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LANDSCAPE ECOLOGICAL PLANNING AND MANAGEMENT OF ANANTAPUR DISTRICT, ANDHRA PRADESH

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Introduction

Reliable information on geomorphological units with respect to their nature, extent, spatial distribution, potential and limitations is very useful for evaluation and optimal utilization of natural resources and environmental management on sustainable basis. The geomorphological mapping of a terrain is a pre-requisite for the soil resources mapping, groundwater potential zones identification, landscape ecological planning, hazard mapping and other environmental applications (Fairbridge, 1968 and Bhat, 1989). Geomorphological processes are part of a whole system of interactivity phenomena and their significance to geoenvironmental problems has to be assessed in the light of sustainable physical landscape management and maintenance of geo-ecological balance of the study area. Studies on geomorphology and evaluation of landforms has been carried out by Strahler (1946), Cotton (1948), Fairbridge (1968), and Ollier (1977a and b). Prabhakara Rao (1981) has described the applied geomorphic studies in the semi-arid Anantapur district. Sambasiva Rao and Vaidyanadhan (1979) have made an attempt to study the morphology and evolution of Godavari delta. The studies on environmental geomorphology and management are carried out by Cook and Doorcamp (1974) and Coates (1973).

Quite number of works are reported from different parts of the globe on the study of the landscape ecology in different contexts. In the early 80's the term landscape ecology was coined by the German Geographer Carl Troll who saw it as the union of the geography and ecology. Forman and Godron (1986) defined more technically that landscape ecology is the study of the structure, function and change in heterogeneous land area composed of interacting ecosystem. Temporal changes in landscape composition and structure result from physical, biological and human influences (Turner and Ruscher, (1988). Turner and Gardner (1993) followed the remote sensing applications at macro level and field surveys at micro level in analyzing the landscape fragmentation indicators. The use of satellite imagery as source of information for landscape monitoring was investigated as part of the project 'Environmental Monitoring of the protected Landscape (Brown, et al., 1996). In the present study an attempt is made to delineate the various geomorphic units of the district with the help of satellite data and available collateral data to evaluate for sustainable physical landscape management and maintenance of the vital geo-ecological balance of the semi-arid Anantapur district.

Study Area

The Anantapur district lies between 13°14' to 15°15' N latitude and 76°50' to 78°30' E longitude. It is bounded on the north by Kurnool district, east by Cuddapah and

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Chittoor districts, south and west by Karnataka state and it covers an area of about 19,125 km^2 (Fig.1). The general elevation ranges from 280 m above msl in the north-eastern parts to 670 m above msl in the south-western parts of the district. The annual mean temperature and rainfall of the district are 27.5°C and 558 mm, respectively.

