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# HYDROGEOMORPHOLOGICAL MAPPING OF GREATER VISAKHAPATNAM MUNICIPAL CORPORATION, VISAKHAPATNAM DISTRICT, ANDHRA PRADESH USING REMOTE SENSING AND GIS

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## ABSTRACT

Remote Sensing (RS) and Geographical Information Systems (GIS) play a basic employment in creating topical maps and incorporating examination for mapping, overseeing and observing the regular assets. RS and GIS innovations have propelled another period in the field of connected topography and geomorphology. Geomorphology is the exploration of landforms present on the Earth's surface and their deliberate examination is vital and special keeping in mind the end goal to decipher them as marks of the past and continuous topographical procedures. The present examination intends to outline geomorphological highlights in the location of Visakhapatnam in perspective of visual picture interpretation system. The examination territory principally contains Moderately Weathered Pediplain(39%) trailed by Shallow Weathered Pediplain(21%) and Structural Hill (16%). These maps would be helpful in further invisitation for common Earth assets arranging, administration and basic leadership. Topical maps of geomorphology have been produced on satellite information. Standard visual

clarification strategies as per the norms given by NRSC have been pursued and depicted on-screen digitations of highlights.

**KEYWORDS:** Geomorphology, Natural resource planning, Remote Sensing (RS), Geographical Information Systems (GIS) and GPS.

## I. INTRODUCTION

Remote sensing data is an important and effective tool to evaluate the hydrogeomorphological and hydro geological zones, which will be highly depending up on the physical, geological, hydro geological and geomorphological characteristics.[1] Therefore, studies have been carried out using remote sensing & GIS technique for hydrogeomorphological investigation. Besides these, many other studies in India and abroad have been carried out for the hydrogeomorphological evaluations using remote sensing data. Hence, the through survey of literature proved that, the remote sensing is a quick and efficient method for demarcating and evaluating the zones of ground water. In the study area, the remote sensing has been effectively used as an important tool to delineate hydrogeomorphological features using standard remote sensing techniques.

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.[2] Tulli Chandrasekhara Rao, G. Jaisankar, AdityaAllamraju 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.[3] 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.[4] 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.[5] 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.[6] TanzeerHasan 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.[7]

S.N. Mohapatra, PadminiPani and Monika Sharma examined the implications on the rapid urban expansion and its suggestions on Geomorphology with the help of Remote Sensing and GIS.[8] AungLwina and MyintMyintKhaing 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.[9] 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.[10] G.Brierley, in his examination considered geomorphic perspectives on ecosystem approaches to river management.[11] S. J. Walsh, D. R. Butler and G. P. Malanson performed the satellite image processing, change-detection analyses.

## II. STUDY AREA

The area under the investigation lies between the $83^{o}5'0''$to $83^{o}2'0''$ East Longitude and $17^{o}32'0''$to $17^{o}54'0''$ North Latitude. The area is located in and around the Visakhapatnam City in Visakhapatnam District of Andhra Pradesh. The urban area of GVMC is divided into eight zones including the Anakapalli and Bhimili Municipalities along with the actual 6 zones.The study area was taken only six zones excluding the Anakapalli and Bhimili Municipalities with 72 municipal wards covering a total area of around 598 $Km^2$. The city was bounded with Bay of Bengal on the Eastern Side, Duvvada hills (Adavaivaram hills) on the western Side, and YaradaKonda on the Southern side and Madhurawada dome on the Northern side shown in fig.1.

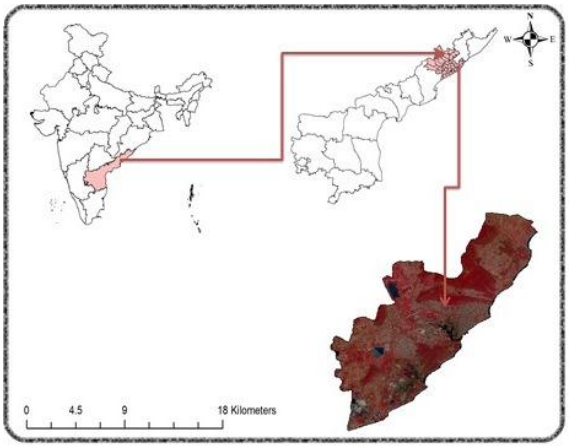


**Fig. 1: Location map of the study area.**

## III. METHODOLOGY

The investigation zone covers 2 sequences of the Survey of India (SOI) toposheets, they are 65 0/1, 65 0/2 & 0/3, 65 0/5, 65 0/6, scale 1:50,000. 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 Arc GIS 9.3.

