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Research Article

REMOTE SENSING BASED HYDROGEOMORPHOLOGICAL MAPPING OF MAHESH RIVER BASIN, AKOLA AND BULDHANA DISTRICTS, MAHARASHTRA, INDIA - EFFECTS FOR WATER RESOURCE EVALUATION AND MANAGEMENT

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ABSTRACT
The study area under investigation is traversed by Mahesh River basin experiencing sub-tropical or tropical monsoon climate. The storage capacity of the rock formations depends on the porosity of the rock. In the rock formation the water moves from areas of recharge to areas of discharge under the influence of hydraulic gradients depending on the hydraulic conductivity or permeability. The area in nearby Balapur urban faces acute water scarcity and frequently drought prone region. The present study was under taken to evaluate various hydrogeo-morphological units of the area through the use of high resolution satellite data and field survey. The evaluated hydrogeo-morphological units along with geological setup and topographic condition are integrated in GIS environment on the basis of contribution of particular factor in groundwater occurrence and movement. Digital image processing techniques were also applied for better understanding of the features which are helpful for identification of boundaries of various landforms and geology. The deeply and moderately weathered Moderately Dissected with shallow alluvial plains is the most potential zones for groundwater exploration and site for water management plan. During the process of integration, the geomorphic units and rock types are made coterminous by adjusting the boundaries. As a result of the integration, the areas having unique lithology, landform and structure were delineated. These integrated lithological structural geomorphic units were treated as homogenous areas with respect to hydrogeological properties. During the process of integration, the geomorphic units and rock types are made coterminous by adjusting the boundaries. As a result of the integration, the areas having unique lithology, landform and structure were delineated. These integrated lithological structural geomorphic units were treated as homogenous areas with respect to hydrogeological properties.

Keywords: *GIS, Remote Sensing, SRTM Data and Hydro-geomorphology Mapping*

INTRODUCTION
The satellite imagery was visually interpreted into geomorphic units/ landforms based on image elements such as tone, texture, shape, size, location and association, physiographic, genesis of landforms, nature of rocks/sediments, and associated geological structures. The topographic information in Survey of India aids in interpreting satellite imagery. Three major geomorphic units –hills and plateaus, piedmont zones, and plains- based on physiographic and relief. Within each zone different geomorphic units will be mapped based on landform characteristics, their areal extent, depth of weathering, thickness of deposition, etc. Specific stream pattern develops in response to the initial topography of an area and the distribution of the rock types of varying erosion resistance. The shape of the pattern depends on rock, soil, climate and the changes made to the river. Drainage patterns are good indicator of the underlying rock types, structural features, nature of terrain and topography. Groundwater's is a dynamic and replenish able natural resource for the survival of human beings and the development of society. Therefore accurate and reliable information was required for water resources assessment and management. One of the most concerning issues currently being faced by the society, is the growth of population and its impact on the water resources. A groundwater resource plays a fundamental role in the sustainability of livelihood and regional economies throughout the world. It is the primary safeguard against drought and plays a central role in food security at local, national as well as global levels. Space borne remote sensing information

with its unique capabilities of spatial, spectral resolutions and temporal availability covering large and inaccessible areas within short time has become a very versatile tool in natural resource mapping. Geographical Information System (GIS) is a powerful tool for collection; storing, retrieving, transforming and displaying spatial data from the real world (Brunner *et al.,* 2007 and Leblanc *et al.,* 2007). Remotely sensed data provides is a rapid and cost-effective tool in generating valuable data on geology, geomorphology, land/ use, lineaments/structures and slope, etc. that helps in demarcating groundwater prospect zones over a conventional techniques of hydrological analysis (Singh *et al.,* 2011). A systematic integration of these data with field information provides rapid and cost-effective tool for identification of groundwater prospect zones and management of water resources in hard rock areas (Singh, 2012; Imran *et al.,* 2011).

The groundwater occurrence and movements in hard rock areas are depending on the underlying rock formation, thickness of weathered material, topography, secondary porosity (fold, fault, fractures and lineaments) and climatic conditions. It is well known that hard rocks are having very less prospect for groundwater storage due to hard in nature, diversify physiographic conditions and climate change resulting is a severe crisis of availability of portable drinking water. The available water resources are inadequate to meet all the water requirements as well as high cost of exploration make the serious concern to find out the groundwater prospect zones with cost-effective techniques especially in hard rock terrain. In this direction mapping and monitoring of existing groundwater resources and predicting the future scenarios are the major issues in hard rock areas such as basaltic terrains in India. The incorporation of various field information collected from several sources are the key input data for groundwater prospecting of hard rock area with sustainable manner (Jasmin *et al.,* 2011; Singh *et al.,* 2011; Jha *et al.,* 2007; Khadri, 2013).

