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Research Article

Development of Different Thematic Layers for the Identification of Artificial Groundwater Recharge Zone around Devi river, Odisha, Using Remote Sensing GIS and AHP Technique(MCDA)

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Abstract

Groundwater recharge zones in Devi watershed, Odisha, India, have been mapped for the first time as part of a study. The research was performed by delineating possible recharge zones in the Devi watershed utilizing geospatial techniques and a Geographical Information System. The factors used to estimate the Groundwater Recharge Potential Zone comprise lithology, geomorphology, drainage patterns, precipitation, soils, and land use-land cover (LULC). SRTM Digital Elevation Model (DEM) was used to obtain the slope. The Analytical Hierarchical Process (AHP) method is based on subjective approach in which weightages are assigned by pair wise comparison between various criteria obtained through policies by decision makers Saaty (1980). The Analytic Hierarchy Process (AHP) method calculates the required weights associated with the respective criterion map layers with the help of a preference matrix, in which all relevant criteria identified are compared against each other on the basis of preference factors then the weights are aggregated. GIS-based AHP has gained popularity because of its capacity to integrate a large quantity of heterogeneous data. This GWRZ statistics will be valuable in identifying optimal areas for water extraction in the research region. According to the groundwater prospective map, the SW parts of the territory have very poor, as does the SE part to some extent, while the majority of the land has good groundwater recharge possibilities. Moderate groundwater recharge are limited primarily to the North West terrain and population regions similarly some areas in E and SE parts showing very good possibilities of artificial recharge zone in the watershed.

Keywords: Devi River; Watershed; Groundwater recharge zone; RS; GIS; AHP Technique; MCDASS; Odisha

Introduction

For domestic, industrial, and agricultural needs, groundwater is the most desired source of water. The natural and available resources in an area determine the growth and survival of a population. Groundwater is unique among natural resources because it is required for the survival of living beings as well as the operation of various industrial and agricultural units. For the delineation of groundwater or its potential zone, various methods like geological methods and geophysical methods are used but though they are very expensive and hard to perform, Remote sensing (RS) and Geographical information system (GIS) are used for simple and quick methods in these areas. Industrialization is yet to take place in these districts. Therefore a study using the virtual data has been carried out in mapping the distribution of groundwater zones in the Mahanadi river basin covering the study area (Devi watershed) for the proper development of groundwater resource. Studies carried out in different places especially in Indian subcontinent indicates that more than half of the population depends on the groundwater as a result of it increasing demand than the surface water [7]. Even though, the surface water is utilizing for the domestic and agricultural activities, most of the industrial as well as agricultural areas interested to rely on the groundwater resources along with the surface water for the fulfillment of their demand. Various methods can be utilized for locating the groundwater potentials areas, which includes suitable and scientific methods such as specific geophysical, resistivity methods etc., demands high expenditure manpower and time [6, 7]. Therefore, the same can be resolved by applying the inexpensive methods such as remote sensing and GIS. Integrated application of both can give a rough idea about the groundwater resources of the area, which can validate with the field measurement, help to build a reliable result [7].

Objective of this paper

- After use of satellite data from multiple reliable sources and GIS techniques we have to create thematic maps such as Lithology, Geomorphology, LULC, Drainage Density(DD), slope, rainfall, water level, along with lineament.
- Then to reclassify each map with normalized weightage obtained from AHP technique, Demarcate map of the groundwater artificial recharge zone of the specified research region to be determined by overlaying all of the above mentioned thematic layers to identify various artificial recharge zones of the specific region.

Study Area Location

The area for study is located at Devi river which is located in between latitude 20°0'0" N to 20°20'0'' N, and longitude 86°0'0"E to 86°20'0" E fall in between Jagatsinghpur, Puri, and Cuttack district of Odisha, respectively and in the Survey of India Toposheets No. 73 L/4,73 L/8 and 74 I/5, with Tropical climate with annual rainfall of 1481 mm with average temperature 29°C, that supports the agricultural and socio economic lifestyle. The watershed covers an area of 740 sq.kms. Devi(One of Mahanadi's main distributaries) meets Bay of Bengal near Nuagarh and Mankadakhia in Puri and Jagatsinghpur district respectively.

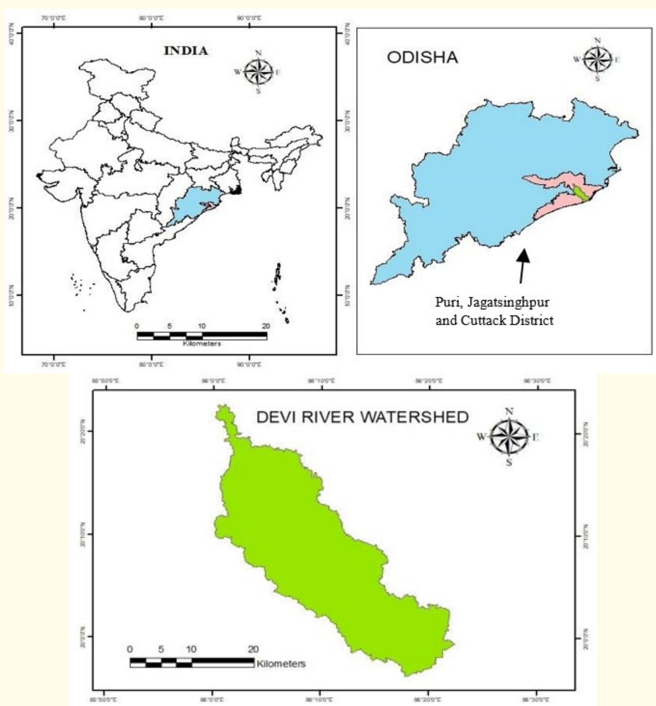


Figure 1: Study Area Location.