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 Sentinel-2A (10m resolution) - dated April, 2017(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 NRS 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.

## IV. RESULTS AND DISCUSSION

### Geomorphological features in hilly terrain

The entire study area has been interpreted using satellite data of Sentinel-2A, both digital and FCC imagery has been used. In the existing lithological groups various geomorphic units

have been interpreted from satellite data and hydrogeomorphological map was prepared by incorporating the geological, structural, groundwater data. The major geomorphological units identified in the study area described below and methodology followed has been described in methodology.

**Structural Hills (SH-K)**

These structural hills are formed as linear to arcuate hills showing definite trend lines associated with following faulting. The rock types are mostly Khondalite, Leptynites and in few places Charnockite. These landforms occupied in north and southern side of Visakhapatnam (Kailasa, Yarada and, Narava hill ranges) and villages of Gopalapatanam, Gajuwaka, Malkapuram, and Kaputungalam areas. A groundwater condition of this unit is poor to nil, where as moderate condition along the valley portions of this unit.

**Inselbergs / Residual Hills (RH, K, Lpt, Ch)**

These are the resistant isolated, steep sided, usually smoothened and rounded hill or rock outcrops of circular denudation raising abruptly from and surrounded by and extensive and nearly level plains in tropical regions (Woodworth, J. B. 1912). In the study area outcrops with an elevation of 25 to 30 mts above msl have been described as residual hills Inselbergs which are exhibiting conical to rounded forms with steep to very steep debris slopes. King (1989) called Inselbergs to those residual hills, which are resulting from scarp retreat and pediplanation. These types of geomorphological features are observed in the study area as well. This landform formed due to differential weathering and erosion. This unit consists of fractures, joints, and lineaments. These hills are low relief features and occupied in very limited area. The rock types are Khondalite, Leptynites and Charnockite. These units are occupied in the main city (Tatichetlapalem, Convent junction, near cyclone warning center, near circuit house, Dasapalla hills, and Rossi hill (Near harbor) nearby NSTL, in the Malkapuram, BHPV areas. Prominent Inselberg exist near Airport (Charnockites). In this groundwater prospects are poor to nil.

**Pediment (P-K)**

These are being constituted by erosional surface which extent downwards from hill to neighboring basin consist of phylite, quartzite showing gentle slope sparse vegetation (Webb, R. W. 1946). Rock floor with a very thin or low soil cover has been identified on pediments the lineament intensity is low. Drainage density is moderate and it is characterized by very gentle slope vary from 5 to 10 degrees. Therefore these are poor potential units from the point

of view of ground water occurrence. In Visakhapatnam region 1 - 12 mts thick with 20 - 30 slope pediments is observed at some places viz. M.V.P. Colony, Madhavadhara, Malkapuram and Gopalapatanam area mostly cover with red sandy soil. In this region the groundwater condition is poor to moderate, lithologically the area exists over Khondalite.

**Geomorphological units in the plain areas**

The continuous process of pedimentation occur formation of pediplains. Pediplains are almost flat area with vary gentle slope ranging from 1-5 degree. The altitudinal variation is relatively high for rolling plain and is about 5 -10 m. Pediments with more or less overburden of accumulated materials on the shallow to moderately weathered, deeply weathered rock have been identified in various lithologies (Sankar, G. J., et al., 2001) . The extent of weathering and thickness are critically examined (with litho log data) cohering fieldwork. Extents of weathering in Khondalite are described below.

**Shallow weathered pediplain (SWP-K)**

The study is developed in Khondalite, which is exposed along the foothill of Kailasa, Narava and Yarada hill ranges. The studyis found around M.V.P. Colony, H.B. Colony, Seetammadhara, Madhavadhara, and Gopalapatanam adjacent to the Narava hills, Gajuwaka, near Zinc Smelter and Malkapuram area. The study consists of Khondalite, which is having flat and smooth surface they also show fractures, joints and lineaments. 9 to 0.5-m thick overburden cover of pediment are observed. It is formed due to intensive weathering of Khondalites. The study offering good yield along fractures, lineaments zone for groundwater exploration.

