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ANALYSIS OF GROUNDWATER POTENTIALITY ZONES OF TAPI BASIN IN NANDURBAR DISTRICT, USING GIS-BASED AHP APPROACH

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ABSTRACT

Ground Water is one of the prime sources of fresh water contributing significantly for the survival of mankind. Groundwater is globally used for drinking and domestic purposes in both urban and rural areas. As the demand and needs of the population towards water is growing, The value of water is felt in all sectors. At the same time, because of less rainfall surface water resources are becoming insufficient to fulfil the water demand. In this context, There is a need of systematic planning of ground water improvement using modern techniques and there is a need to demarcate groundwater potential area for the proper management and utilization of water. Groundwater Resources have not yet been properly exploited. Keeping this in view, the present study has been undertaken to delineate the ground water potential zone in Tapi River Basin in Nandurbar District sub watershed area using RS and GIS approach. The present study also demonstrates the use of the geospatial technique for mapping of groundwater quality of Tapi basin area in entire district. The multiple thematic layers of influencing parameters viz. geology, geomorphology, soil, slope, drainage density, rainfall and land use are used in the study. AHP is applied to these factors and potential recharge zonesare identified. Based on the field condition, weight and rank values were assigned to respective themes and their classes. In this research Paper, demarcate groundwater potential zone in entire tapi river basin.

Keywords: Groundwater potential zone , GIS and Remote sensing, Analytical Hierarchy Process (AHP)

1.1 Introduction

As the demand and needs of the population towards water is growing, the value of water is felt in all sectors. At the same time, because of less rainfall surface water resources are becoming insufficient to fulfill the water demand. There is a need of systematic planning of ground water improvement using modern techniques and there is a need to demarcate groundwater potential area for the proper management and utilization of water. In the state of Maharashtra surface water resources are uneven and the entire state is mostly dependent on groundwater. Tapi alluvial formation occurs in the central area of the Nandurbar district. Geographically and geomorphologically region is divided into 2 divisions that are as **Deccan trap formation-** near about sixty-percentage area covers mostly the Southern and Northern portion of the district (Satpuda mountain ranges) , Central plain alluvium area (Tapi alluvium)

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The problem is a consequence of low precipitation and hence low recharge to aquifers and high evapotranspiration. The purpose of groundwater potential demarcation in this study is to identify groundwater accessible locations throughout the study region in an easy and simple way. The rainfall is erratic and there is a large variation in the rainfall pattern in the Tapi Basin region. Average annual rainfall of the study area is 512 mm. The region has witnessed frequent drought and famine conditions in the past 50 years. Groundwater is not available in many parts even for drinking and agricultural purpose. This work well be increasing awareness of ground water management problems has resulted in a need for information on ground water quality and quantity so that remedial action may be taken in time to mitigate these problems or to prevent their re-occurrence in future.

1.2 Study Area:

The study area comprises of major watershed of Tapi River, basin. The total length of the river from the is about 80km. Nandurbar district was derived from Dhule district on 1st July 1998 and it lies between north latitude 21°00'00" to 22°00'30" and east longitude 73°31'00" to 74°45'30". The district covers a total geographical area of 5034 sq.km. Nandurbar is a part of the Deccan Plateau and covers consisting of 6 Talukas namely Nandurbar, Navapur, Shahada, Taloda, Akrani & Akkalkuwa with district head quarters located at Nandurbar city. Geographically the district is divided into 3 physiographic divisions namely i) Southern hilly areas of Nandurbar & Navapur taluka, ii) Alluvium deposits around Tapi river of Shahada, Taloda & Akkalkuwa taluka, iii) Northern part of district forming part of Satpuda range. The highest elevation is Asthamba peak with an elevation of 1150 m & second highest hill station of Maharashtra i.e. Toranmal plateau with about 1100 m. height. The average elevation of the plain area ranges between 550 to 675 m above mean sea level. The central part is covered by the plains of the Tapi river basin. The maximum temperature is recorded at 45^0 C and minimum temperature about 22^0 C . In winter season, the minimum temperature varies from 3 to 8o C. The area receives ~0% of the total annual rainfall 600-700 mm average annual rainfall from southwest monsoon from June to September.

