

Geotechnical Study for Groundwater Management a Case Study of Peddavagu Mini Watershed in Telangana State

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ABSTRACT: Watershed is an area, which catches the water from precipitation and then is drained by a river and its tributaries. It is a “resource region” where the ecosystem is closely interconnected around a basic resource - water. The watershed is therefore an ideal management unit. The watershed provides a powerful study and management unit, which integrates ecological, geographical, geological, and cultural aspects of the land. The watershed is also a useful concept for integrating science with historical, cultural, economic, and political issues. Geomorphology is the science of evolution of landforms in terms of its lithology, structure, basin geometry and other morphometric factors. Landforms on the earth surface are expensive to map or monitor. Remote Sensing observations from space platforms provide a synoptic view of terrain on images. Satellite multispectral data have an advantage in that the image data in various bands can be subjected to digital enhancement techniques for highlighting contrasts in objects for improving image interpretability. Landforms are interpreted on the basis of interpretation element keys namely such as- tone, texture, size, shape, color etc. and extract the specific information from the false color composites LISS-IV sensor images and SOI topographic sheet of the region. Geomorphological units are classified on the basis differential processes. In the study area, mainly Pediplain Moderately (Weathered), Pediplain Shallow (Weathered), Pediment, Mesa, Dyke Ridge, Denudational Hill and Residual Hill are predominant landforms. These above geomorphic units are mapped using IRS-ID LISS-IV satellite imagery using visual interpretation technique along with field check. Remote Sensing and GIS offers detecting, analyzing and time cost effective way to fulfill these goals. In this study, Remote Sensing and GIS, tools and techniques are used to identify landform, geomorphic units and area mapping because geomorphology is the base of watershed management. The study area is a small watershed in Telangana state namely Peddavagu mini watershed. The study area is situated between 77° 54' to 78° 26' east longitudes and 17° 01' to 17° 22' north latitudes and situated in the southwestern part of Telangana state. In this study area 8 mandals are covering. The study area has a population of more than 400000, which accounts for 0.27% of the total population of the Telangana State and households are 97,036. The climate of the study is characterized by a hot summer and is generally dry except during the southwest Monsoon season. The cold weather comes towards the end of November when the temperature begins to fall rapidly.

KEYWORDS: Groundwater Management, Geotechnical, Geomorphology, Watershed, GIS, Remote Sensing, Stream Order, Geology, Slope, Aspect, Contour, Lineaments.

I. INTRODUCTION

Ground water is one of the Nation's most important natural resources. Ground water is an important source of drinking water and irrigation in everywhere. Ground water is a major contributor to flow in many streams and rivers and has a strong influence on river and wetland habitats for plants and animals. Groundwater is a strategic resource due to its usually high quality and perennial availability. However, groundwater management all over the world often lacks sustainability as evidenced by falling water tables, drying wetlands, increasing sea-water intrusion and general

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deterioration of water quality, as groundwater cannot be renewed artificially on a large scale, sustainable management of this resource is vital. A number of scientific tools are available to assist in his task. Three items are discussed here. They include methods for the determination of groundwater recharge, groundwater modeling including the estimation of its uncertainty, and the interfacing to the socio-economic field. Generally the quality of water management work can be largely enhanced with new tools available, including remote sensing, digital terrain models, differential GPS, environmental tracers, automatic data collection, modeling and the coupling of models from different disciplines