**Moderately weathered pediplain (MWP-K)**

This moderately weathered pediplain is derived from mainly Khondalite rock and found in the MVP Colony, Marripalem, Gopalapatanam, Marutinagar, Akkireddypalem, Mindhi, HPCL, Zinc and Coromandal Fertilizers and in the old post office areas. This moderately weathered pediplain is a gently undulating with less than 15-m thickness weathered Khondalite. This zone consists of the consolidated alluvial material made up of rock debris and soil deposited in pediment areas. This zone is fairly thick with recharge from small streamlets offering good to very good groundwater potential.

**Deeply weathered pediplain (DWP-K)**

This deeply weathered pediplain is mainly formed due to intensive weathering of Khondalite rock. It exists on either side of NaravaGedda River and marshy area of the study area. It occupies Narava, Muralinagar, Gopalapatanam, MVP Colony, old town area, 104 areas, Kancharapalem, Marripalem, Malkapuram, Gajuwaka, Sheelanagar, Lawson's bay colony. It consists of unconsolidated alluvial material made of rock debris and soil. This unit is more than 15 m thick which contains recharge from the streams they offer excellent yield from bore wells.

**Dissected slope (DS-K)**

Gullies and rills are geomorphic feature typically developed on exposed slopes that the gradients are in the order 3-35. Generally these places are affected by intense soil erosion due to streams and local drainage. This intense dissection of the land surface results this landform. Apart from the natural processes, soil erosion influence by man quarrying and removal of material for construction etc. near hill slopes result this type of erosional feature. This will ultimately lead to increased runoff, and groundwater prospects are moderate in this unit. In the study area a number of similar features could be observed all along the Kailasa, Yarada and Narava hill ranges. Majority of these features is the result of un-discriminate quarrying and removal of surface material.

**Marshy Area**

About 15-sq. km. of Visakhapatnam is occupied by salt-marshy wetland. Some part of this land has been reclaimed for various industrial and urban constructions. This pace of reclamation indicates that the entire marshy area will be vanished in near future. Generally marshy wetlands can be divided into lower wetlands and upper wetlands. The lower wetlands are areas having or surface elevation between mean low tide and mean high tide. The area is covered by salt water at any high tide reaching at the level of mean high tide. The upper wetlands of all areas are marked by salt-tolerant plant species in a zone at elevations ranging from mean high water to annual high water.

**Beach Sands**

The beach sands of the study area are known as placer or sands or black sand concentrates. These sands are important because they contain economical quantities of monazite and ilmenite. Besides these minerals the beach sands composed of quartz, feldspar, garnet, sillimanite, zircon, rutile and other minor minerals. Under the conditions of wave action and

wind action density stratification is common phenomena in beach where light minerals are separated from heavy minerals. The stratification is best developed on the foreshore of the beach and usually this slope parallel to the surface slope. Generally white sand layers are thicker than the black sand layer. Ground water prospects of this unit are moderate to good (In Maharanipeta old sand mound are very deep groundwater condition) but most of the waters are having saline nature.

**Valley Fills**

It is the waste produced by mountain top removal mining, named because it is typically piled high in nearby valleys. In the study area we can find this region around Vepagunta and in Arilova in between Kailasa and Kamabalkonda mountain ranges.

**Intermountain Mountain Valley**

In the study area we see the region along the sides of Kamabalkonda mountain range sloping toward Arilova.

**Pediment Slope**

The angle of a pediment's slope is generally from 0.5° to 7°. Its form is slightly concave, and it is typically found at the base of hills in arid regions where rainfall is spasmodic and intense for brief periods of time. There is frequently a sharp break of slope between the pediment and the steeper hillside above it. Water passes across the pediment by laminar sheet flow, but if this is disturbed, the flow becomes turbulent and gullies develop. The attribute table of Hydrogeomorphology map is shown below in Table.1.