The framework in which the ground water occurs is as varied as that of rock types, as intricate as their structural deformation and geomorphic history, and as complex as that of the balance among the Lithological, structural and geomorphic parameters. The combined units in which the lithology, landform, structure and recharge conditions are unique are called ‘hydrogeomorphic units’. They are considered as three dimensional homogenous entities with respect to hydrogeological properties and the recharge condition. In other words, they are treated as the aquifers. The ground water prospects are expected to be uniform in a hydrogeomorphic unit. The landforms can be grouped in to structural, denudetional and fluvial origin. The occurrence of groundwater in lava flow is prominent in highly altered fractured, jointed horizon which serves as a potential flow zones for the accumulation of the groundwater. Where as in vesicular formations groundwater occurs in interconnected vesicles both under water table and confined conditions. In order to delineate the aquifers the lithological, geomorphological and structural map overlays are subjected to overlay analysis by superimposing the layers one over the other in the GIS environment. The present study has been taken for the Mahesh River basin area using remote sensing and GIS techniques for understanding the terrain for groundwater assessment and management.

Study Area

The Mahesh River basin is situated in Akola and Buldhana districts of Maharashtra which is located between 76° 46’11’’ E and longitude 20°40′ 36” N latitude covered by survey of India Toposheets no. 55 D/9, 55 D/7, 55D/11,55D/13,55D/14and 55 D/15on 1:50,000 scale. It can be approached from Amravati by road transport which is about 120 Km. The Mahesh River basin which is a major tributary of Mun River lies towards the western and southern part of Akola and Buldhana districts. The total area covered by Mahesh River Basin is 328.25 Sq. Kms. the study area is occupied by alluvium and Deccan basalts which are horizontally disposed and is traversed by well-developed sets of joints. The Ajanta hill ranges are bordering the district in the Southern with their slope towards Western. The starting part of Akola district is plain whereas the western part is again elevated with its general slope towards Sothern. The Mahesh River Basin flows in the Southern to Western direction having western slope and meets the Mun River near Balapur village in Akola district. Purna is the major river of the Akola and Buldhana districts. The important tributaries of Purna River are Katepurna, Morna, Man, Vidrupa, Shahanur, Van and Nirguna. Most of the watershed area was covered by unconsolidated sediments, black cotton soil, Red soils and basaltic rocks of Deccan Traps. The study area was drained by Mahesh River basin flowing south to western with almost dendritic to sub-dendritic pattern.