Groundwater is best described as the world's real hidden treasure. Almost everywhere it has made a difference in providing safe drinking water and livelihood security in times of drought. Major agricultural economies in arid and semi-arid regions are sustained by groundwater use. The development of pumps and drilling technologies along with government subsidies has allowed groundwater to become a new frontier in resource exploration. Compared to surface water, the development of groundwater has brought many advantages. Groundwater for example, is less vulnerable to sudden changes in availability, offering a better insurance against climate variations. Furthermore, irrigation with groundwater needs little transport from source to plot and offers individual farmers water on demand. In India, the use of water from substantial and easily-accessible aquifers has allowed people to circumvent the inconvenience of poorly functioning public systems or polluted surface waters on a large scale. Groundwater moves through aquifers (permeable strata) from areas of recharge to areas of discharge (determined by the geological structure), normally at slow rates ranging from 1-m/year to 100s-m/day. Tens, hundreds or even thousands of years may elapse between initial recharge and eventual discharge, to a spring, stream or the sea. These slow flow rates and long residence times, consequent upon large aquifer storage volumes, are among the numerous distinctive features of groundwater systems. Groundwater resources management has to deal with balancing the exploitation of a complex resource (in terms of quantity, quality and surface water interactions) with the increasing demands of water and land users (who can pose a threat to resource availability and quality). This note deals mainly with the quantitative, essentially resource-related, issues of groundwater management, and only touches marginally upon groundwater pollution protection. Groundwater is the most preferred source of water in various user sectors in India on account of its near universal availability, dependability and low capital cost. The increasing dependence on ground water as a reliable source of water has resulted in indiscriminate extraction in various parts of the country without due regard to the recharging capacities of aquifers and other environmental factors. On the other hand, there are areas in the country, where ground water development is sub-optimal in spite of the availability of sufficient resources, and canal command areas suffering from problems of water logging and soil salinity due to the gradual rise in ground water levels. Groundwater has emerged as the primary democratic water source and poverty reduction tool in India's rural areas. On account of its near universal availability, dependability and low capital cost, it is the most preferred source of water to meet the requirements of various user sectors in India. Ground water has made significant contributions to the growth of India's Economy and has been an important catalyst for its socio economic development. The watershed provides a powerful study and management unit, which integrates ecological, geographical, geological, and cultural aspects of the land. The watershed is also a useful concept for integrating science with historical, cultural, economic, and political issues. However, GIS technology and available data has advanced to the point where agencies, organisations, or individuals can delineate watersheds for any area they desire, at a very high level of precision. This ability does not replace the need for a standardized system of watershed cataloging, but augments it; supplying data where gaps exist, and providing more detailed boundaries where required. Large scale watershed boundary data is very useful in evaluating potential land use impacts when writing comprehensive plans at the town and village level. It can also be used for flood hazard mapping, storm water management projects, and aquatic and riparian monitoring programs. Geomorphology is the scientific study of the origin and evolution of topographic and bathymetric features created by physical, chemical or biological processes operating at or near the Earth's surface. Geomorphologists seek to understand why landscapes look the way they do, to understand landform history and dynamics and to predict changes through a combination of field observations, physical experiments and numerical modeling. Geomorphologists work within disciplines such as physical geography, geology, geodesy, engineering geology, archaeology and geotechnical engineering. This broad base of interests contributes to many research styles and interests within the field. Earth's surface is modified by a combination of surface processes that sculpt landscapes, and geologic processes that cause tectonic uplift and

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subsidence, and shape the coastal geography. Surface processes comprise the action of water, wind, ice, fire, and living things on the surface of the Earth, along with chemical reactions that form soils and alter material properties, the stability and rate of change of topography under the force of gravity, and other factors, such as (in the very recent past) human alteration of the landscape. Many of these factors are strongly mediated by climate. Geologic processes include the uplift of mountain ranges, the growth of volcanoes, isostatic changes in land surface elevation (sometimes in response to surface processes), and the formation of deep sedimentary basins where the surface of the Earth drops and is filled with material eroded from other parts of the landscape. The Earth's surface and its topography therefore are an intersection of climatic, hydrologic, and biologic action with geologic processes, or alternatively stated, the intersection of the Earth's lithosphere with its hydrosphere, atmosphere, and biosphere. The widespread distribution and extended graphical capabilities of GIS-software as well as the availability of high-resolution remote sensing data such as aerial and satellite imagery or digital elevation data has led to a rejuvenation of the method. Geographical Information Systems (GIS) are now widely used in geomorphology to watershed management, stream network analyses. Several commercial GIS software packages are available which provide terrain analysis functionalities for geomorphology.

II. STUDY AREA

The study area is a small watershed in Telangana state namely Peddavagu mini watershed. The study area is situated between 77° 54' to 78° 26' east longitudes and 17° 01' to 17° 22' north latitudes and situated in the southwestern part of Telangana state. In this study area 8 mandals are covering. The study area has a population of more than 4 lakhs, which accounts for 0.27% of the total population of the Telangana State and households are 97,036. The climate of the study is characterized by a hot summer and is generally dry except during the southwest Monsoon season. The total Population is 428792 and the male Population is 220414 and female Population is 208378. The ST population is 26196 which account of 6.1% in the study area, the SC population is 88706 which account of 20.68% in the study area, and the literacy Population is 234998 which account of 64.8% in the study area (Figure.1). In the study area is mainly covered by three types of soils Viz. red sandy soil (Dubbas and Chalkas) Red earth (with loamy sub-soils and Chalkas) and black cotton soils. Red sandy soils and red earth are permeable and well drained. The cold weather comes towards the end of November when the temperature begins to fall rapidly. December is generally the coldest month, with the mean daily maximum temperature at about 27° C and the mean daily minimum at about 14° C. The period from March to May is the hottest month with the mean daily maximum temperature about 51° C and a mean daily minimum of about 27° C. The days are intensely very hot and on individual days the temperature may go up to about 45° C. With the advance of south-west monsoon by about middle of June there is an appreciable drop in temperatures.