Devi-River Watershed

This river bed area is made up of Alluviums, Lateritic patches, Sand, silt, clay which has been mainly secondary transported sedimentary rocks. Devi river is flowing mainly in Jagatsinghpur and Puri district of Coastal Odisha, India (Fig:1).

As Kathajodi river, the prime southern distributaries of Mahanadi river branching off at Cuttack, Odisha so, Devi river originates near Gopalpur, Cuttack. (Kathajodi river later acquires the name Devi as it flows further east.). The river basin is made up of older alluviums and laterite rich soil and deltaic alluvial soils belong to this group and occupies major parts of the area. Deltaic soils in this area are generally poor in P2O5 and N2. K2O are quite enough, and pH ranges between 6.5 and 7.3 [13] (www.cgwb.gov.in). These soils, which are limited to the Krushnaprasad and Astarang blocks, often sustain rice cultivation together with salty sodic soils located along the shore. It occurs along the course of the Devi River in the Astarang block. These soils are rich in calcium and magnesium, making the area particularly fruitful from an agricultural standpoint. The yearly temperature ranges from 9 to 41 degrees Celsius. From June through September, around 75% of the total rainfall is obtained. Flooding is a typical occurrence in the region. Because it is mostly influenced by the irregular southwest monsoon [4].

Geology

The lands under the watershed are mostly fluvio-lacustrine sedimentary formations of the Gondwana super group along the grabens that have evolved in the river valleys. Various river systems deposited recent to subrecent sediments to create up deltas at river mouths, which combined to form the narrow coastal strip (http://cesorissa.org/). The alluvium and sand of this area are massive with better porosity and permeability. Intensity of weathering is higher in the plain area that covers 95% along the river coast. The Borewell are generally having depth 60-150m with less than (<)5 probable yield tapping weathered and vesicular zones, It is noticed that the yields of the wells drastically get reduced in summer months from first half of March up to Mid-June.

Data used in preparation of Thematic layers

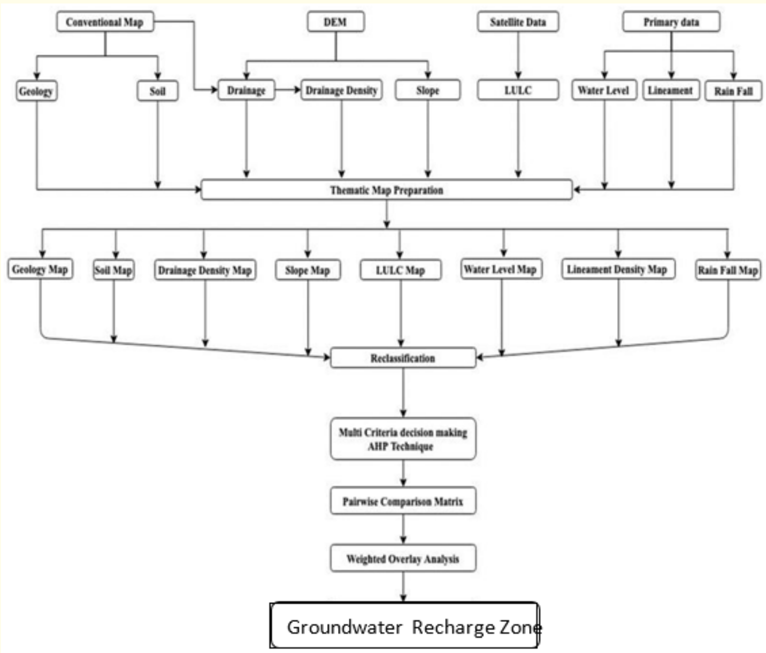
ArcGIS and QGIS are the GIS programs that were utilized to create all of the thematic layers. The drainage and slope maps were created using SRTM DEM information from the satellite. The source of data is described below (Table-1).

Sl. NO	*Thematic Layers*	*Data Source*	*Application USED*
01	SLOPE	DEM DATA (https://earthexplorer.usgs.gov)	ArcGIS
02	RAINFALL	INDIA WRIS (https;//indiawris.gov.in)	ArcGIS
03	LITHOLOGY	BHUKOSH,GSI (https://bhukosh.gsi.gov.in)	ArcGIS
04	GROUNDWATER LEVEL	INDIA,WRIS (https;//indiawris.gov.in)	ArcGIS
05	DRAINAGE DENSITY	DEM DATA (https://earthexplorer.usgs.gov)	ArcGIS
06	LINEAMENT BUFFER	BHUVAN-NRSC (https://bhuvan.nrsc.gov.in)	ArcGIS
07	LANDUSE AND LANDCOVER	SENTINEL-2 DATA, (https://earthexplorer.usgs.gov) ESRI Landcover (https://livingatlas.arcgis.com/)	ArcGIS
08	GEOMORPHOLOGY	BHUKOSH,GSI (https://bhukosh.gsi.gov.in)	ArcGIS

Table 1: The Source of Data of Thematic Layers.