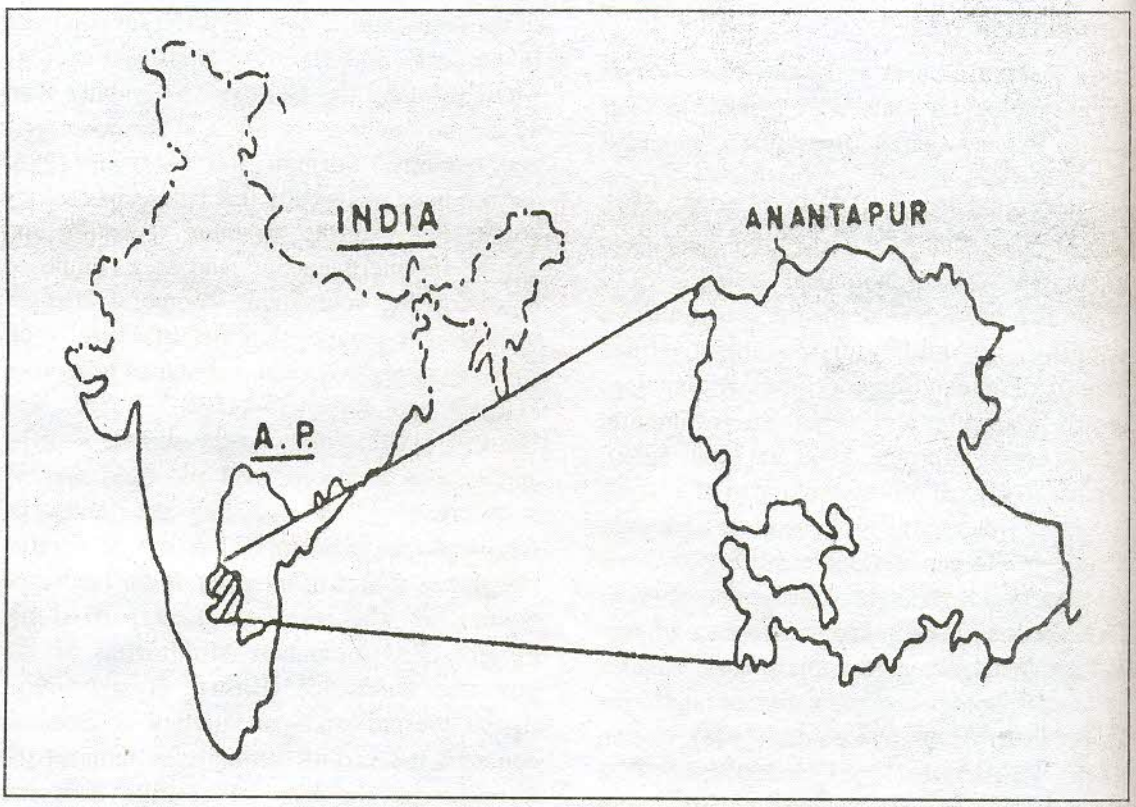

Figure 1: Location Map of the Study Area

Methodology

The Survey of India (SOI) toposheets on scale 1:250,000 are used as base maps for studying the physical characteristics of the district. The various geomorphological units of the district have been delineated using IRS-IA LISS-I FCC's (bands 4, 3 and 2) and Landsat TM (bands 5 and 7) data in association with Survey of India topographical sheets on 1:250,000 scale and available collateral data. Visual interpretation of the satellite imageries are based on photo-elements like tone, texture, shape, drainage pattern, colour, association, different erosional characteristics etc. Based on geomorphic processes, agents and landforms, the geomorphic classification of the district has been carried out. Based on terrain characteristics, soils and geomorphic processes acting on each geomorphic unit, a detail surfacial expression has been carried out which are further verified with intensive ground checks before finalization of geomorphology map of the district on 1:250,000 scale. After critical analysis of each geomorphic unit, its

relief and surfacial expression, generated technically feasible and economically viable landscape management measures at the each geomorphic unit to restore the fragile geo-ecological balance of the district in view of prevailing climatic, geomorphological, economic and ecological conditions.

Results & Discussions

Geology

Geologically the district can be broadly divided into two distinct and well marked groups. The older group of metamorphic rocks belong to the Archean and the younger sedimentary rocks pertain to the Proterozoic age. The Archeans have been subsequently metamorphosed and intruded by various igneous rocks and comprise of gneisses, migmatites, younger granites, pegmatite veins and basic dykes which occupy a greater part of the district mainly in northern, central, western and southern parts of the district. The younger sedimentary rocks belong to Cuddapah and Kurnool Super Groups and they consist of clastic rocks such as sand stone, shale and limestones. These rocks were formed by the denudation of the pre-existing Archean rocks. These formations occupy northern and north-eastern parts of the district.

Geomorphology

The major geomorphic units of the district have been delineated based on the visual interpretation of IRS-1A, LISS-I data (Sambasiva Rao et al., 1979). The major geomorphic units of the district are mainly divided into five types based on landform genesis, elevation, slope, geology and soil. They are denudational hills, dissected pediments, pediplains, alluvium and colluvium (Fig. 2).