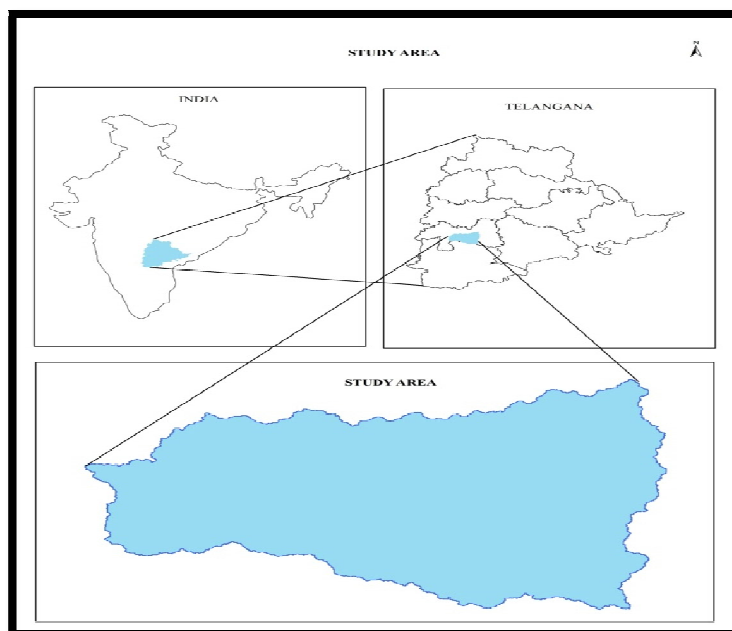


Fig.1

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The rainy season starts in June and ends in September. The rainfall in the district increases from the south-west towards the north east. About 83% of the rainfall is received during the rainy season. July is rainiest month. The Normal rainfall in the study area is 1300 mm.

In study area geomorphological units are classified on the basis differential processes. In the study area, mainly Dyke Ridge, Pediment, Flood Plain Shallow, Pediplain Shallow Weathered, Pediment Inselberg Complex, Residual Hill, Denudational Hill, Inselberg, Buried Pediplain Moderate, Buried Pediplain Shallow, Plateau Moderately Dissected, Plateau Slightly Dissected, Valley Fill Shallow, Plateau Weathered –Shallow are major landforms.

III. OBJECTIVES

1. To study the physical features of the study area.
2. To analyze different types of geomorphic features.
3. To analyze the drainage network in the study area.
4. To investigate and suggest the recharge structures in the study area.

IV. DATA BASE AND METHODOLOGY

In the present study Survey of India topographic maps 56G15, 56G16, 56K3, 56K4, 56K7, 56K8 at scale 1:50,000 published by Survey of India (SOI) have been utilized and Remote Sensing data collected in digital form from NRSC (National Remote Sensing Center, Hyderabad) the image pass on IRS-1D LISS-IV data. Geomorphological units, mapping with image interpretation techniques, digital image processing, existing geology and geomorphology map using Erdas Imagine 2015 and ArcGIS 10.1 and verified in field work with GCPs collection to understand the distribution of the landforms, Stream Order and the lineaments. The basic method adopted was visual interpretation of FCC and B&W data. From the image interpretation characters as tone, texture, colour, form and shape various landforms and land units were distinguished. The response of materials in the different wave length bands are also used to identify surface materials as water bodies, Dyke Ridge, Pediment, Flood Plain Shallow, Pediplain Shallow Weathered, Pediment Inselberg Complex, Residual Hill, Denudational Hill, Inselberg, Buried Pediplain Moderate, Buried Pediplain Shallow, Plateau Moderately Dissected, Plateau Slightly Dissected, Valley Fill Shallow, Plateau Weathered –Shallow etc.

V. CONTOUR OF THE STUDY AREA:

Which shows vertical elevations or contours, as well as physical details above, on and below the ground is contour in the study area. Contours are lines on the drawing that join points that have the same elevation on the ground. Contour lines never cross each other, and the closer the lines are to each other, the steeper the slope. Conversely, the further apart the lines are from each other, the flatter the slope. Contour lines cannot overlap with other contour lines. Contour lines, cannot cross themselves. Scientific analysis cannot be done without contours (Figure.2). This contour map is classified into high value to low value. Different color combinations are used for different elevations. A large part the study area lies in the elevation zone of about 591 to 620 metres. Edge, in the southern part of the study area have quite higher elevations, going beyond 720 metres. In Residual Hill area has very closed and dense contours and high elevated in the study area. Less elevated contours lies in the Pediplain Shallow area in the study area because it is a weathered area.

