# Groundwater Potential Zone Mapping of Kaliyasot And Kerwa Watershed Of Upper Betwa River Basin (M.P.), Using Remote Sensing And GIS

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*Abstract :* For integration of water resources and urban planning, it is prime requisite to know the groundwater potential sites, surface water availability and quality of water resources available or to be available for the population of the area. Urban planner must consider the fact that requirement of quality and quantity of water is different for various sectors like residential, commercial and industrial of urban area. As stated earlier there are two ways to fulfill the need of population of any town; one is groundwater and second is surface water.

Now days the dependency for water requirement is increased on groundwater because of limited availability of surface water resources for domestic and other uses. People fulfill their need either through bore well, hand pump or by wells. Groundwater is one of the most valuable natural resources, which supports human health, economic development and ecological diversity. Because of its several inherent qualities it has become an immensely important and dependable source of water supplies in all climatic regions including both urban and rural areas of developed and developing countries (M.L.Waikar et al, 2014). Groundwater potential zone mapping is done using integration of various parameters responsible and indicator of groundwater recharge sites. Groundwater potential zones are identified in the study area for integration with other layers to obtain optimum sites for urban planning and development. Groundwater potential zones are delineated on the basis of some thematic layers like Lithology, geomorphology, soil, landuse, lineaments, slope and drainage of the study area.

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***Index Terms* - Remote sensing, GIS, Weighted overlay, Landsat.**

## I. INTRODUCTION

Groundwater is considered as the preferred source of water for meeting domestic, industrial and agricultural requirements, due to its longer residence time in the ground, low level of contamination, wide distribution, and availability within the reach of the consumer. Hence, development of ground water gets first priority, both at individual as well as governmental level, for different uses. However, the occurrence and distribution of ground water is not uniform throughout the country and is subject to wide spatio-temporal variations depending on the underlying rock formations, their structural fabric and geometry, surface expression, etc. Groundwater is a major source for all purposes of water requirements in India. More than 90% of rural and nearly 30% of urban population depend on it for drinking water.

The occurrence and distribution of the ground water is not uniform throughout the country and varies significantly based on geology, rainfall and geomorphology. India is a vast country comprising of diversified geology, topography and climate. The prevalent rock formations range in age from Archaean to Recent and vary widely in composition and structure. Similarly, the variations in the landforms are also significant. They vary from the rugged mountainous terrains to the flat alluvial plains of the river valleys, coastal tracts and the aeolian deserts. The rainfall pattern also shows similar region-wise variations. The topography and rainfall virtually control runoff and ground water recharge

There is an inherent linkage between development and management of ground water resources. For an effective supply side management, it is essential to have full knowledge of hydrogeological controls which govern the yields and behavior of ground water levels under abstraction stress. The effects of ground water development can be short term and reversible or long term and quasi-reversible which require a strong monitoring mechanism for scientific management. There is a need for scientific planning in development of ground water under different hydrogeological situations and to evolve effect management practices. Demand driven development of ground water resources by different user groups without any scientific planning and proper understanding of the behavior of local ground water regime, leads to sharp depletion of the resources and also degradation of quality. Signals of mismanagement of ground water resources are seen in areas where ground water extraction rate has exceeded the natural recharge. Ground water management has become the foremost challenge for the Organizations dealing with ground water in India. The activities of the Organizations and policies affecting ground water need to reflect the priority issues with the overall objective to provide water security through ground water management. Therefore, a comprehensive and a reliable scientific database on ground water for the entire country is a pre-requisite for proper management of ground water resource in the areas where it is over-exploited and for planning its optimum development and effective utilization in hitherto unexploited areas. (NRSA,2008)

For integration of water resources and urban planning, it is prime requisite to know the groundwater potential sites, surface water availability and quality of water resources available or to be available for the population of the area. Urban planner must consider the fact that requirement of quality and quantity of water is different for various sectors like residential, commercial and industrial of urban area. As stated earlier there are two ways to fulfill the need of population of any town; one is groundwater and second is surface water. Application of GIS and RS can also be considered for multi criteria analysis in resource evaluation and hydrogeomorphological mapping for water resource management.

