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Geomorphological Mapping Through Geospatial Technologies In The District of Visakhapatnam, Andhra Pradesh, India

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***Abstract*—** Geo-spatial advancements like Remote Sensing (RS) and Geographical Information Systems (GIS) play an essential job in developing thematic maps and integrating analysis for mapping, managing and monitoring the natural resources. RS and GIS technologies have advanced a new era in the field of applied geology and geomorphology. Geomorphology is the science of landforms present on the Earth's surface and their systematic study is important and unique in order to interpret them as signatures of the past and ongoing geological processes. The present examination plans to delineate geomorphological features in the district of Visakhapatnam in view of visual image translation strategies. The study area mainly comprises Pediment slope(27.39%) followed by Structural hill(25.51%) and Pediplain shallow(18.06%).These maps would be useful in further analysis for natural Earth resources planning, management and decision making. Thematic maps of geomorphology have been generated on satellite data. Standard visual elucidation methods according to the standards given by NRSA have been followed and portrayed on-screen digitations of features.

***Keywords*—** Remote Sensing, Geographic Information Systems, geomorphology, natural resource planning, decision making.

I. Introduction

Remote Sensing is the science of making inference about objects from measurements made to a distance, without coming into physical contact with the objects under study (George Joseph 2005). While acquiring information from the pre determined path, the reflected signals from the objects may be attenuated, and therefore objects may not be clear, owing to the background noise. The satellite data can be used for different thematic information. This is the reason why this technology is becoming popularized in recent years. The satellite brings land to the laboratory and the data can be interpreted visually. It gives synoptic view of the interrelationship between natural and cultural features. The drastic improvement of the spatial resolution and also development in the Microwave and Thermal Remote Sensing has added new dimensions for acquiring data on different natural and cultural features. The thematic information extracted from the satellite data can be overlaid in GIS environment. GIS software techniques identify to take decisions on the basis of attributes. Remote sensing provides a regional, synoptic view and permits recognition of large structural patterns and landforms over contiguous geomorphic domains. It enables the location and delineation of the extent of identified features observed over large areas.

The repetitive coverage of terrain in multispectral mode provided by satellite mounted sensors enables comparison of scenes of the same location in different periods/ seasons. This is extremely valuable for monitoring change as well as extracting more information about significant earth features from scenes by viewing under seasonal conditions (temporal and spectral resolutions). Geographical Information System has become an important tool for spatial analysis. Digital coverage and its attribute data have been generated in ArcMap 9.2.software package. Different thematic layers of geomorphologic features have been generated and different weights were assigned for different classes. All the themes are overlayed with a view to generate final output map.

The term Geomorphology is the combination of three Greek words; i.e. Geo (earth), Morpho (form) and logos (discourse) which means the study of forms of the earth's surface. But landforms have far less attention, even though landform mapping dates back to early geological research (Close,1867) and has been subject to a number of studies in the 1960's and 70's (Rose and Letzer, 1975). The identification of landforms and geomorphologic domain on remotely sensed data is based on area association (arid, mountainous, glacial, coastal, flood plain, tropical etc.), association of features, landform shape and size, drainage patterns/ dissection, relief, tone, texture, land use/land cover, erosion and many other patterns leading to "convergence of evidence" upon logical inductive and deductive reasoning. Analytical "Keys" can also be developed for an area of study based on field criteria and a priori knowledge of typical forms as seen on images. In this examination, visual understanding of remotely detected information is a basic step to take in the system for different applications, and consequent to change over the deciphered maps into computerized frame for use in a GIS. IRS–ID LISS–III data has been utilized for elucidation of geomorphological highlights.

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. 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. The study area is a part of Visakhapatnam and Bheemili municipalities. Bheemili is a town and mandal headquarters in Visakhapatnam district, Andhra Pradesh. The 25 kilometers stretch of road from Visakhapatnam along the coastline to Bheemili is a picturesque. The study is confined to recent expansion of four lane roads connecting Visakhapatnam and Bheemili. The road lay adjacent to the sea coast of Bay of Bengal and is under the natural vagaries of sea coast on one side; land and its natural activities on the other side render the road vulnerable. Recently; IT Parks, Rama Naidu Cinema Studio, several resorts and urban built-up lands came into existence. These anthropogenic activities have altered the topography along the road system. The traffic load is increasing year after year. In view of the traffic load recent road expansion has been taken up in place of old road network. This activity has led to cutting of hill flanks, foothills, sea sand dunes, culverts, drainages and highly denuded land forms etc. Hence, this study has been taken up to investigate the various geomorphological features in order to access the recent and further developments of the region.