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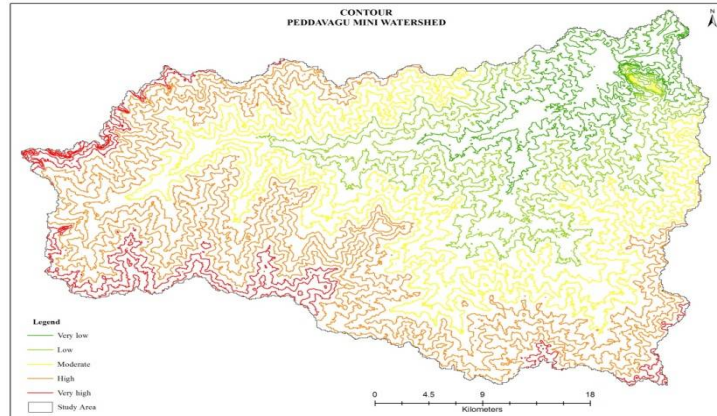


Fig.2

Geology of the Study Area:

Table- 1 Features wise Percentage of Geology in Study Area

S.No	Geology Features	Percentage of Area
1	Laterite	0.75
2	Deccan Trap	48.75
3	Gneissic Complex Granite	22.71
4	Granite Gneiss	24.34
5	DR	0.21
6	Water	3.23

Source: Liss IV Image

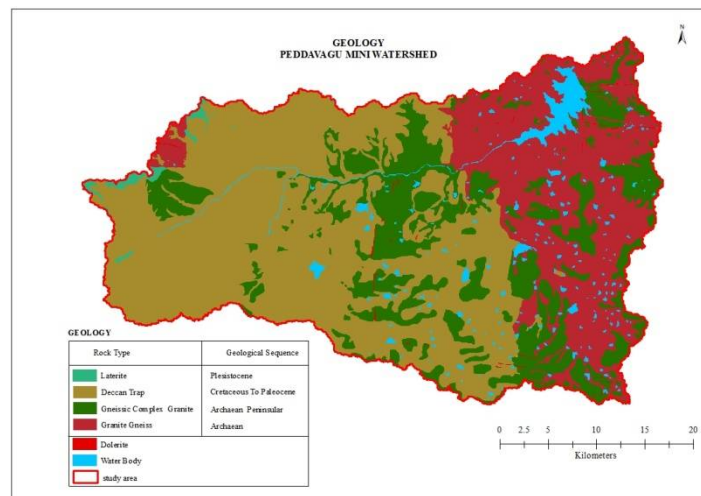


Fig.3

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In study area geology units are classified under four classes namely Dolerite, Granite Gneiss, , Granite Gneiss Complex , and Deccan Traps on the base of LISS IV image. The highest percent of geology feature is Deccan Trap in study area is 48.75, followed by Granite Gneiss, and Dolerite, the lowest percent of geology feature is Laterite (Table.1). Deccan Trap area is having very high elevated and Granite gneiss is having very low elevated area in the study area. Streams are dense in the Deccan Trap area and in Pediment, Dyke Ridge and Denudational Hills area have very less (Figure.3).