**Table 1: Attribute table of hydrogeomorphology map.**

| S. No. | Geomorphic Unit | Area (Sq Km) |
|---|---|---|
| 1. | Moderately Weathered Pediplai | 231.3582 |
| 2. | ShallowWeatheredPediplain | 124.4038 |
| 3. | StructuralHill | 96.94315 |
| 4. | InterMountainValley | 6.20264 |
| 5. | ValleyFills | 10.90467 |
| 6. | WaterBody | 12.92559 |
| 7. | DenundationHills | 22.4731 |
| 8. | PedimentSlope | 9.306194 |
| 9. | DeeplyWeatheredPediplain | 29.72137 |
| 10. | BeachSand | 0.1101 |
| 11. | DissectedSlope | 5.765474 |
| 12. | MarineClay | 9.137644 |
| 13. | Inselberg | 1.789458 |

| | | |
|---|---|---|
| 14. | MarshyLand | 21.73316 |
| 15. | ResidualHill | 14.64616 |
| 16. | Pediment | 1.356001 |

The area covered by each class is represented in the form of pie chart in term of percentage as shown in Fig.2. The classified hydrogeomorphological map is as shown below in Fig.3

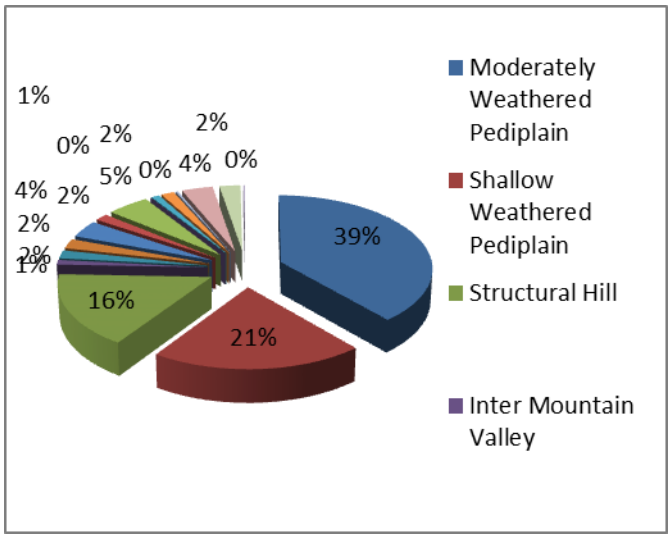


**Fig.2: Hydrogeomorphology mapof percentage.**

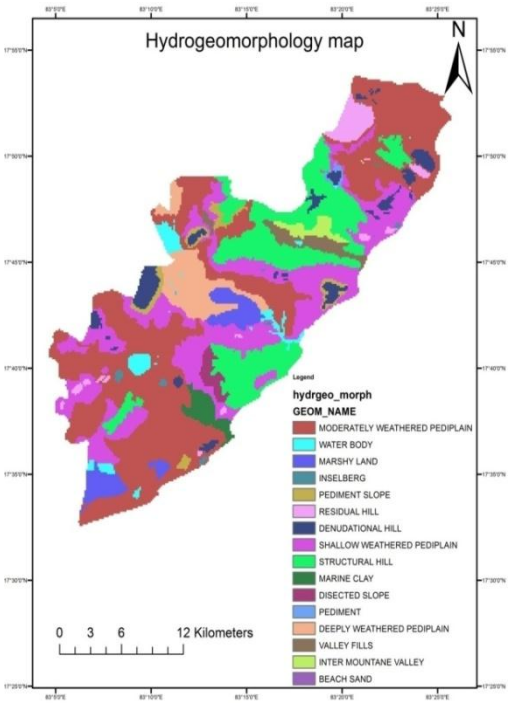


**Fig. 3: Hydrogeomorphology map.**

## V. CONCLUSION

In this research, the area of investigation covers a total area of 598 $Km^2$ 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 Sentinel-2A satellite imageries. In total, 16 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 148.001 $km^2$ and suitable areas for infiltration (recharge zones) cover about 450.059 $km^2$. Moderately Weathered Pediplain is the major landform covering an area of 231.35 $km^2$ 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 96.94 $km^2$; Shallow Weathered Pediplain covering an area of 231.3582 $km^2$.

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