Methodology

The following layers were produced and used in the current investigation to discover optimal recharging sites. The GIS study was carried out with the help of ESRI Inc's ArcGIS 10.3 and QGIS 3.20.2 software. Data from the aforementioned sources were used to map the GWRZs in the target area. Integration of the required methodologies aided in the charting of data, which was followed by the creation of theme layers. Demarcation of the study area i.e. the Devi watershed was created through Google Earth Pro and then saved as KML file in system. Earth Explorer or USGS Earth Explorer [http://earthexplorer.usgs.gov]data in tiff type file and Sentinel-2 data (Specifically data from zero cloud cover) collected by using Earth Explorer or USGS EE [http://earthexplorer.usgs.gov]. Mapping and integration of eight thematic layers were completed by using GIS Platform, specifically Arc GIS mentioned above.



Flow chart: Representing the Methodology

Thematic layers like Lithology, Geomorphology, and Landforms were produced from http://bhukosh.gsi.gov.in. The DD(Drainage Density) map then created from DEM(SRTM) data with Arc GIS 10.3 map. Then data processing with the help of spatial analyst tool, followed by the line density tool. A portion of the slope map was completed as well. SRTM data was used to create the drainage layer. From The Geological Survey of India, the geology map. The GW density map and rainfall map of the region were disguised out of real rainfall data (2020-21) from http://indiawris.gov.in/wris/. ArcGIS 10.3 was used to create the drainage density, which was done with the spatial analyst tool and the polyline density tool. The surface tool caused the slop. Then both datasets were being processed by IDW interpolation tool. Then Lineament map was being prepared from the thematic services of BHUVAN by using http://bhuvan.nrsc.gov.in. Then there's the LULC map. Arc-GIS 10.3 map is used to analyze LANDSAT data from http://livingatlas.com/landcover. We must project the data in the World Geodetic System (WGS) 1984 and the Universal Transverse Mercator (UTM) Zone in order to retain the accurate data projection. (44,45, it might be according to the research area covering).

Result and Discussion

Thematic Layers

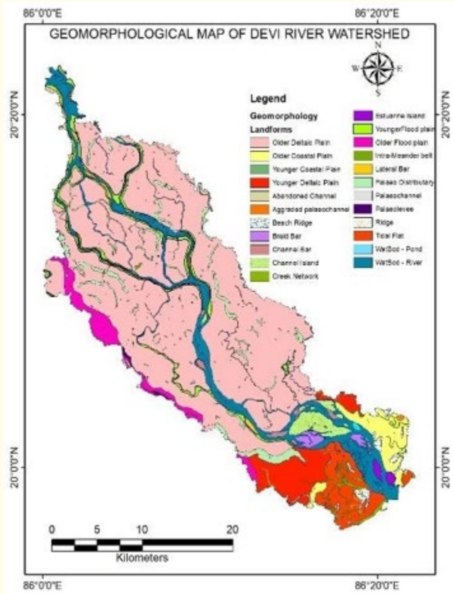
Thematic layers that play significant role for groundwater occurrence and management of aquifer system in study area are as follows;

The Geomorphology Map

The major rivers flowing in this area are The Devi, The Kushabhadra, and The Prachi. Geomorphology is the systematic study of topographic features and landforms formed by various geomorphic agents through time. The area comprising Devi river has near to plain/flat topography. The Prachy and Kushabhadra Rivers are distributaries of the Kathajodi River, while the Devi River, which is a portion of the Kathajodi, is one of the Mahanadi's primary distributaries (The main southern distributary of The Mahanadi). Dendritic drainage has been observed only in the major parts where alluvial deposits or thick soil cover is present. The soil of the area is underlain by partially degraded sedimentary rock which overlies the base of the area. This site's Quaternary formation contains lateritic soils and alluvium, while laterite is only found on the site's western and north-western edges, and alluvium of varying thickness covers the majority of these districts. [www.cgwb.gov] Laterite pitches are generally 7.5 to 10 meters thick. [in] The older alluvium soil is often apparent in the north-western parts, along with a sequence of sand, clay, and grey-to-brown kankars. The newer alluvium is found in floodplain deposits along main stream routes, accounting for 85-90 percent of the land. These are sediments with varying amounts of silt, sand, gravel, and pebbles in them. The layers thicken as you come closer to the Bay of Bengal, revealing a steady decline. This watershed (Fig: 2) constitute a number of geomorphological features like older deltaic plain, channel bar, channel island, younger flood plain, ridge, tidal flat, paleochannel, paleo-distributary, beach ridge, estuarine island, braid bar, younger coastal plain, older and younger floodplain, water bodies(pond, river) and many more. (according to the Bhukosh- Geological survey of India classification schemes). The coastal plain is the delta area which is highly fertile. Elevated region of sediment that has been deposited by the flow known as channel bar. Types of bars include braid bars, point bars. The newer, younger deposits of the flood plains are called khadar same as the older deposits are called Bhangar, composed of loose sedimentary deposits (alluvium) and subject to periodic flood by the stream. A partially enclosed coastal body of brackish water known as estuarine island forms a transition zone between river environments and maritime environments of the region. It is found that the older flood plains and channel bar may be the last stage of landform deposits, As a result of the processes of erosion, thus serving as a good potential for groundwater. water bodies are lakes, ponds, streams and rivers which can act as good recharging zones [7, 8, 12], hence artificial recharge zone should be neglected in such areas as geomorphology here shows higher potential zones of groundwater hence no need of artificial recharge in most of the area.

The Lithology Map

Lithological study has a variable lithology that have a major role to control the presence of groundwater. As it represents a delta type environment here more sediments accumulate rather than rock mass. The study area does not have much variation in lithology. The area (Fig:3) as a whole is monotonously covered by Sand, Silt, Clay and Gravel with some Compact clay with caliche nodules covered by a thin mantle of soil almost everywhere that results in a flat eroded surface all around. The fine grained grey sand and clay with gravel flows constitute the flood plains in the area. Compact clay with Caliche found on the border part of the watershed. They usually contain eroded parts of rocks of transported origin and indicate the periods of no volcanic activities since a long period.