Denudational Hills

The denudational hills are mainly formed due to differential erosional and weathering processes and as a result more resistant formations stand as hills occupying nearly 30 per cent of the TGA of the district. The structure of the denudational hills consist of joints, fractures/lineaments and which are remnants of the natural dynamic process of weathering and denudation aided by fluvial action. The denudational hills of the district are subdivided into five categories based on the broad lithological associations.

Denudational hills in granites, gneisses and migmatites

These formations constitute stony, grey and pink granites, gneisses and migmatites with very little soil cover and vegetation which cover nearly 20 per cent of the district. In western and south-western parts of the district the geomorphic forms like inselbergs, exfoliation domes and tors and in northern parts low mounds, knolls, exfoliation domes, bornhardts and inselbergs are noticed. In central parts of the district these units with rugged surface of rockfall, debris slides, debris cones and fans and in southern parts of the district rockfall and debrisfall along the slopes of the hill ranges are noticed.

Denudational hills in schistose formation

These formations are made up of low grade metamorphic rocks of meta-volcanic and meta-sedimentaries. In central parts of the district, these hills occur as low mounds; moderate weathering and soil development is fairly good with thick clayey brown soil. In south-eastern parts of the district schistose formations are noticed in two separate low hill ranges with subdued relief namely Kadiri