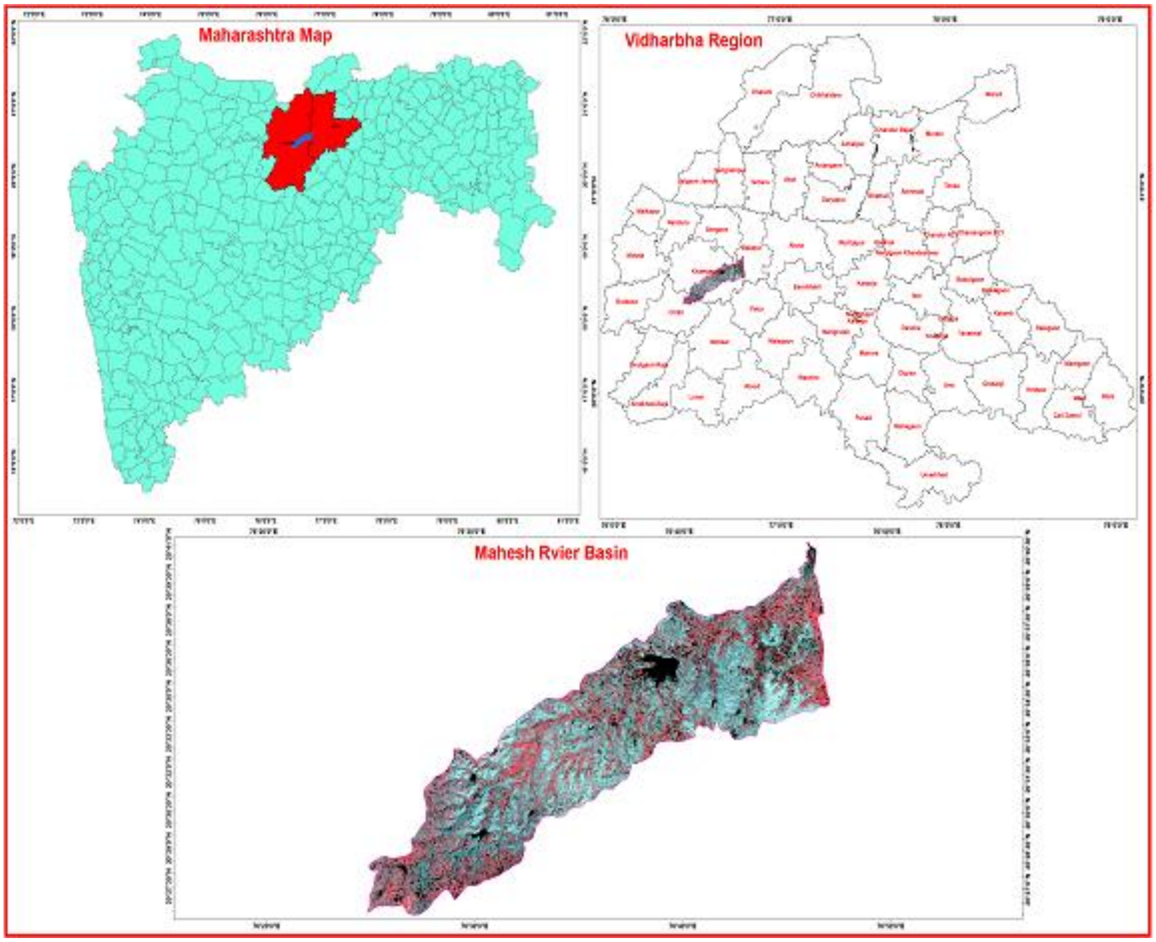

Figure 1: Location Map of Mahesh River Basin

Geology

The northern part of the Mahesh River basin is characterized by presence of alluvial deposit and southern part is covered by Deccan trap ,the alluvium deposit belongs to quaternary age and can be broadly divided into older and younger alluvium and it shows graded pattern, the older clay silt and coarse sand grading upward into fine sand silt and clay and unconformably overlies the basaltic lava flows, whereas the younger alluvium consists of fine sand silt and clay deposits with few lenses of pebble beds in between. The alluvial deposits in the area are basically derived from the disintegration and decomposition of the basaltic rocks and are classified into two broad groups. The study area is characterized by the presence of nearly 200 to 250 m. thick horizontal basaltic lava flows showing Cretaceous to Eocene age with a mantle of recently formed soil. The lava flows can be grouped into massive basalt showing limited water resources. The vesicular and amygdaloidal basalt containing weathered and jointed horizon indicating potential aquifers. The thickness of flows varies from few feet to more than 30 meters, showing both simple and compound nature. The compound flows are characterized by the presence of more than two flow units showing pipe amygdales with massive nature at the base and dominated by vesicles at the top. Despite widespread acceptance of the impact hypothesis, the lack of a high-resolution eruption timeline for the Deccan basalts has prevented full assessment of their relationship to the mass extinction. However, recent research carried out by Blair *et al.*, (2015) through Uranium - Lead (U-Pb) Zircon geochronology to Deccan rocks has showed that the main phase of Deccan eruptions initiated ~250,000 years before the Cretaceous-Paleocene boundary and that >1.1million cubic kilometers of basalt erupted in ~750,000 years and their results are consistent with the hypothesis that the Deccan Traps contributed to the latest Cretaceous environmental change and biologic turnover that culminated in the marine and terrestrial mass extinctions.

Table 1: The Geology of the Study area

Recent	Younger alluvium	Black cotton soil. Dark gray fine sand silt and day deposits with a few lenses of pebble beds
Unconformity		
Quaternary	Older alluvium	Light chocolate brown and light yellow Caulfield lay and silt. Thin pebble beds with pebbles and coarse sand, grading upward into fine sand, silt and clay.
Unconformity		
Upper Cretaceous To Eocene	Deccan Traps	Basaltic lava flows.

MATERIALS AND METHODS

Data Used and Methodology

Assessment and management of groundwater from the remote sensing, field data and other published maps required a systematic methodology in which entire dataset support for the integration and analysis in GIS environment. For the groundwater resource evaluation of an area, a multiparametric data set comprising remote sensing data (IRS ID, SRTM data), Survey of India toposheets and published geological map of GSI along with other published maps of the district. The IRS –ID LISS III and PAN data were geometrically rectified and registered with SOI topographical maps using ERDAS 9.1 image processing software through map to image registration techniques. The digitally rectified images were spectrally merged by principle component analysis based on image fusion techniques. Image enhancement techniques have been applied for the preparation of hydro-geomorphological map on the basis of their image characteristics to enhance lithological boundary and landforms. Topographic analysis and generation of slope and aspect map has been derived from satellite borne SRTM DEM using surface analysis tools. The interpreted geomorphic units/landforms was verified through field visits, in which the depth of weathering, nature of weathered material, thickness of deposition, nature of deposited material, etc. are examined at nala and stream cuttings, existing wells, and lithology of wells drilled (Figure 2 and Plate1).