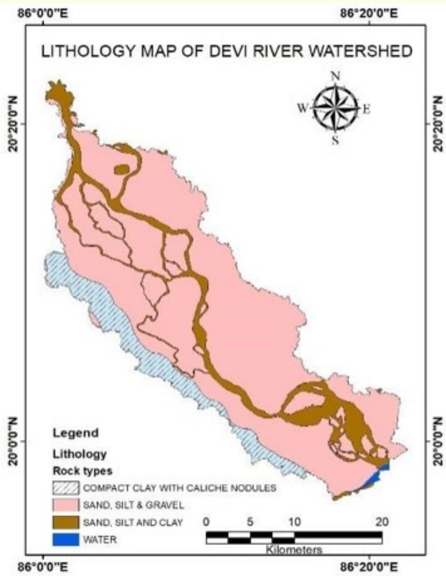


Figure 2: Geomorphology of Devi Watershed. ***Figure 3:*** Lithology of Devi Watershed.

There are size variation in sand grade and There is also a gradual variation in Groundwater yielding under the surface. The groundwater reserve in the district is not entirely dependent on the amount and distribution of rainfall, as some part is conserved from the river itself too, hence high potential zone and low possibilities of artificial recharge zone is to be noted around this area. Hence these zones can be categorized under low recharge zones.

The Land use & Land cover (LULC) Map

The storage, discharge and infiltration of groundwater, depending on the different land use patterns, are some of the key factors considered by researchers at the University of Bristol.

The LULC (Fig:4) of the Devi river watershed may be categorised into seven types: water bodies (river/canals/ponds), vegetation cover, grassland, agricultural land, scrubland with river sand, and settlements. With the help of Sentinel-2 data and Arc-GIS software land use and landcover map is being prepared and processed too Based on the field data, topological maps, and IRS LISS 1B FCC, a LULC map was created. The conventional false color composite produced by projecting bands 1, 2, and 3 on blue, green, and red offered important information on flora, water bodies, land usage, land cover, rock kinds, and structure [9]. Land usage and land cover represent the area's numerous man-made and natural features, as well as the successful exploitation of land for various purposes. Consideration of such factors is significantly more relevant since it can indirectly regulate the research region's runoff/infiltration capacity [7]. The agricultural land regions are known to have covered ~75 percent of land, followed by the water bodies (river, ponds, canals etc.) ~19% followed by shrubland and settlement respectively. Land Use/Land cover patterns provide information about infiltration and runoff, which are controlled by the nature of surface material. Remote sensing was used to identify land use patterns such as built-up, agricultural land, and bare ground. The ranks were assigned to each LULC type based on its unique characteristics that influence groundwater recharge, retention, and occurrence. Hence with areas having low potential zones there needs artificial recharge zones to avoid groundwater depletion. Information about infiltration, soil moisture, and vegetation can be found in the land use and soil section.

The Rainfall Map

Rainwater is the primary source of groundwater recharge as well as all hydrological processes. The India-Water Resources Information System (India-WRIS)[http://indiawris.gov.in/wris/] publishes annual precipitation statistics. for yearly rainfall statistics from the study region's rain gauge stations [3]. The rainfall map (Fig:5) has been categorized into five classes of rainfall zones(in mm) namely, (1)1,676.64-1,711.88 (2)1,711.88-1,747.12 (3)1,747.12-1,782.36 (4)1,782.36-1,817.60 (5) 1,817.60-1852.84.

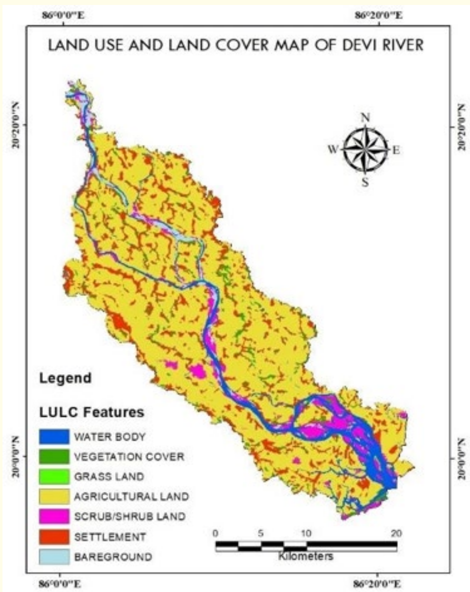


Figure 4: LULC of Devi Watershed.

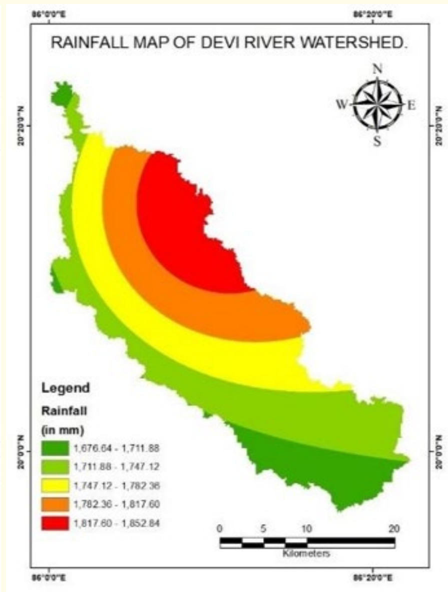


Figure 5: Rainfall Map of Devi Watershed.