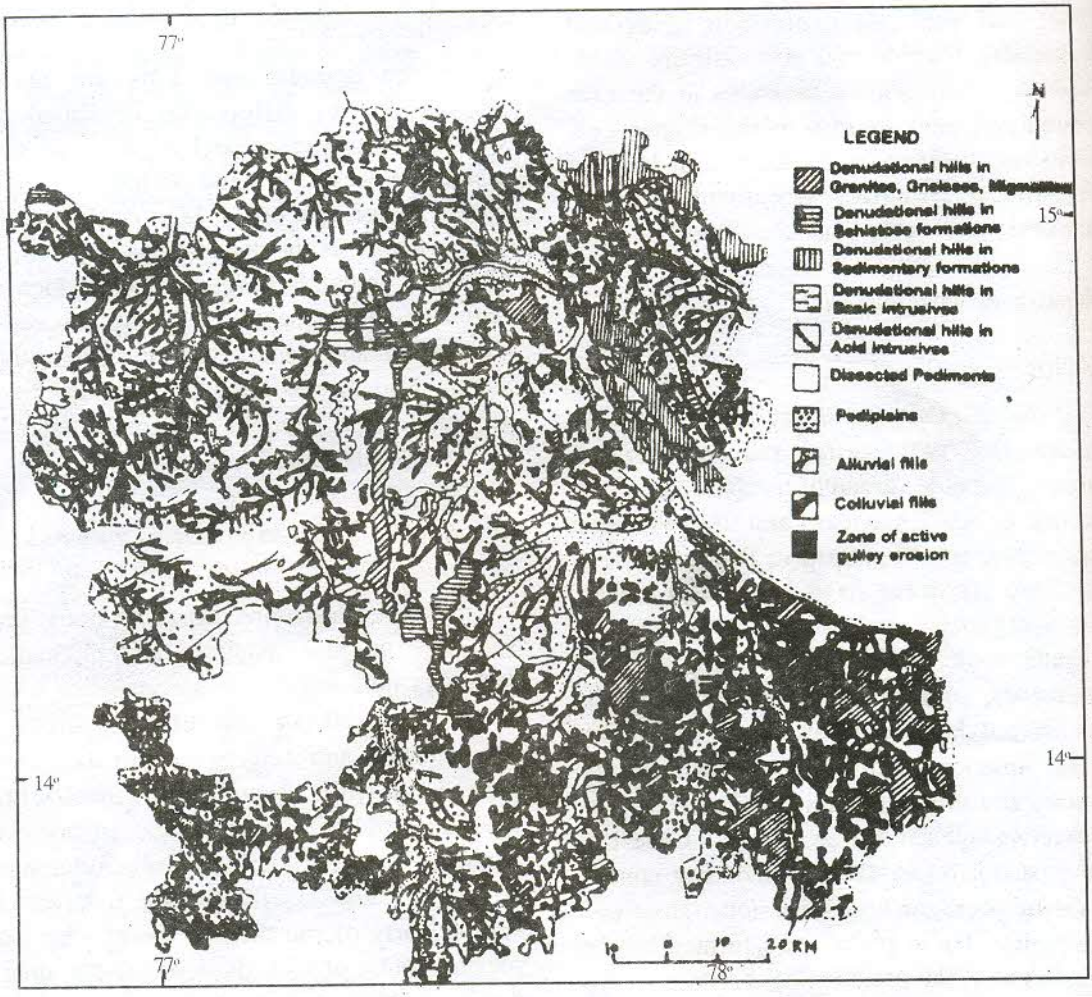

Figure 2: Geomorphology Map of Anantapur District

schist belt and Veligallu schist best comprising of conglomerate and quartz, sericite schists, amphibolite and hornblende schist with the intrusive veins of quartz with smooth scree covered slopes having an average relief varying from 30 to 50 m above the pediplain. The soil is more clayey in nature and deep gulleying is found in the impermeable soil. In the north and north-western parts of the district these hills are made up of low-grade metamorphic rocks mainly composed of amphibolite-hornblende schist and ferruginous quartzite of Dharwar Super Group. Due to the action of erosion, gulleys are well developed in the slopes of these hills and the drainage is medium to coarse and is dendtritic in type.

Denudational hills in Sedimentary rocks

These formations of Cuddapah Super Group basin consisting of quartzite, dolomite, limestone and shales with basic intrusives, extend from N-S to NW-SE and consist of undulating topography. These hills are

generally stony in nature characterized by coarse dentritic drainage while at places parallel drainage controlled fracture and joint is also observed. The weathering is very shallow with thin soil cover ranging in thickness from 10 to 50 cm. The shales have low to moderate clayey soil cover with thickness varying from 0.6 to 2.4 m with open shrubby jungle of low trees. The cultivation of dry crops is noticed along the gentle slopes of these denudational hills of sedimentary formations.

In the north and north-eastern parts of the district, these formations are made up of quartzite, cherty dolomite, shale, limestone and the associated basic intrusives of lower Cuddapah and Kurnool Group of Pre-Cambrian age. The extension of prominent N-S strike ridges in the northern part of Tadpatri with narrow valleys and also the western part of these hills, are characterised by hogbacks and cuestas with moolerdce to gentle dip slopes in the Cuddapah Super Group rocks. The extensive plateau of Kurnool Group of quartzite and limestone is noticed in northern parts of Yadiki, with typical mesa type of topography and with fairly thick soil cover, except in the case of quartzite and the chert beds. The weathering is very shallow in quartzite resulting in sandy and gritty soil with shrubby growth of vegetation along the scree slopes. The area of denudational hills in shale and dolomite with gentle to moderate slopes is under dry cultivation of groundnut and millet crops.

Denudational hills in Basic Intrusives

These geomorphic forms are easily distinguished in the field by their expression as linear, sharp ridges, dark colour, rugged and coarse appearance with moderate to steep debris covered slopes of the denudational hills in basic intrusives. They stand out prominently along dissected pediplains with slope ranging from 15° to 20°. The basic intrusive rocks are easily weathered along the joints, giving rise to an expression of a heap of angular and subrounded blocks and also the soil development is relatively poor along the slopes of these hills with a barren vegetation cover. These formations occur throughout the district and the dominant trends are in NW-SE, E-W, ENW-WSW, WNW-ESE and N-S directions.