Now days the dependency for water requirement is increased on groundwater because of limited availability of surface water resources for domestic and other uses. People fulfill their need either through bore well, hand pump or by wells. Groundwater is one of the most valuable natural resources, which supports human health, economic development and ecological diversity. Because of its several inherent qualities it has become an immensely important and dependable source of water supplies in all climatic regions including both urban and rural areas of developed and developing countries (M.L.Waikar et al, 2014). Groundwater potential zone mapping is done using integration of various parameters responsible and indicator of groundwater recharge sites. Groundwater potential zones are identified in the study area for integration with other layers to obtain optimum sites for urban planning and development. Groundwater potential zones are identified in the study area for integration with other layers to obtain optimum sites for urban planning and development. Groundwater potential zones are delineated on the basis of some thematic layers like Lithology, geomorphology, soil, landuse, lineaments, slope and drainages of the study area.

## II. STUDY REA

### 2.1 General

The Region lies between the Latitudes 23° 02′ 16" to 23° 14′ 45" N and Longitudes 77° 17′17" to 77° 34′55" E and covering an area around 364.40 Sq. km . The study area is lying mainly in the southern part of the Bhopal district and very little part in Raisen and Sehore District of Madhya Pradesh. The study area lies mainly in Huzur Tehsil of Bhopal District. The northeast and eastern boundary shared by Vidisha and Raisen district. Rajgarh and Sehore districts lie on the Western and southwest boundary of the region and Guna district form Northern boundary, these districts are interconnected with each other and also linked with neighboring districts through rail and national and state highways. The Study area is drained by the Kaliyasot and Kerwa rivers which are the tributaries of Betwa river. The Betwa flows along the southern boundary separating from Raisen District of Madhya Pradesh. The annual precipitation effectiveness of the study area is 63.7 cm.

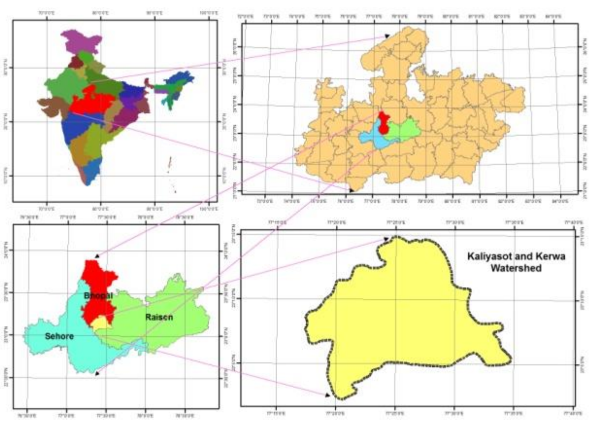



*Figure 1 :Location Map of The Study Area*

### 2.2 Geology

Geology of the study area varies from Quaternary Alluvium to Upper Proterozoic Sandstone. The maximum portion of study area is covered by Alluvium and Soil in the North east ,south east and central portion and some part by Unclassified alluvium. Laterite is seen as isolated cappings over the Deccan Trap above 500 msl in the north west and central part. Weathering and accumulation of fragments of laterite and subsequent consolidation has given rise to secondary laterite at places. Three Basaltic Flow of Indore formation is trending from north west to north east direction and Aa And Compound Basaltic Lava Flows(5 Flows) of Kankariya Pirukheri formation in the south west central portion which is underlain by lower Bhander sandstone. Sirbu Shale is found in the contact of upper and lower Bhander sandstone in central portion. The Upper Bhander Sandstone is found in north, north west, south east , east and central portion. Upper Bhander Sandstone is trending from north west to southwest direction. The upper Rewa sandstone is found at southwest and northwest portion of the study area.