From the rainfall map it is found that the annual rainfall is more as compared to high elevated areas and is generally more during deep depression in the coastal region of Odisha. Rainfall may vary from one region to another region. Rainfall distribution data for multiple years is gathered from rain gauge stations, and an IDW interpolation is utilized to estimate the concentration of rainfall which has been registered in the research region. Amount of recharge varies with rainfall as rainfall is the major source of groundwater availability. If the rainfall is high then groundwater is availability will be more, if rainfall is low groundwater availability will be less. Similarly areas with higher annual rainfall needs no development of artificial recharge zones until and unless the rainwater does not penetrate into the ground surface for some reasons. And lower rainfall regions need special attention about the development of artificial recharge zones.

The Groundwater Level Map

The groundwater level (Fig:6) ranges from 0.81-3.16 m bgl mostly. As a consequence, the region's subterranean flow is low to moderate. During the summertime, dug wells get dry, and boreholes suffer to pump water from specific depths.

The major part of the area is located near Devi river so any further ground water development to meet drinking water requirements can be suitable on a village to village basis. The diameter of the well can be 3.m to 6.m, so that the storage in the well can also be made use of in addition to the ground water. More to medium depth of the ground water level will provide more space for the storage, so due to availability of more space recharge will be more there. Water level has an inverse relation with recharge. Less depth of groundwater will have saturated zone above it at shallow depth. In the study area regions having 3.5-5m depth will have more potential to recharge.

With more depth of water level, areas need more attention for development of artificial recharge zone as over exploitation of water resulted lowering in groundwater level from the surface, in this map we can see SW part of the area is having more depth in groundwater level, which needs more attention regarding artificial recharge zone development.

The Lineament Map

Lineament is depicted as the tectonically produced linear and curvilinear features that represents geological structures underneath along with discontinuities like faults, fractures, joints, fissures, etc. Lineament-controlled terrains with an elevated porosity and permeability zone underneath them. Underground water presence is inherently related to lineament density mapping, which really is crucial for shallow groundwater management. Lineament, a linear feature on the earth's surface, is the interfacial reflection of the underneath geologic formation. Lineaments serve as prospective groundwater circulation routes, and their existence suggests favorable groundwater conditions. The existence of lineaments indicates the presence of a penetrable zone, and more dense lineaments in a region suggest good groundwater potential.

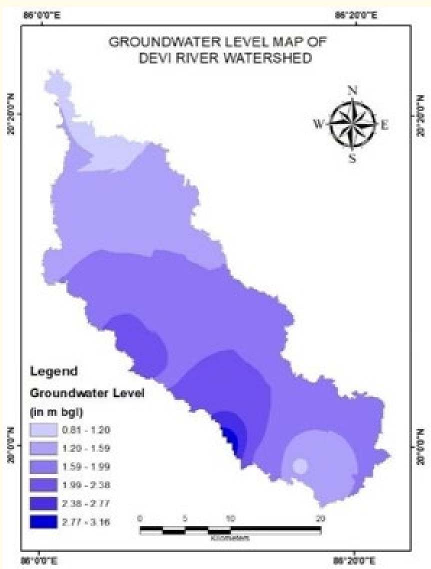


Figure 6: GW Level of Devi Watershed.

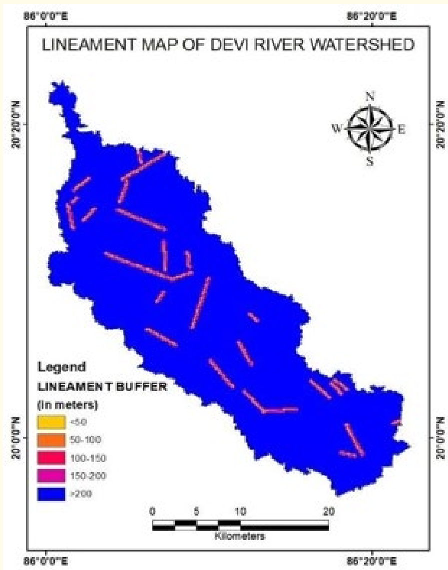


Figure 7: Lineament map of Devi Watershed.

The lineaments located there at research region's terrain in the northern portion (Fig:7) and with buffer zones that seem to be markers of the modulator of freshwater presence, with an increment in buffer zone area away from the lineament reduces the impact of lineaments on potential groundwater [7].

Lineaments are those linear features which provide suitable conditions for both the potential and recharge zone. More the amount of groundwater percolation, more will be the movement along linear features, hence more will be the recharge. In our study area the lineament density is quite moderate making this region suitable for ground water recharge [10].

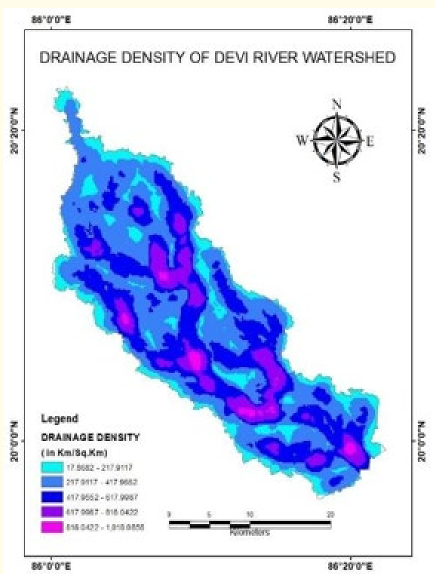
The Drainage Density Map

The DD (Drainage Densities) map was constructed via the use of Srtm dem using a line density evaluation technique and is associated to the soil water content and weight, which is designated low density and the inverse is allocated high density in Arc-GIS 10.3