Plate 1: A view of Pediplan landforms at Ambikapur village of Mahesh River Basin

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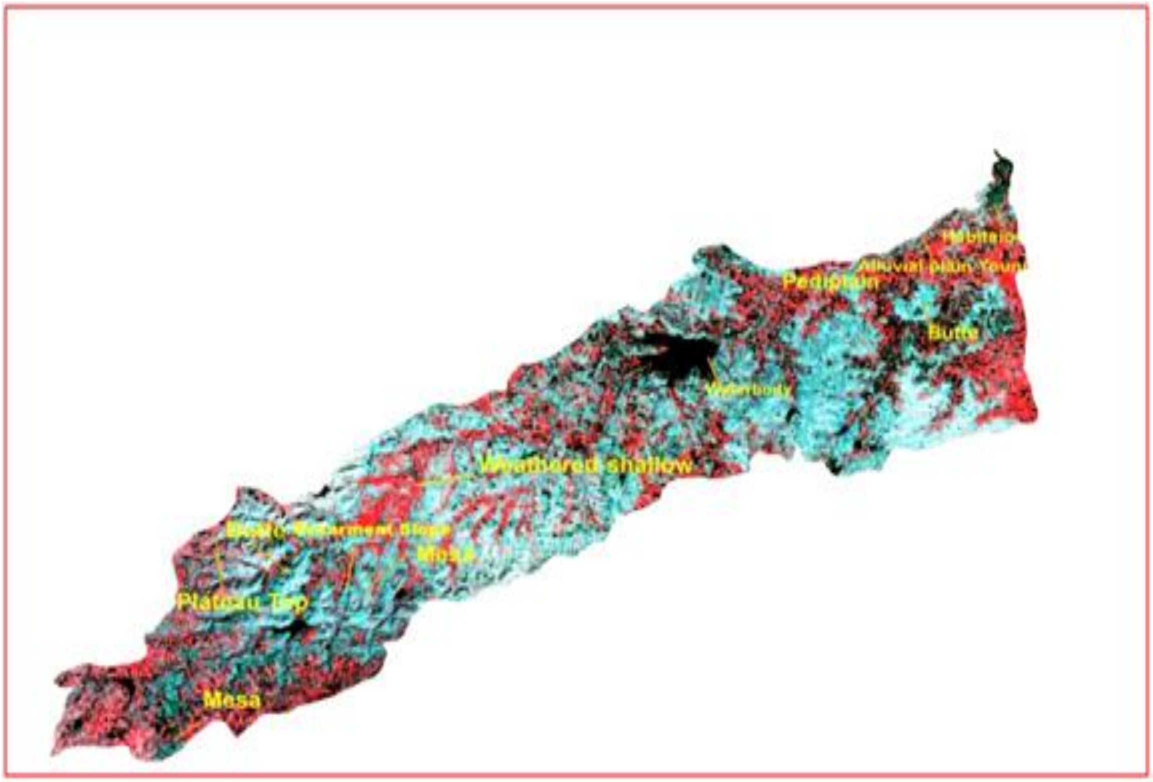

Figure 2: Satellite image map showing hydro-geomorphological landform

Slope Analysis (S_a)

Slope is the most important and specific feature of the earth's surface form. Maximum slope line is well marked in the direction of a channel reaching downwards on the ground surface. In any region valley slopes, occupy most of the area of erosional relief in greater extent in comparison to flood plains, river terraces and other local depositional landforms.

In geomorphology, the slope is combined effect of form (Environmental conditions of slopes such as the geology, climate and vegetal cover) and process (agents, such as soil creep, surface wash and the process of weathering).

Form and Processes - both have existed right from the remote past. The sequence of the past forms prepares the way for the present ones, and this constitutes the evolution of a slope.) Slope is the basic elements for analyzing and visualizing landform characteristics.

They are important in studies of watersheds units. Landscape units, and morphometric measures. When used with other variables slope and aspect can assist in runoff calculation, forest inventory estimates, soil erosion, wild life habitat suitability and site analysis.

An aspect-slope map simultaneously shows the aspect (direction) and degree (steepness) of slope for a terrain. Slope is evaluated as quantitatively parameter. Slope map has created by using Surface Analysis Tool in ARC GIS 10.1 software and mean slope has computed, which is 0.0 to 89^{o}.99'(Figure 3). Slope is a critical parameter which directly control runoff and therefore on infiltration and also important in geomorphic evaluation.

The topographic analysis has carried out using digital elevation models (DEM) from SRTM data using ARC GIS software (Figure 4). On the basis of topographic height, the study area is divided into nine topographic elevation classes.

The highest topographic elevations (about 598m MSL) exist in the western part of the area which encourage highest runoff and hence less possibility of rainfall infiltration. The low topographic elevations are observed in the eastern portions of the study area.