### 2.3 Geomorphology

The geomorphic features and landforms present in the study area are mainly divided into Denudational and Structural Landforms. The genetic based classification system has been adopted for mapping the landforms using satellite data and digital elevation models and Survey of India toposheet for height perception. The Structural landforms comprises of Homocline and Cuesta and Scarps. The Denudational landforms are mainly Pediplain, Residual mound and Pediment. The other landforms are formed due to anthropogenic activity such as active quarry (mining). Almost half portion of the study area is covered by Pediplain in northwest, central, eastern and south eastern part. The south-western part is covered by a large Homocline dipping towards eastern and having scarps in the centre as well as on western margin. The Cuesta are present in the NNW and SSE direction. Plateau Remnants are present in north to north west and NW direction and also residual mound in NW portion. Under the anthropogenic terrain there is some mining activity classified as active quarry in SW direction and the other are kaliyasot and kerwa Dam and reservoir.

### 2.4 Soil

Soil in the present study area have Classified as fine, loamy, loamy skeletal, clayey and sandy. Rest of the area is covered by waterbodies ,builtup and mining area. The soil of the area show variation in colour and texture they are light black to dark black, alluvium, red mixed soil, black soil and brown soil. The area covered with alluvium soil have high clay content high plasticity and high moisture retention and water retention capacity the fine soils are restricted to pediplains while pediments and structural hills are occupied by loamy and loamy skeleton soil.

## III. DATA SOURCES

Georectified Landsat-8 OLI data for the year 2015 were used for the thematic layer generation such as geology, geomorphology, landuse etc.. OLI has 30 spatial resolution for 8 multispectral bands and one band is panchromatic having spatial resolution of 15m data were used in this study. Apart from the space-based data, ancillary data such as Topographic map on 1:50,000 scale with a 20 m contour interval and District Resource Map (GSI) on 1:250,000 were also used in this study. Contours were also generated from Topographic sheets.

## IV. METHODOLOGY

The method adopted for identification of groundwater potential zones involves various steps and stages like digitization , thematic mapping analysis etc. in the first step the satellite data and SOI toposheets were georeferenced. The drainage is digitized from toposheet and landuse landcover map were prepared using the unsupervised classification technique. The geology map was prepared from satellite data and reference was taken from district resource map published by GSI. Geomorphology , lineament and soil map was also prepared using the satellite data.

The second stage involved preparation of digital elevation model (DEM) by interpolating contour map that is digitized from SOI toposheet. In turn DEM is prepared to generate slope map.

All thematic layers are assigned theme weight and class weight to each class which is converted into reclassified raster layer. Raster layers of each theme are used for overlay analysis in Arc GIS. During weighted overlay analysis, a rank was given for each individual parameter of each thematic layer map.

Groundwater potential zones are delineated on the basis of some thematic layers like Lithology, geomorphology, soil, landuse, lineaments, slope and drainages of the study area.

The composite groundwater suitability is calculated using following formula:-

$$\boldsymbol{GWP = LUwt * LUCwt + GMwt * GMCwt + LTwt * LTCwt + DDwt * DDCwt + SOILwt * SOILCwt + LDwt * LDCwt + SLwt * SLCwt}$$

Where, GWP=Groundwater prospect, LUwt=Landuse theme weight, LUCwt=Landuse class weight, GMwt=Geomorphology theme weight, GMCwt= Geomorphology class weight, LTwt= Lithology theme weight, LTCwt= Lithology class weight, DDwt= Drainage density theme weight, DDCwt= Drainage density class weight, SOILwt= Soil theme weight, SLCwt= Soil class weight, LDwt= Lineament density theme weight, LDCwt= Lineament density class weight, SLwt= Slope theme weight, SLCwt= Slope class weight.