VI. SLOPE OF THE STUDY AREA

In the above map the percentage of slope is divided into five classes. They are

1. Very Low, 2. Low, 3. Average, 4. High and 5. Very High.

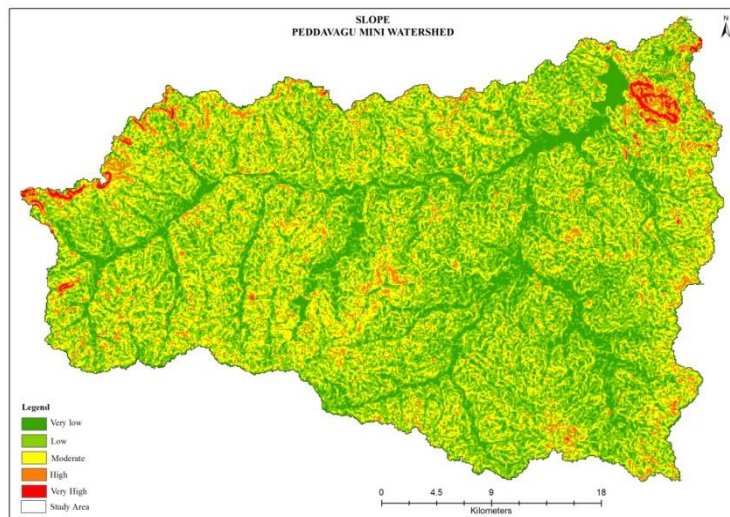


Fig.4

In the study area south side part having very high value slope and in north side part having very low value slope. More than 87 percent of slope value is very low, low value slope is 5 percent, average value slope is 3 percent, high value slope is 5 percent in the study area. Slope is one of the most important factors controlling the watershed management and groundwater infiltration (Figure.4).

VII. ASPECT OF THE STUDY AREA

Aspect identifies the down slope direction of the maximum rate of change in value from each cell to its neighbors in the study area. It can be thought of as the slope direction. The values of each cell in the study area raster indicate the compass direction that the surface faces at that location. It is measured clockwise in degrees from 0 (due north) to 360 (again due north), coming full circle. Flat areas having no down slope direction are given a value of -1. Find all north-facing slopes on a mountain as part of a search for the best slopes (Figure.5).

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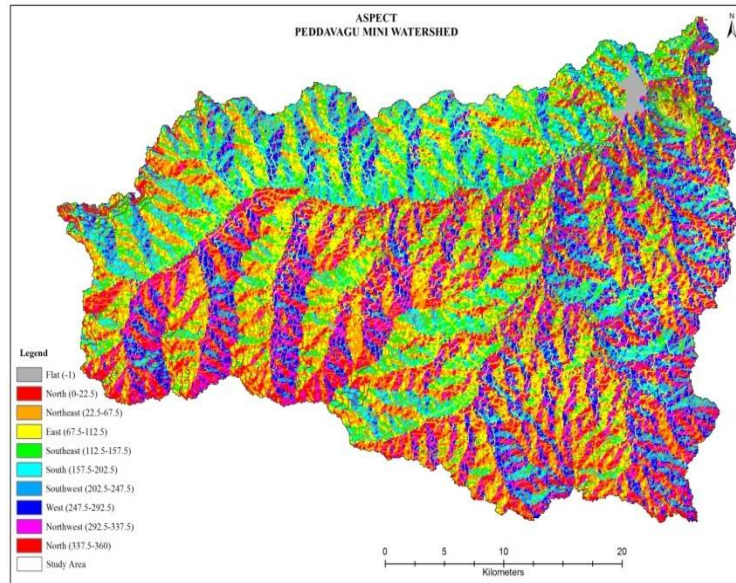


Fig.5

Calculate the solar illumination for each location in a region as part of a study to determine the diversity of life at each site. Identify areas of flat land to find an area for a plane to land in an emergency.

In study area aspect is classify into ten classes. They are

1. Flat (-1)
2. North (0-22.5)
3. Northeast (22.5-67.5)
4. East (67.5-112.5)
5. Southeast (112.5-157.5)
6. South (157.5-202.5)
7. Southwest (202.5-247.5)
8. West (247.5-292.5)
9. Northwest (292.5-337.5)
10. North (337.5-360)

Stream Order of the Study Area:

Stream systems have been classified according to their relative position within a stream network in order to help us understand, discuss, and explore similarities and differences between them. Many stream order classification systems have been developed, but no single system has been universally accepted. One of the earliest methods developed, and arguably the most commonly used method today, was developed by Strahler. In this system, the smallest headwater tributaries are called first-order streams. Where two first-order streams meet, a second-order stream is created; where

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two second-order streams meet, a third order stream is created; and so on (Figure 6). Streams of lower order joining a higher order stream do not change the order of the higher stream.

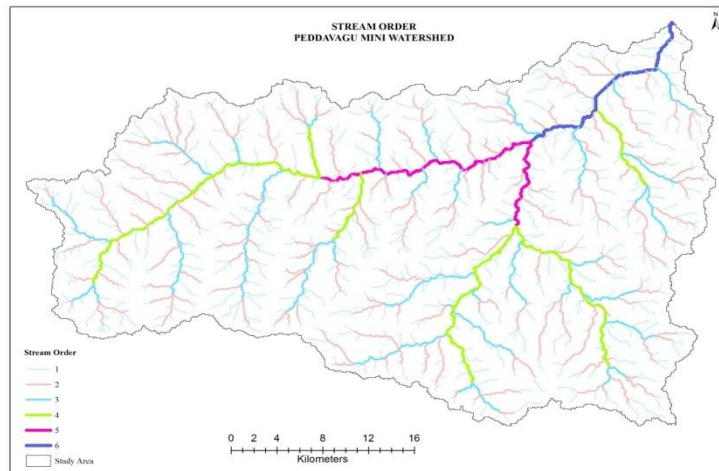


Fig.6

Stream order is an important characteristic of stream systems and watershed management because it can be related to drainage area and stream size and it can be related to the expected ecological function of a stream system. In present study area has six types of stream orders. In the study area begin with first order and the stream order is increased when moving to northeast part of the study area. The sixth order is lie in the northeastern side of the study area.