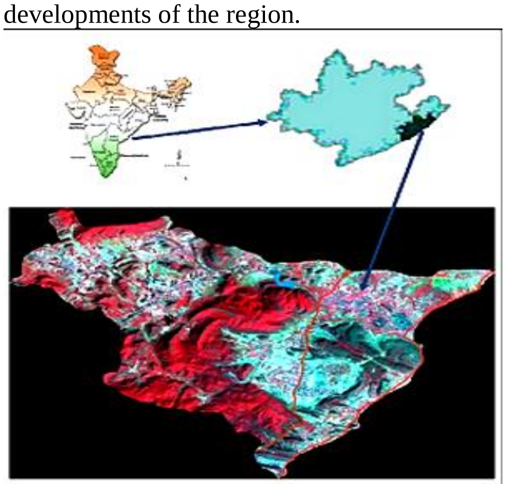

Figure1: Location Map of the Study Area as viewed on IRS 1D LISS III, 2004.

II. Related Work

M. Sunandana Reddy and L. Harish Kumar;in their investigation built a land evaluation strategy based on land information system for a region that will contribute to the National Land Information System. They additionally guaranteed that the outcomes will advance great administration and offer certainty based data to the decision makers. [1]. Tulli Chandrasekhara Rao, G. Jaisankar, Aditya Allamraju and E. Amminedu; in their study meant to delineate the geomorphological features in the Janjhavathi river basin based on visual image interpretation techniques which would be further valuable for essential analysis of important natural resource planning [2]. Suraj Kumar Singh, Vikash Kumar, Shruti Kanga; in their study analysed the Land use/land cover change dynamic and water quality assessment using geospatial techniques for Harmu river. It was observed that the river/drainage channels were primarily infringed by built-up land and few of the drainage channels were extinct due to urban activities [3]. V. Sivakumar; in his investigation has demonstrated that the satellite information is extremely valuable in different aspects of land, geomorphological and lineament mapping studies and it furnishes quick and exact information with minor subtle elements [4]. Tripti Jayal; in her study of geomorphology and drainage basin characteristics found out that the drainage features are interlinked with geology, geomorphology, topography and climate [5]. Tanzeer Hasan studied the Geobotanical and geomorphological approach to map the surface lithology using remote sensor data to assess the capability of ASTER imagery for lithologic mapping in the intensely vegetated zones using digital image processing [6].

S.N. Mohapatra, Padmini Pani and Monika Sharma examined the implications on the rapid urban expansion and its suggestions on Geomorphology with the help of Remote Sensing and GIS [7]. Aung Lwina and Myint Myint Khaing dealt with Geomorphology identification and its Environmental Impacts Analysis by Optical and Radar Sensing techniques for their identification and management. They conveyed an investigation for the effect of land use/ land cover (LULC) changes on stream flow patterns. They construed that the hydrologic response to intense, surge delivering precipitation occasions bears the signatures of the geomorphic structure of the channel network and of the characteristic slope lengths defining the drainage density of the basin [8]. C. Siart, O. Bubenzer and B. Eitel examines the application and quality of SRTM and ASTER DEMs, high resolution Quickbird satellite imagery and GIS techniques for the detection and mapping of karst morphology [9]. G.Brierley, in his examination considered geomorphic perspectives on ecosystem approaches to river management [10]. S. J. Walsh, D. R. Butler and G. P. Malanson performed the satellite image processing, change-detection analyses, digital elevation models, GIS-derived geomorphic indices and variables, composition and pattern metrics of landscape organization, and scale-dependent analyses which are depicted and identified with the investigation of geomorphic research, and demonstrate the use of such techniques in the application of the scale, pattern, and processes in the point of view with geomorphic studies [11]. J. Krishnamurthy and G. Srinivas; in their study created selected digitally enhanced products and utilized for extraction of important subtle elements on lithology, structure and landforms by their distinct image characteristics. The integration of the details extracted from digitally enhanced products along with morphometric parameters derived from the drainage maps, helped in the assessment of the ground water and similar types of hydrogeomorphic landforms have developed over these drainage basins. The literature reviewed so far revealed that geomorphological studies can be carried out using satellite data obtained by Remote Sensing technology and GIS software to do the spatial analysis [12].

III. METHODOLOGY

The investigation zone covers 2 sequences of the Survey of India (SOI) toposheets, they are 65 O/5 and 65 O/2 on 1: 50000 scale. These toposheets are geo-rectified and projected to polyconic projection (the Metric system units – meters are used as in the present study). The Visakhapatnam toposheet map has been scanned and saved in .jpg format and then it is imported into image format which is then referenced to polyconic projection using ERDAS IMAGINE 9.1 software.