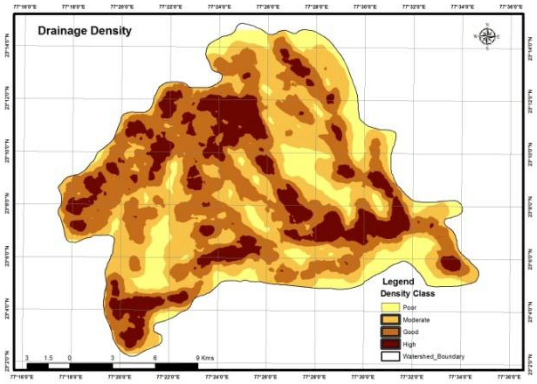



*Figure 2:Drainage density Map of The Study Area*

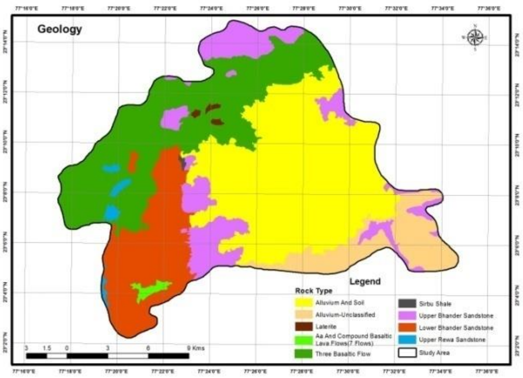
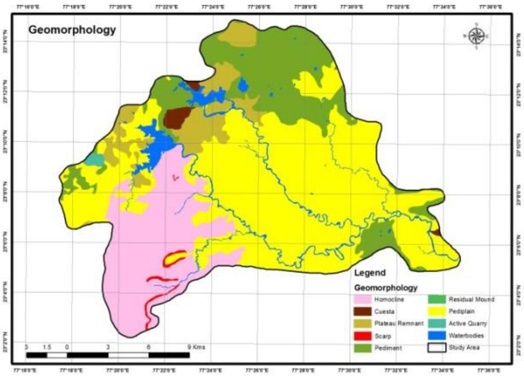



*Figure 3 :Geoloy Map of The Study Area*



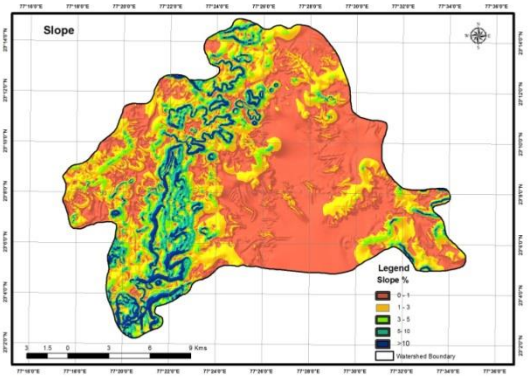
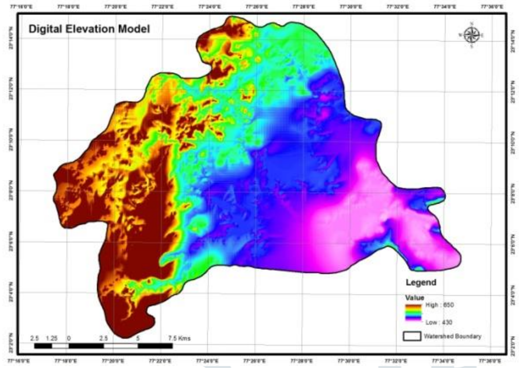




*Figure 4:Geomorphology Map of The Study Area* *Figure 5 :Slope Map of The Study Area*



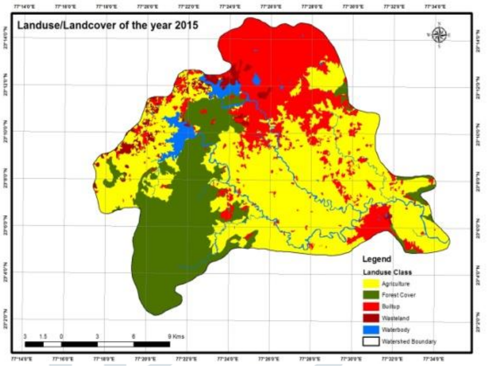




*Figure 6 :DEM of The Study Area* *Figure 7 :Landuse Map of The Study Area*

Five groundwater potential zones are categorize for basis of weightage overlay analysis of all above parameters.
The weight value denotes-
1-2= Very poor
3-4= poor
5-6= moderate
7-8 =good
9= excellent