VIII. LINEAMENTS OF THE STUDY AREA

In study area more than 450 fractures / faults zones are there. 90 percentage of fracture / fault zones are cover in Pediplain Moderate and Valley Fill Shallow areas in the study area. These are the Faults/Fractures zones, which generally act as conduits for movement of ground water in hard rocks. Along these zones, the yields are significantly higher and wells are likely to be sustainable for longer duration. However, the inferred fractures need to be confirmed by detailed ground surveys (Figure 7).

These are the dykes, quartz reefs, pegmatites etc. which generally act as barriers for ground water movement.

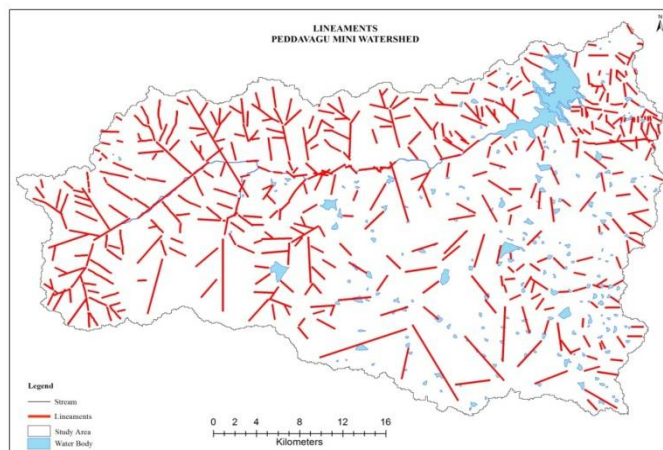


Fig.7

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IX. GEOMORPHOLOGY OF THE STUDY AREA

The earth's surface forms are primarily due to hypogene or endogenous processes. Geomorphology is the science and study of landforms on the earth. Today, all watershed management planning processes in most of the countries are based on geomorphological units. The Geomorphology units are dynamic in nature as they are affected by various human activities, including the expansion of cultivated and irrigated lands, industrialization, urbanization and others because it need to monitoring, mapping for watershed management. Geomorphic units are classified on the basis of differential erosion processes. Mainly denudational hills and pediments of granites are predominant landforms (Table.2) and (Figure 8).

Table1- 2: Features wise Percentage of Geomorphology units in Study Area

S.No	Geomorphology	Percentage of Area
1	BPM	0.06
2	BPS	0.54
3	DH	0.48
4	DR	0.21
5	FPS	0.25
6	VFS	4.2
7	I	0.04
8	PD	14.39
9	PIC	0.68
10	PLM	0.44
11	PLS	6.21
12	PLU	0.27
13	PLWS	31.40
14	PPM	20.79
15	PPS	16.79
16	RH	0.03
17	Water	3.23

Source: LISS IV Image

In present study area geomorphological units are classified on the basis differential processes. In the study area seven types of geomorphology landforms are there.

They are

BPM - Buried Pediplain Moderate

BPS - Buried Pediplain Shallow

DH - Denudational Hill

DR - Dyke Ridge

FPS - Flood Plain Shallow

I - Inselberg

PD - Pediment

PIC - Pediment Inselberg Complex

PLM - Plateau Moderately Dissected

PLS - Plateau Slightly Dissected

PLU - Plateau Undissected

PLWS - Plateau Weathered Shallow

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PPM – Pediplain Moderate Weathered
PPS - Pediplain Shallow Weathered
RH – Residual Hill
T – Tanks
VFS –Valley Fill Shallow