Denudational hills in Acid Intrusives

These formations occur as sharp linear ridges of moderate to low relief above the pediplain country, with steep and smooth scree-covered slopes along the major lineaments and shear zones. These geomorphic units are in the form of quartz ridges of cut across the granite/schists formations and the sedimentary formations indicating their younger age, which are characterized by hogback form with thin soil cover and vegetation on the steep slopes. These hills are essentially composed of massive and breceiated quartz reefs extending in NNW-SSE, NNE-SSW, NW-SE and E-W directions and a few hills along NE-SW directions are also noticed near Dorigallu and Tammala village.

Dissected Pediments

The dissected pediments are formed due to erosion on rock surface of considerable extent at the foot of a mountain slope on granites, gneisses, migmatite schists and sedimentary rocks with a thin veneer of soil, formed normally under semi-arid or arid condition and which occupies nearly 25 per cent of the TGA of the district. The slope is gentle to moderate, nearly 5° to 10°, and is

characterized by a rugged appearance with scanty shrub vegetation. The dissected pediments in the district have an undulating topography broadening the denudational hills. Sheet erosion and gulleying are very active in the zone of dissected pediments exposing the underlying weathered mantle of bedrock. The dissected pediment with shallow cover of red, brown, sandy and gritty soil, are under intensive dry cultivation of groundnut, millets, jowars etc. These formations are noticed in central and southern parts of the district.

Pediplains

Pediplains occupies nearly one-third of the TGA of the district. They are flat or gently sloping surfaces which result from coalescence of several pediments at the foothill slopes and characterized by a low-lying flat terrain with slope of 5°-10° and spread over the weathered gneisses, schists, granites and sedimentary rocks. The drainage over the pediplains is usually coarse and dentritic but parallel when controlled by lineaments, fractures and mega joints. The pediplains are noticed in central parts of the district and are characterized by a vast area of low lying flat terrain with gentle slope of less than 3° and spread over the weathered granite, gneisses and metamorphic rocks. In western part of the district pediplains are covered with black clayey soils with thickness ranging from 50 to 70 cm. The northern parts of the district is represented by a flat country with a gentle slope towards east and underlain by granite gneisses, schists and sedimentary formations.

In south-eastern parts of the district the pediplains are characterised by gently undulating to flat topography spreading over the granite, gneisses and schistose formations. The pediplains are covered with reddish brown, medium to coarse, gravelly soil with thickness varying from 20 to 30 cm. Sheetwash, rill and gully erosion are common, and a major part of the pediplains are under dry cultivation with groundnut, millets, and coarse grains. Cash crops and paddy are grown in the down-stream areas of the major tanks and close to the irrigation canals.

Alluvium

The fluvial sediments derived from the catchment area transported and deposited along the course of major river systems in the district like Hagari, Pennar, Chitravati and Papaghni are grouped under this geomorphic unit which includes natural levees, river terraces, back swamps, sand bars, point bars and splash deposits. They consist of moderate to well sorted, stratified deposits of gravel, silt, clay and rock debris on either side of river together with the flood plain deposits. The alluvial area with the moisture patterns are easily identified on the Landsat imageries by the dark tones. Wherever the alluvium is sandy, light grey to white zones are discernible in the Landsat imageries. The areal extension of alluvium in the northern parts of the district along Pennar river consist of fine greyish, black silty and alluvial deposits. In central parts of the district it is more or less stratified deposit of gravel, sand, silt, clay and other debris which include the natural levees, sand bars, point bars and river terraces on the banks of Pennar and Thadakaleru river with thickness ranging from 5 to 15 m over the weathered granites and gneisses. In the eastern and north-eastern parts of the district alluvium is noticed along the course of Chitravati, Papaghni and Maddileru rivers. They comprise of gravel, sand, silt and clayey silt with thickness from 2 to 5 m over the granites and schists. In the southern parts of the district the alluvial unit

is developed along Pennar and Jayamangala river courses and other stream channels with thickness ranging from 3 to 5 m. In the western part of the district the alluvium is restricted to the main Hagari and Chinna Hagari river courses with a thickness varying from 2 to 4 m which consist of gravel, sandy silt and clay. These alluvial zones are extensively under wet cultivation growing paddy, groundnut, sunflower, fruits and vegetables.