The study area boundary is digitized and overlaid on Mosaic; demarked the study area boundary on 1:50000 toposheet and later verified by ground truthing. Necessary corrections were made and checked in the field with the help of GPS. Image processing was carried out for IRS – ID LISS –III (23.5m resolution) - dated April, 2004 (satellite imagery shown in Figure 1). After applying necessary image enhancement, the landforms are delineated from geo-coded satellite imagery along with the available geological and geomorphology details. The geomorphic units are delineated based on the Standard visual interpretation techniques as per the norms given by NRSA and represented on screen digitations of features. In these terrain elements, nearly ten geomorphic erosional and fluvial classes have been delineated. The major features of the area are pediplain shallow, pediplain moderate, etc. as shown in figure 2. The run-off features of hills are exposed prominently in the northern part of the area. More inselbergs, pediment inselberg complexes have been delineated in an irregular manner. The area of each class and its percentage is given in Table 1. The geomorphology map of the area is shown in Figure. 2.

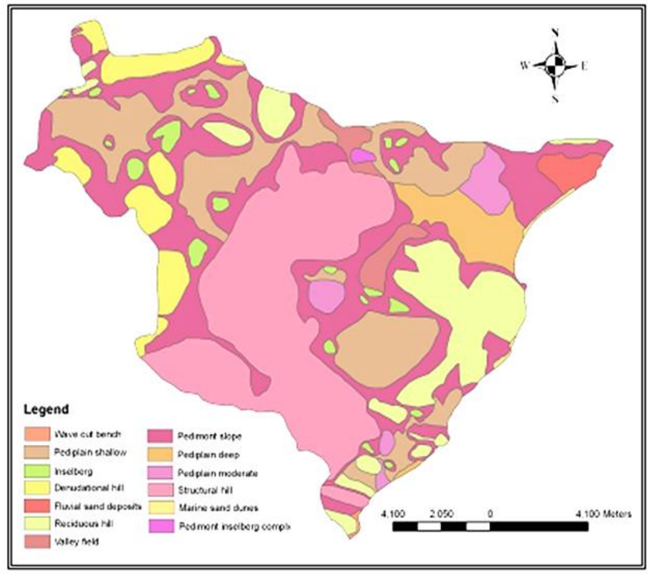

Figure 2: Geomorphology of the study area.

IV. RESULTS AND DISCUSSION

The fluvial and erosional landforms of the area have been delineated on satellite image and the geomorphological map has been prepared on 1:50000 scale based on the procedure suggested by RGNDWM of NRSC, (1996). The major features of the area are pediplain shallow, pediplain moderate. More inselbergs, pediment inselberg complexes have been delineated in an irregular manner.

Denudational Hill

Denudational hills are formed due to differential disintegration and weathering with the goal that more resistant formations stand as mountain hills or they are relief hills which have undergone the process of denudation generally exposing as barren rocky and steep sided. The structure consists of fractures, points, lineaments etc. The hills are relatively low relief features and of less aerial extension occurring on the plains detached from high mountain/hills. These land forms occur both on fluvial plain, pediment and pediplains. The denudation hills are formed due to brittle nature of material being eroded by circumdenudation. The denudation hills mainly consist of highly fractured rocks covered with pebbles and sparse vegetation occurring superficially due to the accumulation of moisture holding soils. This zone is generally potential for ground water because of occurrence of fractured rocks through which rain water percolates and ground water is recharged (Gangadhar Bhat, 1992). It covers 14.246 km^2 which is 6.04% of the total study area.

Fluvial sand deposits

Fluvial sand deposits or Alluvium is a loose, unconsolidated (not solidified together into a rock) soil or sediments, which has been eroded, reshaped by water in some form, and re-deposited in a non-marine setting. It is typically made up of a variety of materials, including fine particles of silt and clay and bigger particles of sand and gravel. When this loose alluvial material is deposited or cemented into a lithological unit, it is called an alluvial deposit. Alluvium can contain valuable ores such as gold and platinum and a wide variety of gemstones which are commonly is termed a placer deposit. It covers 2.891 km^2 which is 1.23% of the total study area.

Inselberg

An inselberg is a segregated rock hill, knob, ridge or small mountain that ascends abruptly from a gently sloping or virtually level surrounding plain. Inselbergs are relict features. They have maintained their relief as the adjacent surrounding landscape was lowered. The occurrence of inselbergs suggests immense variations in the rates of degradation action on the land surface. These structures are one of the several varieties of landforms called paleoforms that can survive with little modification for tens of millions of years. In inselberg landscapes, the active erosion processes are confined to valley sides and valley floors. It covers 4.750 km^2 which is 2.01% of the total study area.