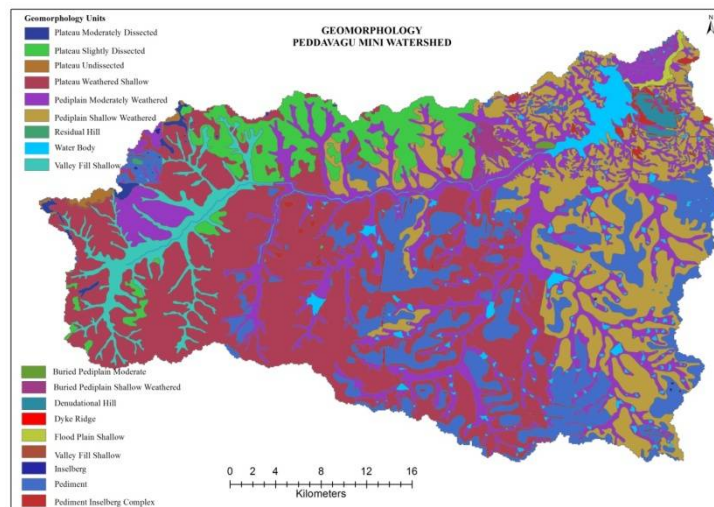


Fig.8

Buried Pediplain (BP):- The surface of the pediplain which normally supports vegetation no fracture present will support to content more water deposition. The pediment content with no rock cut materials on the plain surface is called Buried Pediplain. This portion shows greenish red tone and regular texture in the satellite imagery. It is favourable for vegetation growth. Buried pediplains with black cotton soils. Black cotton soils have good potential is highly Identification of Potential Zones for Groundwater favorable for ground water exploration and development. In the study area Buried Pediplain Moderate (BPM) is 0.06%, Buried Pediplain Shallow (BPS) is 0.54%.

Denudational Hills (DH):- Denudational hills are the massive hills with resistant rock bodies that are formed due to differential erosional and weathering processes. These hills are composed of fractured, jointed having no soil cover moderate to steep slope. On the satellite image, these landforms were identified by light or dark brownish with mix green color due to thick forest cover. It covers an area of 0.48% in study area.

Dyke Ridge (DR):- These landforms are generally acted as barriers for ground water movement. Dyke ridges are there in the present study area. It covers an area of 0.21% in study area.

Flood Plain shallow (FPS):- A floodplain or flood plain is an area of land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge. It includes the floodway, which consists of the stream channel and adjacent areas that actively carry flood flows downstream, and the flood fringe, which are areas inundated by the flood, but which do not experience a strong current. In other words, a floodplain is an area near a river or a stream which floods when the water level reaches flood stage. It covers an area of 0.25%. in study area.

Valley Fill Shallow (VFS):- Alluvium or other material occupying areas below mountain slopes. It covers an area of 4.2%. in study area.

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Inselberg (I):-The term applied only to arid landscape features. However, the term inselberg has since been used to describe a broader geography and range of rock features, leading to confusion about the precise definition of the term. The term has been defined as "steep-sided isolated hills rising relatively abruptly above gently sloping ground". This definition includes such features as buttes; conical hills with rectilinear sides typically found in arid regions; regolith-covered concave-convex hills; rock crests over regolith slopes; rock domes. It covers an area of 0.04% in study area.

Pediment (PD):-In the study area, pediments is gently sloping areas or erosion surface of bed rock. Pediments may or may not be covered by a thin layer of alluvium and are mostly developed at the foot of the hills. Pediment area is covered middle portion of the study area and in the southern portion of the study area. These landforms are fine texture. It covers an area of 14.39 % in study area.

Pediment Inselberg complex (PIC):- This complex consists of small isolated like standing out prominently 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 difference between the pediment inselberg complex and pediment inselberg is that in case of pediment inselberg, it is a single isolated low relief hill but in the case of pediment inselberg complex it is more than one isolated low relief hill but occurring closely. It covers an area of 0.68% in study area.

Plateau Moderate dissected (PLM):- is a plateau area that has been severely eroded so that the relief is sharp. Such an area may be referred to as mountainous, but dissected plateaus are distinguishable from orogenic mountain belts by the lack of folding, metamorphism, extensive faulting, or magmatic activity that accompanies orogeny. It covers an area of 0.44% in study area.

Plateau Undissected (PU):-A plateau or other relatively level surface that has not been deeply cut by streams. It covers an area of 0.27% in study area.

Pediplain Moderately (PPM):-Flat and smooth buried pediplain and pediment with moderately thick overburden are called pediplain moderate. Thickness of weathered material is high compare to pediplain shallow. The weathered materials are chiefly constituted by gneisses and migmatites. They are extended towards northeastern side of the study area. It covers an area of 20.79 % in study area.

Pediplain shallow (PPS) -They are formed by coalescence of buried pediments, where a thick overburden of weathered materials accumulates. The intensely 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. These land forms are more area spread in study area. It covers an area of 16.79% in study area.