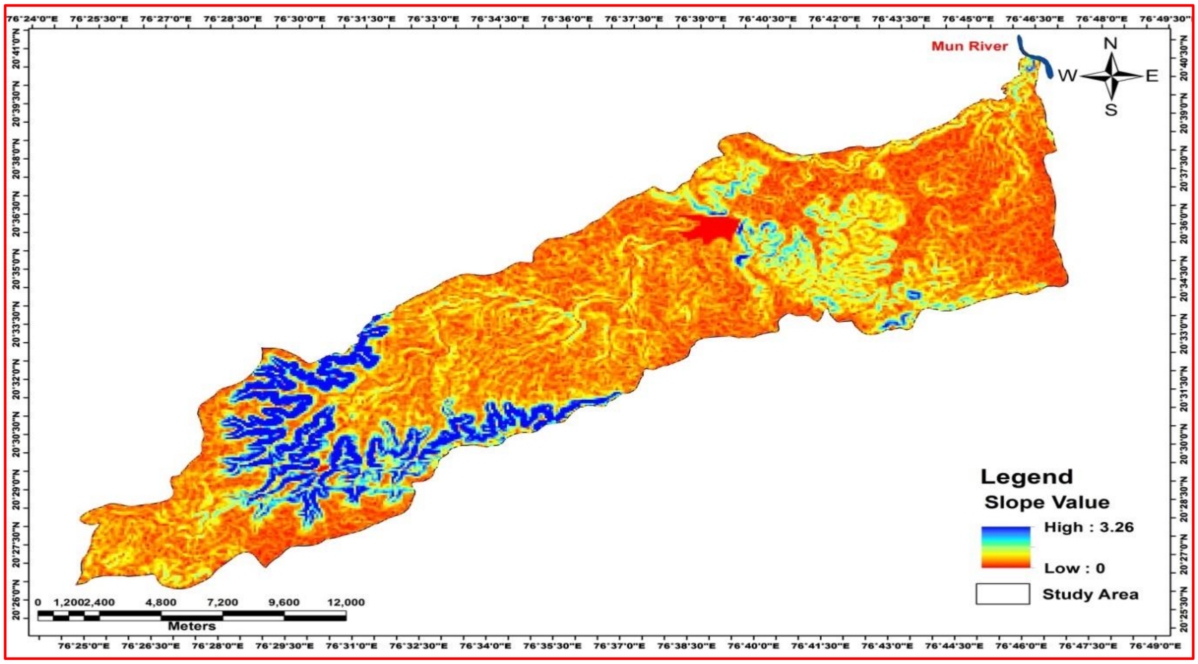

Figure 3: Slope Analysis map of Mahesh River Basin

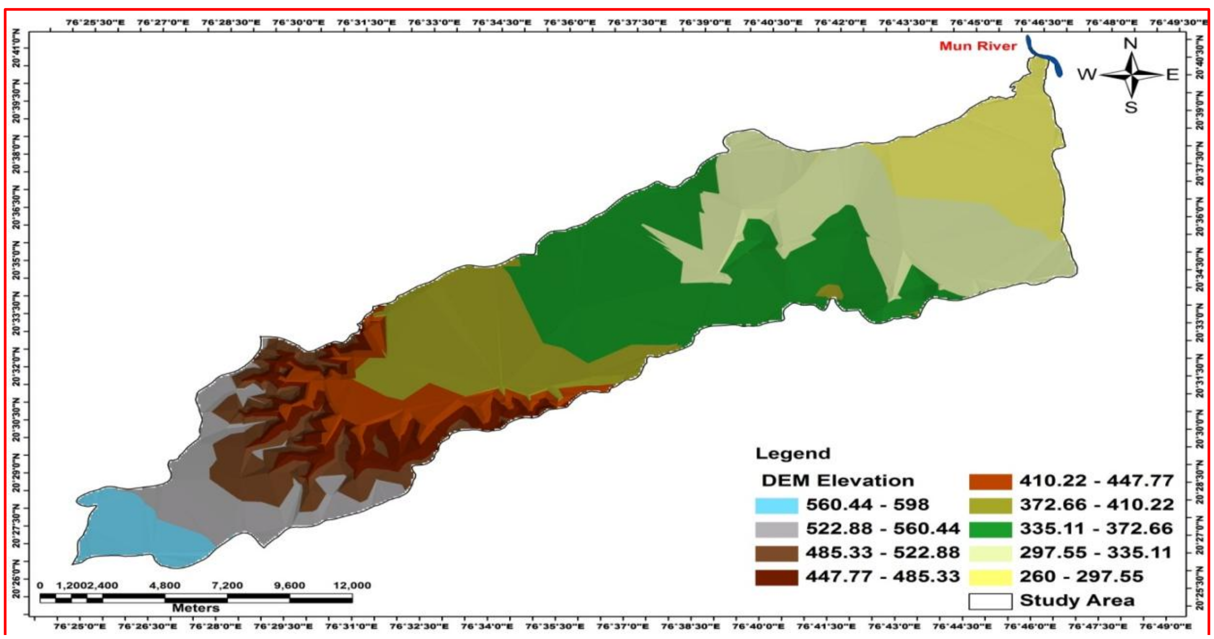

Figure 4: DEM map of Mahesh River Basin

Hydro-geomorrphology

Hydro-geomorphological map depicts a essential indication about the geomorphic units and landforms along with their underlying rock formation so the detail geomorphologic investigation provide an important input data for understanding the entire processes of deposition, lithology / structure and various geological controls responsible for the occurrence and movement of groundwater resources (Singh *et al.*, 2011; Machiwal *et al.*, 2011; Khadri, 2014). The major Hydrogeomorphic landforms demarcated in the study area are Moderate, Moderately Dissected, Slightly Dissected, Undesecated and Weathered. Slightly Dissected comprise gently undulating plains covered with weathered basalt materials, and are the most

favourable zones for groundwater accumulation and movement (Figure 5 and 6). The groundwater storage depends upon the thickness of the weathered material and the soil cover. On satellite images, they have a yellowish-red colour and coarse texture. Slightly Dissected are covered by thick vegetation and are characterized by low-lying flat terrain.
On the basis of thickness and composition of weathered material, the Slightly Dissected have been classified into Shallow weathered buried Slightly Dissected and moderate weathered buried covered with black soils most of the area cover under shallow pediplans hence this landform classified as moderate to good groundwater accumulation zones.

Thin Alluvial deposits are also observed close to drainage channels and having highly porous and permeable alluvial deposits hence are characterized as ‘moderate’ zone for groundwater accumulation in upper level for dug well construction.

Moderately dissected and undesecated are the massive hills with resistant rock bodies that are formed due to differential erosion and weathering processes. On the satellite image, these landforms were identified by dark brownish red colour due to thick forest cover. These hills are characterized by high surface runoff and are categorized as poor groundwater prospect zones.

Forms of Fluvial Origin