Application. Because of the deltaic environment, the SE section of this study region is covered by a high drainage density. Because the underlying strata are more saturated when drainage density is high, more surface runoff rather than percolation occurs. More infiltration is seen on the low drainage density area, i.e. the NW side. The outflow systems in the studied region are predominantly dendritic and sub-dendritic [9]. The map (Fig. 8) illustrates the drainage parameters for the research region. Areas with low drainage density indicate comparatively higher infiltration, low runoff and higher the probability of recharge of groundwater zone. Here, maximum area is showing low to moderate drainage density which considered as the highest probability of recharge of groundwater zone. The high drainage density indicates the area comparatively medium to low infiltration, high runoff and having a lower recharge of ground water The drainage density map depicts 5 classes in terms of km/km2, ranging from Low a.(17.86-217.91) b.(217.91-417.95) c.(417.95617.99) d.(617.99-818.04) e.(818.04-1018.08) to High drainage density. The map used next for the utilization of characteristics like DD and DF (drainage frequency) [9, 11].

The Slope Map

Any terrain's gradient plays an important function in figuring out prospective zones in reference to groundwater, which can have a direct impact on infiltration rate. In order for water to permeate the subterranean environment, the inclination of any ground is critical. The moderate slope provides for slower runoff and more time for rainfall to percolate in this location, whereas the near vertical slope allows for rapid runoff and less time for rainwater to percolate. About 95 percent of the research area is covered by a moderate slope, indicating that groundwater recharging is very good in these places. The grades were assigned to the available slope classes based on their individual characteristics that influence groundwater recharge, retention, and occurrence. The geography of the region may reveal the area's infiltration state; for example, a gentler slope leads in more water penetration [7]. The research region's slope map (Fig. 9) was constructed using a DEM that was divided into three categories: 0-2 percent, 2-8 percent, 8-15 percent, and 15-30 percent. The slope components were separated into three groups based on the hydrological features of the watershed [9], using the slope vector map as a basis map. The classifications are as follows: (1) 2%; (2) 2%; (3) 2%; (4) 2%; (5) (2) 2%-8%, (3) 8%-15%, (4) 8%-15%, (5) 8%-15%, (6) (4) between 15 and 30%.



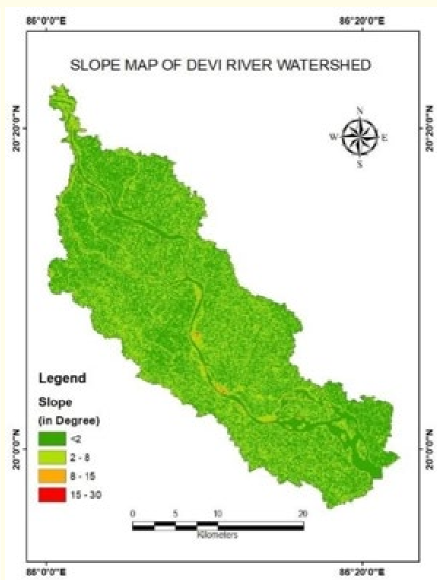


Figure 8: Drainage Density of Devi Watershed. ***Figure 9:*** Slope of Devi Watershed.

We can consider the Slope as an Influential geographic factor that is proportional directly to the water flow on the surface and at below surface [7, 5]. The slope of the land varies between 0-2% with older deltaic plains and tidal flats surrounding the Devi river basin. Slopes vary subsequently from 85° to low as 0°. So, the study area indicates higher probability of natural recharge of groundwater zone.

Overlay analysis is a multi-criteria analysis for discovering specific themes where analysis can be completed with complex things by assigning rank to certain features and weightage to individual parameters. Eight layers were combined in this model by giving weightage to the theme on a scale of 1-100 and ranks to the characteristics on a scale of 1-10. Parameter rankings and weightings are provided. The resulting map was divided into five groups (very high, high, moderate, poor, and very poor categories of integrated values), indicating the region appropriate for artificial recharge.

To control more over the layers with a bigger scale, the overlay analysis was done in GIS using ArcGIS software 10.3.

Generation of pair wise comparison matrices

AHP is firstly introduced by Saaty (1980). The AHP helps to determine the priority of the factors on a particular problem and its relative importance over other factors. This method calculates each individual; parameters by dividing it into matrices consisting of a relative comparison of two factors with respect to each other. Researchers in the field of groundwater studies seeks the help of AHP through remote sensing and GIS to arrange the factors, compare the factors with each other according to their influence on the groundwater potential zone, and finally deciding on the spatial distribution of groundwater prospect zones [5, 7, 3].

The AHP process starts with, Selection of influencing factors for a particular decision-making process.

Comparison of each factor with each other and value has been assigned (Table 4) to them from the saaty's 1 to 9 scale, (Table 1, Table 2) with respect to the priority each factor compared to the other on the potential zone.

Arrangement of Values in a matrix format which will help to find out the priority vector (Table 4).
Derivation of Normalized weight from the priority vector.
Calculation of Eigen value and Consistency Index (eq.1).