## V. HYDROGEOLOGICAL FACTORS IN RELATION TO GROUNDWATER PRODUCTIVITY (Domingos Pinto et al.2015)

Table No 1: Factors controlling groundwater potential

| Category | Hydrogeological factor | Description |
|---|---|---|
| **Topology** | Drainage Density | Drainage density is an inverse function of permeability, and therefore an important parameter in evaluating the groundwater zone. High drainage density values are favourable for runoff, and hence indicate a low groundwater potential zone |
| | Slope | Slope is also important factor as high value slope area is low groundwater potential zone. |
| | Topography | Low land area is more suitable for groundwater recharge and creates a good potential zone. |
| **Satellite Image** | Lineament Density | Structures are the rock failure and deformation created by the changes in stress over time. Lineaments, faults, and fractures are important linear structures for increasing the permeability of the bedrock |
| **Soil** | Soil Texture | The soil texture property is considered for groundwater infiltration. |
| **Geology** | Lithology | Basaltic lava flow is delineated in study area, it also play an important role. |
| | Geomorphology | Alluvial plain is more identical for groundwater recharge. |
| **Landuse/ Landcover** | Landuse Class | Five class of level I are delineated in the study area. |

The influence of slope will have a remarkable effect on the infiltration of surface water from the ground. A low slope percentage indicates that the surface water received mainly because of precipitation will have more time to remain on the ground surface and percolate into the subsurface. In case of highly sloping areas, the run-off is more immediate offering less retention time for the water on the ground surface and significantly reduces the groundwater recharge potential (S. P. Rajaveni et al, 2015). Land use / land cover features control the occurrence of groundwater and also causes for infiltration for recharge, with variety of classes among itself (Shivaji Govind Patil et al, 2014). lineaments reflect a general surface manifestation of underground fractures, with inherent characteristics of porosity and permeability of the underlying materials (Rao, 2006). These features serve as the main conditions for movement and storage of groundwater in impermeable rocks worldwide (Preeja, et al.2011). The drainage density is an inverse function of permeability. The less permeable a rock is, the less the infiltration of rainfall, which conversely tends to be concentrated in surface runoff.( N.S. Magesh, et al, 2012).

## VI. RESULTS AND DISCUSSION

Groundwater is one of the major sources of water where surface water is not available to meet various need of humankind. Groundwater potential zone delineation based on various thematic layer obtained from Remote sensing can help up to a great extent in this regard. Groundwater is mainly used for drinking purpose and industrial activities in urban areas. During urban planning the zones of good groundwater potential should be preserved and moderate zone are used for urban development. In present study very poor ,poor, moderate and good groundwater potential zones are demarcated. The region has dominantly falls in moderate groundwater potential zone.

Remote sensing and GIS and have found an effective and powerful tool and very fast and cost effective method for identification and mapping of groundwater potential zone. In the present study the integration of seven thematic layers such as land use/land cover ,soil, drainage density, slope, geology, geomorphology and lineament density were assigned the theme weight for each layer and in turn the weight to each class of the theme layer.

The very poor class is identified in the northern portion which is densely habited mainly built-up area of landuse and soil with having more slope in the study area and some part in the southern part near obedullaganj which is industrial area. The poor groundwater potential zone identified in western portion which is hilly and rugged area having more slope with homocline landform which in turn does not allow more surface water to percolate in the sub subsurface due to high runoff , northern portion is mainly the dense built-up area and south east portion which is industrial area of Raisen district. The moderate groundwater potential zone covers the maximum portion of the study area which is mostly comprises the pediplain, plateau and pediment landform having nearly gentle slope and mainly agriculture and wasteland area which in turn is also less or inhabited area. The good groundwater potential zone area is identified in mostly along the river and water bodies buffer zone area having less slope with pediplain geomorphology and agriculture landuse class.