The landforms of fluvial of origin can be broadly divided into three types viz. Alluvial plain (AP), Older Alluvial plain (OAP) and Younger Alluvial plain (YAP). An alluvial plain is a relatively flat landform and created by the deposition of highlands eroded due to weathering and water flow in study area. The sediment from the hills is transported to the lower plain over a long period of time.

It identified on the imageries dark reddish moderate to fine texture due to agriculture activities. Alluvial deposits of the area constitute gravel, sand, silt or clay sized unconsolidated material. The alluvial plain consists of gravel, sand, silt and clay, material of varying lithology, which was formed by earlier cycle of deposition of alluvium by major river system.

This unit is characterizing by nearly flat and undulating surface. The older alluvium plain consists of predominantly gravel, sand, silt and clay material of varying lithology which is formed by earlier cycle of deposition showing flat and gentle undulating surface whereas the younger alluvial plain is characterized by the presence of predominantly gravel, silt and clay matter formed by late cycle of deposition. The overall groundwater prospect in this landform is excellent (Figure 5 and Figure 6) having thin 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 vegetative cover. Denudational hills occupying southern portions of the study area. The groundwater prospect in this region is poor due to the presence of massive lava flows, whereas, the denudetional slope consists of moderately sloping region consisting of weathered and fractured lava flows showing moderate prospect of groundwater.

Forms of Structural Origin

Structural hills are representing the geologic structures such as bedding, joint, lineaments etc. The landforms of structural origin consist of moderately dissected plateau (MDP) which is characterized by basaltic plateau with moderate dissection forming moderately high hill upland and may be crisscrossed by fractures, joints and lineaments.

This landform contains deep valley gullies with gentle sloping land developed due to river erosion on the plains. This landform can be further divided into three different zones viz. runoff zone recharge zone and storage zone the runoff zone is characterized by the presence of moderately dissected plateau consisting of very thin soil cover with altered and fractured rocks showing moderate groundwater resources. Whereas the storage zone is dominated by weathered and fractured area with thick soil cover showing good potential for groundwater resource development (Figure 6).