Residual Hill (RH):-Residual hills are the end products of the process of pediplanation, which reduces the original mountain masses into a series of scattered knolls standing on the pediplains. We can also say that the hard rock's left behind after erosion are then called residual hills. Residual hills occur as small hills comprise of more resistant formations formed due to differential erosion are found in the western and southern portions of the study area. In the imageries, these features occur as dark greenish brown patches with forest cover. It covers an area of 0.03% in study area.

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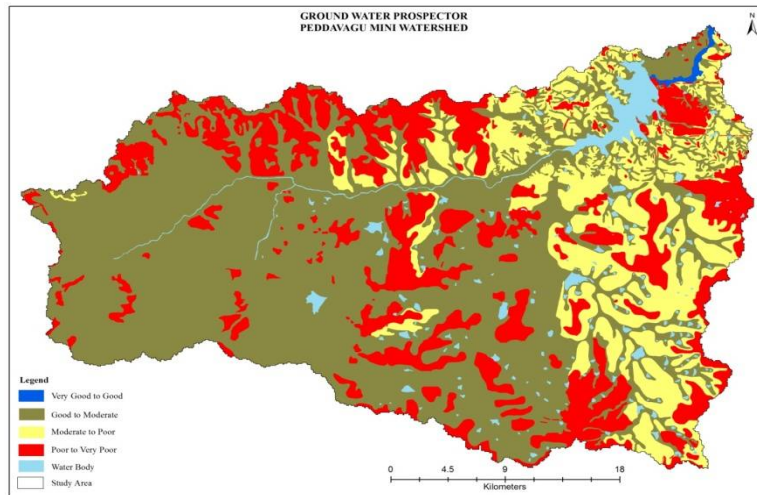


Fig.9

In the study area ground water prospector zones are classified in to four types on the bases of geomorphological features, geology, slope, stream order and lineaments. They are Very Good to Good, Good to Moderate, Moderate to Poor, and Poor to Very Poor. In poor to very poor zone have weathered rock and fractured rock. In moderate to poor zone have loose sediments and fractured rock. In good to moderate and very good to good zone have weathered rock, fractured rock and loose sediments.

X. RECHARGE STRUCTURES SUGGESTED

In present study three types of recharge structures are suggested in different places. They are Recharge Pit, Desilting of tank, Check Dam. The Figure 9 shows the recharge structures in study area. Total recharge structures are 199, check dams are 38, Desilting of tanks are 34, Recharge Pits are 127 in the study area.

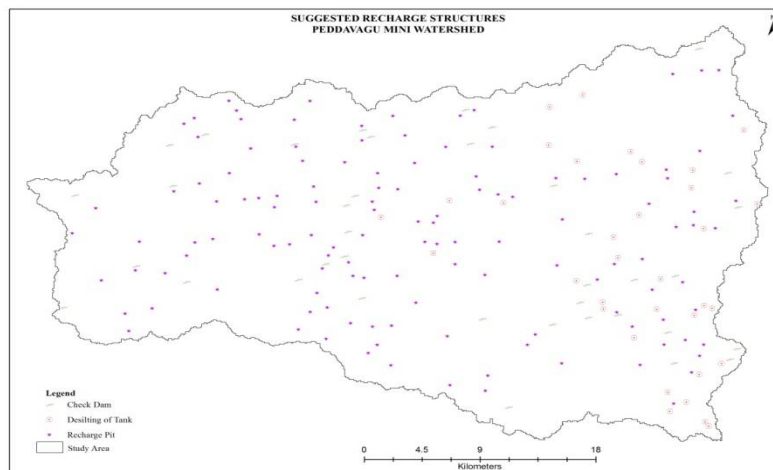


Fig.9

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XI. CONCLUSION

Ground watershed management is continuous process due to natural and human causes. For future watershed management, it is necessary to understand the existing geomorphic units and extents. Remote Sensing and GIS have capability to mapping geomorphic units. It provides the large view of earth surface features on the satellite and have various tools, technique to explore the geographic features. This small study it is observed that geomorphological study has several advantages. The connection of the geomorphological feature characteristics of these areas provided a simple and efficient way to understand the watershed and groundwater circulation model. In the study area four ground water prospector zones are classified and three types of recharge structures are suggested on the bases of geomorphological features, geology, slope, contour, Stream Order and lineaments. The total 199 recharge structures are suggested in that 127 are Recharge Pit, 34 are Desilting of tank and 38 are Check Dam.

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