Colluvium

The colluvial fills are noticed along the minor *nalas* and streams with the pediplain and dissected pediment. The colluvium is predominantly a sheet wash material derived from adjoining uplands transported over short distances into shallow valley and deposited in the low-lying shallow fluvial channel. It consists of a heterogeneous mixture of unsorted fragments of various shape and size together with sand, silt and clay along the streams and shallow channels close to the denudational hills and dissected pediment.

This geomorphic unit is clearly identified on the satellite imageries as infilled shallow valleys and separated from one another by other geomorphological units. The surface runoff along shallow valley is impounded by a number of tank bunds for purposes of irrigation and wider infilled valley bottoms are extensively used for wet cultivation. The thickness of colluvium usually varies from 20 cm to 100 cm and in some places it extends to more than 100 cm. The encrustation of saline efforescene within the colluvial material is due to poor drainage as noticed in many places in the western and northern parts of the district. The soils are deep and sufficient soil moisture is available but erosion seems to be only to a limited extent in the colluvial areas. The narrow but steeply sloping infilled valley bottoms are not used for crop production but are used for grazing.

Landscape Ecological Planning and Management

The detail study of each geomorphic unit of the study area reveals its physical and ecological capabilities for landscape management.

Denudational hills

This geomorphic units in granite and gneisses schistose formations, and sedimentary formations consist of rugged surface with steep slopes, subdued hills with smooth surfaces and gently undulating structural hills of low relief respectively. The landscaping of these geomorphic units has been done by taking conservation methods like development of contour vegetative hedges, fodder, fuel wood, social forestry, pasture etc.

The denudational hills in basic intrusives and acid intrusives have linear ridges of moderate to low relief and linear sharp ridges of moderate relief respectively. The surface expression of these units are rocky linear ridges, rugged in the upper slopes having smooth foot slopes of scree and debris with thin mantle of weathered materials which are favourable for developing social forestry and pastures. The landscape conservation measures that could take place are rock fill dams, terrace bunding, pasture development, social forestry and construction of water harvesting structures along the valley slopes.

Dissected Pediments

The dissected pediments consist of undulating country with gentle to moderate

slopes (5° to 10°) coarse to medium sandy soils which need landscape management measures like contour bunding, contour terracing, gulley stabilisation, agro-forestry and plantation crops.

Pediplains

The pediplains have very gently sloping to flat area with red to brown coloured coarse gravelly clay to sandy clay soils. The landscape management measures are construction of runoff management structures, check dams, rockfill dams, stone checks, construction of water harvesting structures and gully stabilization. The stream bank erosion can be arrested by vegetative growth and at the same time lines and enhance infiltration.

Alluvium and Colluvium

The alluvium and colluvium geomorphic units have flat to very gently slopes (<2°) and consist of fine loamy to loamy soils along the major rivers which are most suitable for wet crops like paddy, sugarcane, sunflower, banana, fruits and vegetables. The landscape is managed by taking measures like land levelling, land mulching, contour cultivation, dead furrows and draining out excess water for avoiding salinization.