Forms of Denudetional Origin

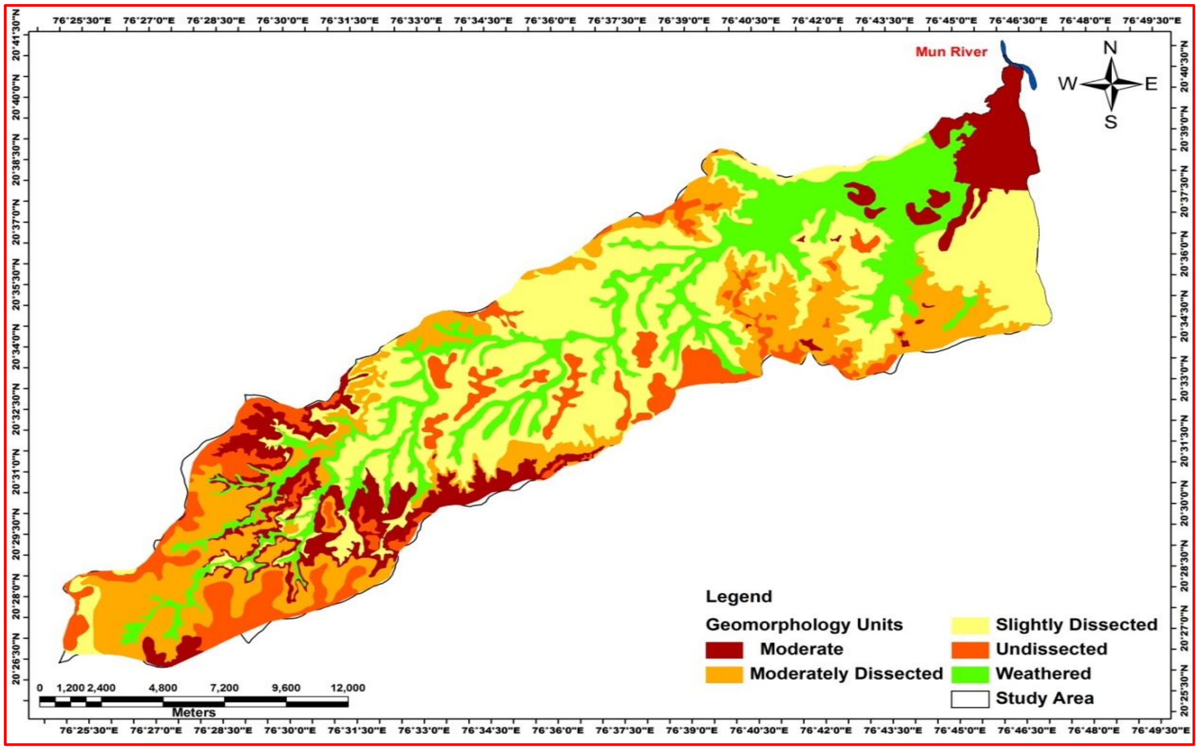

Figure 5: Hydro-geomorphology map of Mahesh River Basin (Level-3)

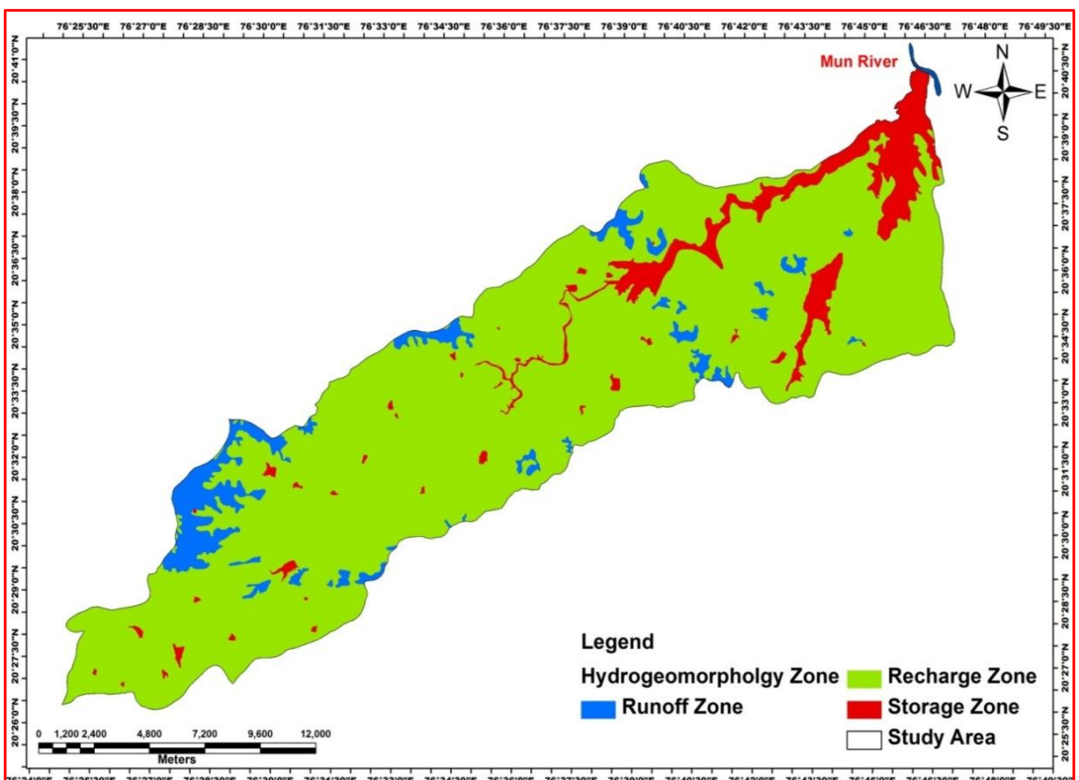

Figure 6: Hydro-geomorphology Zone map of Mahesh River Basin

Landforms of denudetional origin can be grouped into denudation hill (DH) and denudetional slope (DS). Denudational hills are the massive hills with resistant rock bodies that were formed due to differential erosional and weathering processes. These hills are composed of basaltic rock of Deccan Trap.

