irrigability are grouped under class-A class-2 respectively. The crops cultivated are paddy, groundnut, banana, vegetables and orchards.

Class-III

The Class-III lands composed of wash plains. The slope is less than 3^0. The ground water potential is good. The soil fertility is moderate to good. The intensity of soil erosion is low. The soils and land irrigability are grouped under class-B, class-III respectively. The crops cultivated are paddy, groundnut, sunflower, maize and dry food crops. The land development activities that could be carried out are land mulching, land grading and land leveling.

Class –IV

The class-IV land consists of creep built plains. The slope varies from 3^0 to 5^0 and less than 3^0 .The soil fertility is moderate. The ground water potential is very fair. The ground water recharge is very fair. The soil and land irrigability are grouped under Class-C, Class-III respectively. The cultivated crops are paddy, groundnut, sunflower and dry foods. The land developmental activities that could be carried out are land leveling, mulching, grading and bunding.

Class-V

The class-V land consists of pediment plains and pediment inselberg complex. The slopes vary

Sunflower cultivation on loamy soils near Illuru

The pediment plains are used for cultivation of sweet oranges under drip irrigation.

from 5^0 to 10^0 and 10^0 to 20^0. The soil formation is poor and it is less than 0.5 meters in depth. The soil fertility is poor. The recharge is low. The intensity of soil erosion is moderate to high. The soil and land irrigability are groped under Class-C, Class –IV. The crops cultivated are groundnut, sweet orange and dry food crops. The land development activities that could be carried out are land leveling, the land mulching, land grading and land bunding.

Class-V

The class-V land consists of pediment plains and pediment inselberg complex. The slopes vary from 5^0 to 10^0 and 10^0 to 20^0. The soil formation is poor and it is less than 0.5 meters in depth. The soil fertility is poor. The recharge is low. The intensity of soil erosion is moderate to high. The soil and land irrigability are groped under Class-C, Class –IV. The crops cultivated are groundnut, sweet orange and dry food crops. The land development activities that could be carried out are land leveling, the land mulching, land grading and land bunding.

Class-VI

The Class-VI consists of debris slope regions of hilly terrain. The slope varies from 10^0 to 20^0 and less than 20^0. The soil fertility is poor. The recharge is low. It is a run-off zone. The intensity of soil erosion is high .The slopes are covered with scrubs and thorny bushes. In some parts of the slope zones they are disturbed for cultivation of groundnut and orange orchards (Photo). The soil and land irrigability are grouped under class D and class-V respectively. The land development activities that could be taken up are afforestation, terrace bunding, contour bunding, stone bunding and construction of rock fill dams to minimize soil erosion and conservation of soil resources.

Class-VII

The class-VII consists of hilly terrain high slope more than 20^0. It is a run-off zone. The soil fertility is very poor. The intensity of soil erosion is very high. The slope should not be disturbed for crop cultivation. The land development activities are terrace bunding, contour bunding, stone bunding and construction of rock fill dams. This class land should be used for growth of natural forests. Assfforestation activities have to be carried out. The soils and land irrigability are grouped under class –D, and class-V respectively.

Conclusions

Physiographically the relief varies from 300 meters to 460 meters above MSL. About six categories of slope units are found. There are

Sapota with ground nut inter cropping on red sandy soils near Kanampalle

Ground nut crop on pediment plains with sprinkler irrigation near Penakacherla

eight sub-streams in the Garladinne mandal. The major type of drainage is dendritic and sub-denditric.the average bifurcation ratio is 4.33.the major landforms identified are categorized into denudational, fluvio-denudational and fluvial basing on geomorphic process and agents involved in their formation. The major type of soil is red sandy soils found in pediment plains. The mixed soils are found in wash plains are found in wash plains and alluvial soils are noticed in fluvial plains. The northern fluvial plains and southeastern plains of Garladinne mandals used for cultivation of paddy crop. The groundnut, red gram, caster, and orange plantation are found in pediment and wash plains. The intensity of erosion is high in the slope zones of hilly terrain due to steep slopes lack of vegetative cover. Hydro geomorphologically the fluvial plains posses excellent ground water resources. Based on physical characteristics of the Garladinne mandal about seven classes of land are identified. The characteristics and land development activities to be taken for each class of land is described.

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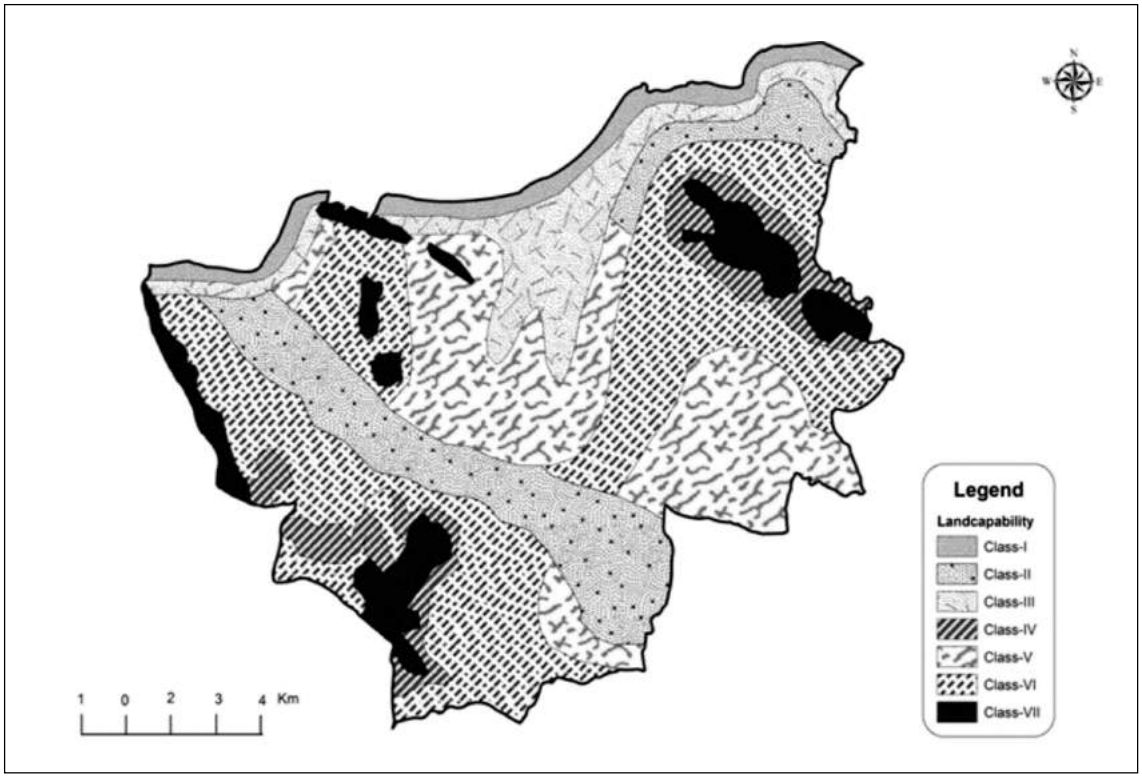

Fig. 10 -Land Capability Map of Garladinne Mandal - Anantapur District

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