Conclusions

The study reveals that the detailed visual interpretation of remotely sensed data coupled with collateral and selected field checks information can be effectively utilized for delineation and assessing the characteristics of different geomorphological units. The demarcation and detail description of different geomorphic units of the district is highly essential for sustainable landscape management based on their physical and ecological capabilities. The study shows that the denudational hills in different geological formations are composed of grey and pink granites, gneisses and migmatites with very little soil cover and mostly having sparse vegetation which covers nearly 35 per cent of TGA of the district. These geomorphic units have to be managed by taking conservation methods like rock fill dams, terrace bunding, pasture development, social forestry, contour vegetative hedges and construction of water harvesting structures along the valley slopes. These units can also be used for fodder, fuel wood, social forestry, pasture development and agave plantation along the contours and development of production systems like forestry programmes, over seeding of grasses, pasture development for eco-restoration. The study shows that comprehensive information on geomorphology and environ will be of immense help in sustainable landscape planning and management and in restoring the vital geo-ecological balance of the area.

References

Bhat, L.S. (1989). Status Report on Land System Analysis for Evaluation of Resources at Micro level. Discussion paper for the Fifth Review Meeting for NRDMS Project, DST, Govt. of India.

Brown, R., Slater, J.A. and Askew, D.R. (1996). Integrating Satellite Imagery and GIS: the experience of a BNSC funded project to monitor Environmentally Sensitive Areas. Remote Sensing and GIS for Natural Resources Institute, Chatham, UK, 18 December 1995 (London: University of Greenwich), pp. 15-22.

Coates D.R. (ed.) (1973). Environmental geomorphology and landscape conservation (Benchmark papers in Geology), Dawden, Hutchinson & Ross, Stroudsburg (Pennsylvania), 360p.

Cook R., V. and Dooncamp J.C. (1974). Geomorphology in environmental management - An introduction, Clarendon Press, Oxford, pp. 413.

Cotton C.A. (1948). Landscape as developed by the process of normal erosion - 2nd edition, Wiley, New York.

Fairbridge R.W. (1968). The Encyclopedia of Geomorphology, Reinhold Book Corporation, New York, pp. 731.

Forman, R.T. and Godren, M. (1986). Landscape ecology, New York; Wiley.

Ollier C.D. (1977a). Application of weathering studies in applied geomorphology. (Ed.) Halis, Elsevior, Sci. Pub. Co. Amesterdam.

Ollier C.D. (1977b). Terrain classification methods. Application and principles in applied geomorphology (Ed.). Hails, Elsevior, Sci. Pub. Co. Amesterdam.

Prabhakar Rao (1981). Applied geomorphic studies in the semi-arid tract of Anantapur district, A.P., India, Unpubl. Ph.D. thesis submitted to Andhra Univ. Waltair.

Sambasiva Rao M. and Vaidyanadhan R. (1979). Morphology and evolution of Godavari delta, India, Z. Geomorphc, N.F. 23(3), pp. 243-255.

Strahler A.N. (1946). Geomorphic terminology and classification and land masses, Jour. Geo. Vol. 54, pp. 32-42.

Turner, M.G., and Ruscher C.L. (1988). Changes in landscape patterns in Georgia, USA. Landscape Ecology, 1, 241-251.

Turner, M.G., and Gardner, R.H. (editors) (1993). Quantitative method is Landscape ecology: an introduction. In Quantitative methods in Landscape Ecology (New York: Springer-Verlag), pp. 3-14.

Table 1: Geomorphic Classification and Measures for Landscape Planning and Management of Anantapur District