Marine sand dunes

Sand dune is any aggregation of sand grains/ particles shaped into a mound or ridge by the wind under the influence of gravity. Sand dunes are distinct to other forms that appear when a fluid moves over a loose bed and sand waves on the continental shelves beneath shallow seas. Dunes are found wherever loose sand is windblown: in deserts, on shore lines, and even on some eroded and abandoned farm fields in semiarid regions. It covers 0.55 km^2 which is 0.23% of the total study area.

Pediment Inselberg complex

The Pediment inselberg complex consists of small isolated like emerging out noticeably in a form because of their resistance to weathering. The pediments dotted with a number of inselbergs which cannot be separated and mapped as individual units are referred to as pediment inselbergs complex having moderate to strong slope. These are controlled by structure like joints, fracture and lineaments. The pediment inselberg complex is more than one isolated low relief hill (i.e. more than one pediment inselbergs) but occurring closely. It covers 0.461 km^2 which is 0.2% of the total study area.

Pediment

A pediment is a very gently sloping (0.5°-7°) slanted bedrock surface. It typically slopes down from the base of a steeper retreating desert cliff, or escarpment, but may continue to exist after the mountain has eroded away. It is caused by erosion. It develops when sheets of running water wash over it in intense rainfall occasions. It may be thinly covered with fluvial gravel that has washed over it from the foot of mountains produced by cliff retreat erosion. It is typically a concave surface gently sloping away from mountainous desert areas. The pediment slope covers 64.63 km^2 which is 27.39% of the total study area.

Pediplain

On the basis of genesis, the pediplains are huge zones created as a consequence of continuous procedure of pedimentation (Thornbury, 1986). On the basis of earth features, the pediplain can be defined as large areas with subdued topography ascending in elevation from 100 m to 600 m towards the origin. The pediplains are characterized by gentle sloping smooth and erosional bed rock with or without this detritus. They are classified into rolling plain and undulating plains. The altitude variation is relatively high for rolling plain and is about 10m to 15 m occurring prominently at the peripheral areas of the foot hills, where as for undulating plain it is about 2 m to 10 m. The pediplain deep covers 9.349 km^2 which is 3.96% of the total study area.

Pediplain shallow

They are formed by association of buried pediments, where a thick overburden of weathered materials accumulates. The highly weathered areas of granitoids constitute these landforms. Varying thickness of shallow over burden can be observed in such areas. Weathering of the bedrocks has been initiated by fractures, joints and minor lineaments. It covers 42.604 km^2 which is 18.06% of the total study area.

Pediplain moderate

Flat, levelled and smooth buried pediplain and pediment with moderately thick overburden are called pediplain moderate. The thickness of weathered material is high contrasted to pediplain shallow. The weathered materials are chiefly constituted by gneisses and migmatites. It covers 5.938 km^2 which is 2.52% of the total study area.

Residual Hills

These hills are formed as a result of complex erosion processes predominantly by erosion, circumdenudation, weathering and mass wasting. The dip of strata controls the rate of denudation process in these structural hills (Sreedevi et al., 2004). Residual hills are the end products of the process of pediplanation, which reduces the original mountain masses into a series of scattered meadows standing on the pediplains (Thornbury, 1990). It covers 25.317 km^2 which is 10.73% of the total study area.

Structural Hill

Under this classification, land form units are shaped by a complex of erosional process predominately by sheet erosion, circumdenudation, weathering, mass wasting and erosion. The dip of strata controls the rate of denudation process. Structural hills are associated with folding and faulting. This zone has great potential for ground water because of geo-structural distortion. The hilly terrain is with less structural distortion and sparse occurrence of faults. Ground water prospecting is moderate but surface runoff is more. These land forms are formed as linear to accurate hills and they show indefinite trend lines associated with folding and faulting etc. It covers 60.196 km^2 which is 25.51% of the total study area.

Valley Fills

These units occupy the lowest reaches in topography with nearly level slope. These landforms are relatively straight structures reflecting the impact of breaks/joints. The valley fills are available along the stream courses varying in thickness and comprising of both alluvial and colluvial soil materials ranging in size from pebbles, sand, fine silt and other detritus materials resulting in high infiltration rate. It covers 4.835 km^2 which is 2.05% of the total study area.