The assigned weights are based on the response of thematic layers to groundwater recharge and expert's opinions. The AHP captures the idea of uncertainty in judgments through the principal eigen value and the consistency index (Saaty 2004). Saaty has given a measure of consistency, known as consistency index (CI) as deviation or degree of consistency derived using Eq. 1.

$$CI = \frac{\lambda max - n}{n-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, λ_{max} shows the largest eigenvalue of the pair-wise comparison matrix, n is the total number of parameters 'λ_{max}' represents the largest eigen value and 'n' is the number of factors considered. The derived consistency matrix will be acceptable only when the consistency ratio (CR) (eq.2) is ≤0.1.

Consistency Ratio (CR) is a measure of consistency of pairwise comparison matrix and is given in Eq. 2. It depends on the number of elements being compared. The value of RI for different n values is given in Table 3. If CR is less than 0.1, the estimate is only accepted. In this study for n= 8, RI = 1.41.

$$CR = CI/RI \text{ -----------(2)}$$

Where, RI is the ratio index, which is the consistency index of a randomly generated pair wise comparison matrix.

CR = 0.12557547 / 1.41 = 0.089060617 [CR≤0.1]

AGRZ = LUwLUwi + DDwDDwi + SLwSLwi + GMwGMwiþRwRwi + GGwGGwi + SwSwi + GDwGDwi + SDwSDwi + LBwLBwi.

Where, 'w' normalized weight of a theme, 'wi' normalized weight of the individual features of a theme, LU landuse landcover, DD drainage density, SL slope, GM geomorphology, R rainfall, GG geology, GD groundwater depth and LB lineament buffer.

Equal Importance Two	***Activities contribute equally to the objective***
Weak or slight Moderate importance	Experience and judgement slightly favour one activity over another
Moderate plus Strong importance	Experience and judgement strongly favour one activity over another
Strong plus Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
Very, very strong Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
If activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	A reasonable assumption
If the activities are very close	Maybe difficult to assign the best value but when compared with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities.

Table 2: Saaty's 1-9 Scale of Relative Importance.

Random index (RI)

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

Source: Satty 1980

Table 3: Random consistancy Index.

The Analytical Hierarchical Process (AHP) method is based on subjective approach in which weightages are assigned by pair wise comparison between various criteria obtained through policies by decision makers Saaty. The Analytic Hierarchy Process (AHP) method calculates the required weights associated with the respective criterion map layers with the help of a preference matrix, in which all relevant criteria identified are compared against each other on the basis of preference factors then the weights are aggregated. GIS-based AHP has gained popularity because of its capacity to integrate a large quantity of heterogeneous data.

	Geol	*LULC*	*RF*	*Water level*	*Geomorph*	*Lin*	*DD*	*Slope*
Geology	1.00	3	4	5	1.5	6	8	8
LULC	0.33	1.00	5	6	3	5	7	7
Rainfall	0.25	0.20	1.00	1.5	2	6	8	8
Water level	0.20	0.17	0.67	1.00	1.8	4	6	7
Geomorph	0.67	0.33	0.50	0.56	1.00	5	7	6
Lineament	0.17	0.17	0.17	0.25	0.20	1.00	1.5	2
Drainag Density	0.13	0.14	0.13	0.17	0.14	0.67	1.00	1.6
Slope	0.13	0.14	0.13	0.14	0.17	0.50	0.63	1.00
SUM=	2.87	5.15	11.58	14.62	9.81	28.17	39.13	40.60

Table 4: Comparison Matrix.

Influencing Factors	*Category (Classes)*	*Groundwater Potentiality*	*Rating*	*Normalized Weightage*
Lithology	Sand	Good	5	0.298246999
	Silt	Good	4	
	Clay	Moderate	3	
	Gravel	Good	3	
	Quartzite, Conglomer-ate	Very Poor	1	
Geomorphology	Older deltaic plain	Good	4	0.123073079
	Old coastal plain	Very good	5	
	Younger coastal plain	Good	4	
	Younger deltaic plain	Very Good	5	
	Channel bar	Good	4	
	Channel island	Very Good	5	
	Aggraded paleo channel	Very good	5	
	Younger flood plain	Moderate	3	
	Ridge	Moderate	3	
	Tidal flat	Good	4	
	Older flood plain	Good	4	
	Paleochannel	Good	4	
	Water Body	Very Good	5	
Lineament Buffer (m)	0-50	Very Poor	1	0.033184025
	50 -100	Poor	2	
	100 -150	Moderate	3	
	150-200	Good	4	
	>200	Very Good	5	
Slope	0-2%	Very Good	5	0.020905481
	2-8%	Good	4	
	8-15%	Moderate	3	
	15-30%	Poor	2	

Groundwater Level (m)	0.81-1.20	Moderate	3	0.109920849
	1.20-1.59	Very Good	5	
	1.59-1.99	Good	4	
	1.99-2.38	Good	4	
	2.38-2.77	Very good	5	
	2.77-3.16	Very good	5	
Rainfall (mm)	1676.64- 1711.88	Moderate	3	0.141676174
	1711.88-1747.12	Moderate	3	
	1747.12- 1782.36	Good	4	
	1782.36- 1817.60	Good	4	
	1817.60-1852.84	Very Good	5	
LULC	Vegetation	Very Good	5	0.248402654
	Scrubland	Moderate	3	
	Sand, Bare Land	Moderate	3	
	Settlement	Very Poor	1	
	Grass land	Good	4	
	Waterbody	Very Good	5	
Drainage Density (Km^{-1})	17.86- 217.91	Poor	2	0.024590739
	217.91-417.95	Poor	2	
	417.95- 617.99	Very Poor	1	
	617.99- 818.04	Very Poor	1	
	818.04- 1018.08	Very Poor	1	

Table 5: Normalised Weightage Table.