There are four groundwater potential classes are identified in study area which are very poor groundwater potential zone, poor groundwater potential zone, moderate groundwater potential zone and good groundwater potential zone. Area covered by different classes is presented in table no 2.

Table No 2 : Groundwater potential zone statistics

| S.No. | Groundwater Potential Zone | Area (Sqkm) |
|---|---|---|
| 1 | Very Poor | 09.92 |
| 2 | Poor | 102.42 |
| 3 | Moderate | 13.54 |
| 4 | Good | 238.51 |
| **Total** | | **364.40** |

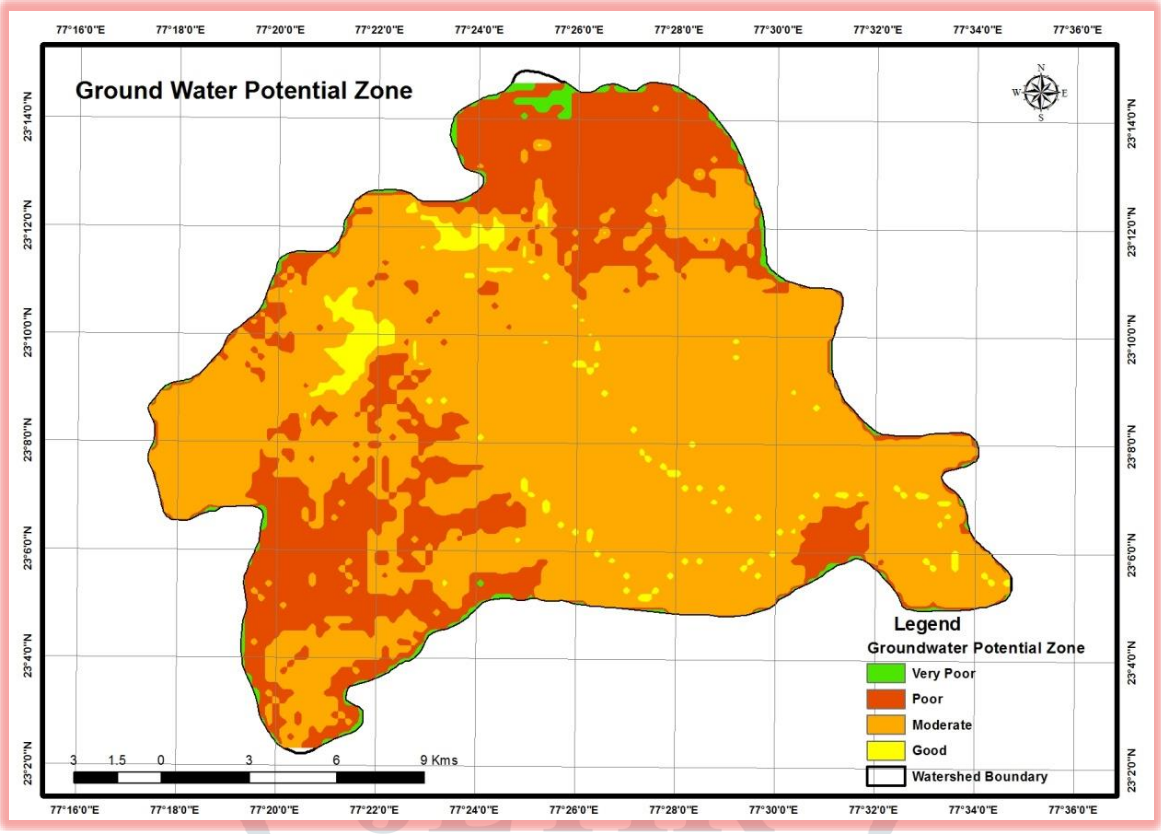



*Figure 8 :Groundwater Potential Zone Map of The Study Area*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