S.No.	Geomorphic units	Elevation (Mts)	Slope (%)	Surfacial expression	Dominant soils	Land use/ Land cover	Landscape management measures
1.1	Denudational hills in granites and gneisses	700 - 760	Extremely steep slopes (>45°).	Rugged surface, mostly devoid of soil cover. The mantle of weathered zone less than 50 cm	Very shallow to shallow, gravelly to very gravelly with coarse texture.	Thorny bushes, short height dry scrubs, the canopy cover is more along the vallevs.	Contour vegetative hedges, fodder, fuelwood and forest development.
1.2	Denudatioinal hills in schistose formation	700 - 760	Very steep slopes (35° to 40°)	Subdued hills with smooth surfaces. Moderately shallow (50 cm) weathered zone.	Very shallow, gravelly soils cover along the upper slopes and shallow soils cover along foot slopes.	Thorny bushes, short height deciduous scrub forest, the canopy cover is more along the valleys.	Rockfill dams across the valleys, afforestration, social forestry and pasture development.
1.3	Denudational hills in sedimentaries (quartzites and dolomite)	700 - 760	Steep slopes (20° to 35°),	Undulating structural stony hills with shallow weathered mantle.	Very shallow to shallow, gravelly soils cover along the upper slopes and shallow soils cover along foot slopes.	Thorny bushes, short height dry scrubs, cultivation of coarse millets, groundnut-pigeon pea along the valleys.	Afforestration, silviculture, fodder and fuelwood development.
1.4	Denudational hills in basic intrusives. (dolerites and their variants)	600 - 700	Moderatel y steep slopes (15° to 20°)	Rocky linear ridges rugged in the upper slopes, lower slopes covered with talus and scree.	Very shallow to shallow, gravelly soils with talus and scree cover along the upper slopes and moderately shallow soils cover along valley slopes.	Dry scrubs, wastelands, cultivation of coarse millets, groundnut-pigeon pea along the valleys	Rockfill dams, contour trenching pasture development, and social forestry.
1.5	Denudational hills in acid intrusives (quartz reefs)	600 - 700	Moderate slopes (10° to 15°)	Rocky Linear sharp or faceted ridges, foot slopes are smooth and gentle with scree and debris. Thin mantle of weathering	Very shallow to shallow, gravelly soils cover along the higher slopes and moderately shallow soils cover along foot slopes and valley floors.	Land with/with out scrub, wastelands, cultivation of coarse millets, groundnut-pigeon pea along the valleys.	Rockfill dams, terrace bunding, fodder, social forestry and pasture development

2	Dissected pediments	500 - 600	Gentle slopes (5° to 10°)	Undulating country, rugged appearance with number of bouldery outcrops.	Shallow to moderate, clay to skeletal soils admixed with coarse gravel to pebbles.	Cultivation of coarse millets, groundnut-pigeon pea and jowar.	Contour bunding, contour terracing, gulley stabilisation, dry land horticulture, agroforestry, and plantation crops
3	Pediplains	400 - 500	Very gentle to gentle slopes (2° to 5°)	Widespread level lands with thick weathered zone over grainites, gneisses and sedimentaries.	Red or brown coloured coarse, moderately deep, gravelly clay to clay soils admixed with coarse fragments. In the north-western parts of the district are covered by black clayey soils of thickness from 60 cm to 100cm.	Intensive cultivation of rain fed groundnut-pigeon pea and jowar . Irrigated ground nut, paddy, fruits and vegetables are cultivating under tanks and tube wells.	Construct runoff management structures, rockfill dams, check dams, stone checks,, water harvesting structures, land levelling and gulley stabilisation
4	Alluvium	280 - 400	Very gentle slopes (< 2°)	Flat terrain consists of silty sands, gravel and sands along the major rivers. Thickness of deposited alluvium ranges from 2 to 5 m over weathered granites and gneisses.	Deep to very deep soils, fine to loamy soils mixed with fine to medium coarse fragmnets	Intensive cultivation of Irrigated ground nut, paddy, mulberry, sunflower, fruits and vegetables under tanks and tube wells.	Land levelling, land mulching, contour bunding, contour bunding, contour cultivation, dead ferrows, strip-cropping and fertility management
5	Colluvium/valley fills	280 - 400	Very gentle slopes (< 2°)	Restricted to minor streams and nalas with limited lateral spread. Composed of silt, sand and fragments of rocks.	Deep to very deep soils, fine to coarse loamy soils mixed with fine to medium coarse fragments	Intensive cultivation of Irrigated ground nut, paddy, mulberry, sunflower, fruits and vegetables under tanks and tube wells.	Land levelling, land mulching, contour bunding and diversion of channels for draining out excess water for avoiding salinization.