Wave cut bench

A wave-cut platform, shore platform, coastal bench, or wave-cut cliff is the narrow flat area often found at the base of a sea cliff or along the shoreline of a lake, bay, or sea that was created by erosion. These platforms are often most obvious at low tide when they become visible as huge areas of flat rock and are usually formed when destructive waves hit against the cliff face, causing undercutting between the high and low water marks, mainly as a result of abrasion, corrosion and hydraulic action, creating a wave-cut notch. This notch then enlarges into a cave. The waves undermine this portion until the roof of the cave cannot hold due to the pressure and freeze-thaw weathering acting on it; and collapses resulting in the cliff retreating landward. The base of the cave forms the wave-cut platform as attrition causes the collapsed material to be disintegrated down into smaller fragments, while some cliff material may be washed into the sea. This may be deposited at the end of the platform, forming an off-shore terrace. It covers 0.1996 km^2 which is 0.08% of the total study area.

Table 1.Areal distribution of Geomorphological features of study area

Geomorphology	Area in km^2	Percentage of Area
Denudational hill	14.246	6.04%
Fluvial sand deposits	2.891	1.23%
Inselberg	4.750	2.01%
Marine sand dunes	0.550	0.23%
Pediment Inselberg complex	0.461	0.20%
Pediment slope	64.630	27.39%
Pediplain deep	9.349	3.96%
Pediplain moderate	5.938	2.52%
Pediplain shallow	42.604	18.06%
Reciduous hill	25.317	10.73%
Structural hill	60.196	25.51%
Valley fill	4.835	2.05%
Wave cut bench	0.1996	0.08%
Total Study Area in km^2	**235.967**	**100.00%**

Table 2.Areal distribution of Run-off and Infiltration zones in study area

Type of zones	Geomorphic classes	Area in km^2
Run-off zones	Denudational hills, Inselbergs, Pediment Inselberg Complex(PIC), Residual hills, Structural hill	105.001
Infiltration zones	Valley fill shallow(VFS), Pediplain shallow, Pediplain Moderate(PPM), Pediplain Deep(PPD), Pedimont slope, Wave cut bench, stable marine sand dunes, Fluvial sand deposits	130.959

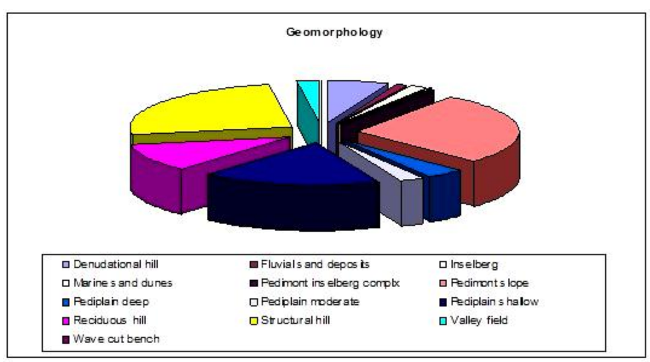

Figure 3: Areal percentage distribution of Geomorphological features of the study area

V. CONCLUSION

In this research, the area of investigation covers a total area of 235.967 km^2 and almost 100% of the area is under Visakhapatnam district of Andhra Pradesh, India. The remote sensing data has been used to delineate geomorphological features using IRS-ID, LISS-IV satellite imageries. In total, 13 landforms were delineated, out of which denudational hills, structural hills, inselbergs, residual hills and pediment inselberg complexes act as run-off zones. These categories (run-off zones) cover an area of 105.001 km^2 and suitable areas for infiltration (recharge zones) cover about 130.959 km^2. Pedimont slope (PS) is the major landform covering an area of 64.63 km^2 in the upstream of Peddagedda river basin and a small portion in the Madhurawada dome area followed by structural hill which covers an area of 60.196 km^2; pediplain shallow covering an area of 42.604 km^2.

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Authors Profile

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Ms. Aditya Allamraju is pursuing her final year, Bachelor of Technology in Geo-Informatics, Department of Geo-Engineering from Andhra University College of Engineering (A). She is an annual member of IEEE (Institute of Electrical and Electronics Engineers) and ISRS (Indian Society of Remote Sensing) from 2017; IEEE Geoscience and Remote Sensing Society member from 2018. She is very passionate about learning new things related to her core subject and likes to assist her research scholars in her department in their research works. She has currently published 3 research papers in Morphometry, Geomorpholgy and Land Use/ Cover. She also received the RULA International Awards' 2018 for 'Distinguished Engineer of 2018' for her outstanding contribution in the field of research and co-curriculum. She is also rewarded three gold coins from the Head of the Department, Geo-Engineering, for her best performance in curriculum.