Artificial Recharge Map

The artificial groundwater recharge zones for the Devi Watershed in Jagatsinghpur, puri, cuttack district were obtained using weighted overlay operation of thematic layers namely drainage, lineament, geology, geomorphology, land cover, rainfall, groundwater depth and slope in GIS environment. To determine artificial groundwater recharge zones, appropriate weights were allotted to these ten thematic layers and their different features. The determined artificial groundwater recharge zones of the Devi Watershed are shown in Fig.10. The groundwater recharge zones are classified into five different categories as very good, good, moderate, poor and very poor. It is found that in these different categories about of the study area falls under Very good, good, moderate zones, poor and very poor artificial groundwater recharge zone, respectively. It is evident from the artificial groundwater recharge zones map that Southeastern and western part of the study area are most suitable for artificial groundwater recharge. At last the conclusive statement over this map is with high groundwater potential zones there comes less investment to identify recharge zone but with low potential zones and over exploited regions along with low potential zones we need to establish artificial recharge zones of the study area.

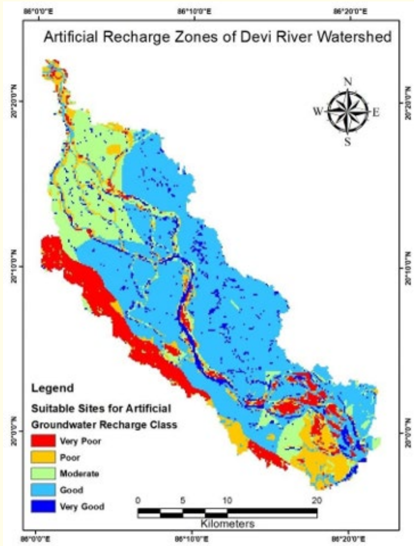


Figure 10: ARZ Map of Devi watershed.

Conclusion

The groundwater recharge map generated by the Multicriteria Decision-making (MCDM) technique by the AHP method for the Devi river Puri, Jagatsinghpur, Cuttack District, Odisha, India, has utilized a number of influencing factors such as Geology / Lithology, LULC, Rainfall, Soil, Slope, Water level, Lineament, and Drainage Density. The thematic maps prepared from different data sets were classified according to their influence on the groundwater recharge zone [5, 7, 3] The Normalized weight was calculated by the AHP method, and the rank assigned according to the sub-factors classification by considering its priority was applied. There are 5 zones of groundwater recharge has been derived from the process. Further, the validated recharge zone can be considered reference data for any other civilian activities directly or indirectly linked with the area's groundwater scenarios. Various groundwater recharge structures have suggested in this study by considering different geological and hydrogeological parameters and feasibility of sites in the study area. Artificial groundwater potential recharge zone determined by MCDA is used here to suggest or identify the different artificial recharge structures. The proposed suitable artificial recharge structures to construct in the study area are mainly, gravity head recharge wells (GHRW), nala plugging (NP).

References

1. Ahirwar Shobharam., et al. "Application of Remote Sensing and GIS for Groundwater Recharge Potential Zone Mapping in Upper Betwa Watershed". Journal of the Geological Society of India 95 (2020): 308-314.
2. Ahmed SA. "Geospatial technology for delineating groundwater potential zones in Doddahalla watershed of Chitra Durga district, India". The Egyptian Journal of Remote Sensing and Space Sciences 19.2 (2016): 223-234.
3. Balachandar D., et al. "Application of Remote Sensing and GIS for Artificial Recharge Zone in Sivaganga District, Tamilnadu, India". Internat. Jour. Geomatics and Geosci 1.1 (2010): 84-97.
4. Barik Kamal Kumar., et al. "Delineation of Groundwater Potential Zone in Baliguda Block of Kandhamal District, Odisha using Geospatial Technology Approach". International Journal of Advanced Remote Sensing and GIS.6. (2017): 2068-2079.
5. Jhariya Dalchand., et al. "Assessment of groundwater potential zone using remote sensing, GIS and multi criteria decision analysis techniques". Journal of the Geological Society of India 88 (2016): 481-492.

6. Jhariya DC., et al. "Integrated Remote Sensing and GIS approach to groundwater potential delineation in the Doon valley, Uttarakhand, India". SSARSC International journal of Geo-science and Geo-informatics (2015).
7. Indhulekha K and Jhariya DC. "Delineation of groundwater potential zones in Samoda watershed, Chhattisgarh India, using Remote Sensing and GIS techniques". In IOP Conference Series: Earth and Environmental Science 597.1 (2020): 012007.
8. Mohanty C and Behera SC. "Integrated remote sensing and GIS study for hydro-geomorphological mapping and delineation of groundwater potential zones in Khallikote block, Ganjam district, Orissa". J. Indian Soc. Remote 38.2 (2010): 345-354.
9. Raj S and Sinha AK. "An integral approach for the delineation of potential groundwater zones using satellite data: case study, Udaipur district, Rajasthan". Journal of Asia-Pacific Remote Sensing (1989): 261-64.
10. Rao NS, Chakradhar GKJ and Srinivas V. "Identification of groundwater potential zones using remote sensing techniques in and around Guntur Town, Andhra Pradesh. India". J Indian Soc Remote Sens 29 (2001): 69-78.
11. Srivastav P and Bhattacharya AK. Delineation of groundwater potential zones in hard rock terrain of Bargarh District, Orissa using IRS, Jour. India. Soc. Rem. Sen 28.2-3 (2000): 129-140 .
12. www.cgwb.gov.in
13. http://cesorissa.org/
14. https://indiawris.gov.in/wris/

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