Conclusion

GIS and remote sensing applications have proved to be indispensable tools in decision making in the case of problem involving watershed conservation because of the enormity of spatial data involved. In this present study, illustration of how we can benefit from remote sensing and GIS technologies in watershed management and planning. Watershed management is the process of creating and implementing plans, programs, and projects to sustain and enhance watershed functions that affect the plant, animal, and human communities within a watershed boundary. The Present study of Mahesh River Basin and its surrounded physiographic conditions reveal a variety of hydrogeological and hydro-geomorphological complexity which are controlled and managed by variety of geo-factors primarily hydro-geomorphology, geological conditions and topographic variation. In present study of Remote Sensing based hydro-geomorphological evaluation and interpretation of different units shows the primary level of prospect for groundwater resources evaluation and management using satellite data. The hydro-geomorphological units such as Slightly Dissected are prospective zones for groundwater exploration and watershed development in the study area.

Slightly Dissected and Moderately Dissected are used for better water management plan for construction artificial recharge structures. The remote sensing data combined with field survey data can provide a unique and hybrid database for optimal planning and management of watershed. Space borne remote sensing technology is a unique tool to provide spatial, multi-spectral and repetitive information for effective planning. The landforms along with slope gradient and relief intensity are other parameters to determine the type of water harvesting and water conservation structures. The methodology may be useful in formulating effective groundwater exploitation strategies and predictive groundwater development and management. The results obtained can be used for sustainable management of groundwater resources in the area in terms of artificial recharge.

REFERENCES

Blair Schoene, Kyle M Samperton, Michael P Eddy, Gerta Keller, Thierry Adatte, Samuel Bowring, Syed FR Khadri and Brian Gertsch (2015). U-Pb geochronology of the DeccanTraps and relation to the end-Cretaceous mass extinction. *Science*, Five year Impact Factor: 34.40, ISSN No: 0036-8075, American Association for the advancement of Science (USA) **347**(6218) 182-184, DOI:10.1126/science.aaa0118.

Brunner P, Hendricks FHJ, Kgotlhang L, Bauer-gottwein P and Kinzelbach W (2007). How can remote sensing contribute in groundwater modeling. *Hydrogeology Journal* **15** 5-18.

Imran AD, Sankar K Dar and Mithas A (2011). Deciphering groundwater potential zones in hard rock terrain using geospatial technology. *Environmental Monitoring and Assessment* **173** 597–610.

Jasmin I and Mallikarjuna P (2011). Satellite-based remote sensing and geographic information systems and their application in the assessment of groundwater potential, with particular reference to India. *Hydrogeology Journal* **19** 729–740.

Jha MK, Chowdhury A, Chowdary VM and Peiffer S (2007). Groundwater management and development by integrated RS and GIS: prospects and constraints. *Water Resource Management* **21** 427–467.

Khadri SFR and Chaitanya B Pande (2014). Remote Sensing and GIS Applications of Geomorphological Mapping of Mahesh River Basin, Akola and Buldhana Districts, Maharashtra, India using Multispectral Satellite Data. *Indian Streams Research Journal*, ISSN: 2230-7850 **4**(5).

Khadri SFR, Chaitanya Pande and Kanak Moharir (2013). Geomorphological investigation of WRV-1 Watershed management in Wardha district of Maharashtra India, using Remote sensing and Geographic Information System techniques. *International Journal of Pure and Applied Research in Engineering and Technology*, ISSN: 2319-507X **1**(10) Manuscript no: IJPRET-76.

Leblanc M, Favreau G, Tweed S, Leduc C, Razack M and Mofor L (2007). Remote sensing for groundwater modelling in large semi-arid areas: Lake Chad Basin, Africa. *Hydrogeology Journal* **15** 97 - 100.

Machiwal D, Jha MK and Mal BC (2011). Assessment of Groundwater Potential in a Semi-Arid Region of India Using Remote Sensing, GIS and MCDM Techniques. *Water Resource Management* **25** 1359–1386.

Singh Prafull *et al.*, (2011). Groundwater resource evaluation in the Gwalior area, India, using satellite data: an integrated geomorphological and geophysical approach. *Hydrogeology Journal* **19** 1421–1429.

Singh Prafull *et al.*, (2012). Assessment of Groundwater potential zones of a hard rock terrain using Geospatial tools. *Hydrological Science Journal*.