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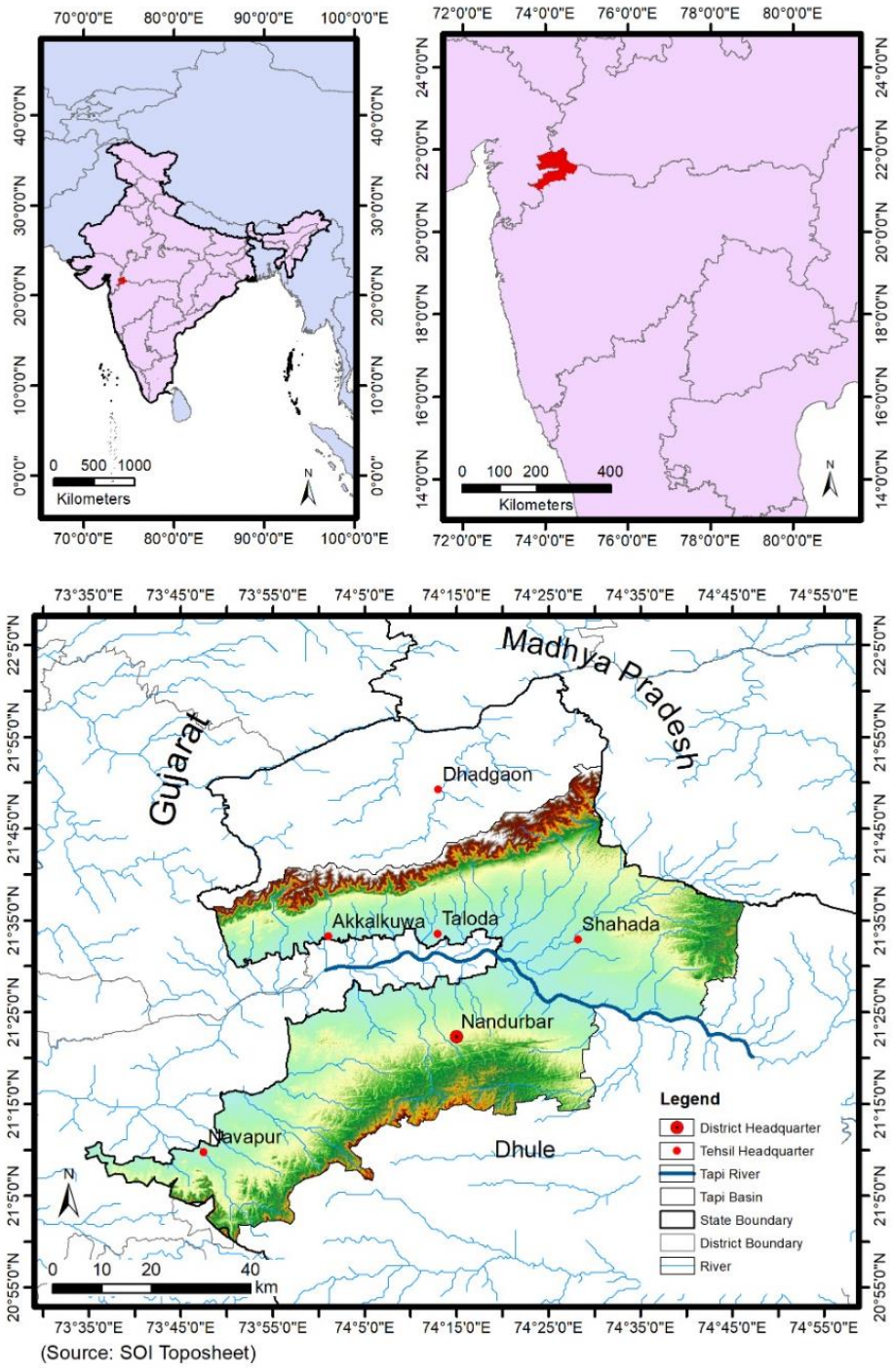
Nandurbar District:Tapi Basin Location Map



(Source: SOI Toposheet)

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1.3 Objective of the Research

1. To assess and demarcate ground water potential zone through various thematic maps of Tapi Basin
2. To prepare different thematic maps of the terrain within the watershed.
3. To develop a GIS model to identify ground water potential zones.
4. To demonstrate the capabilities of remote sensing and GIS in ground water potential zones Mapping.

2.1 RESEARCH METHODOLOGY:-

The methodology adopted for the present study is shown in Fig. 1. The base map of Tapi Basin Region was prepared using a shape file of the India for village level on a 1:50000 scale. The deferent map will be prepared SRTM DEM data in Spatial Analyst module. Same the drainage network has been prepared will the hydrological analysis tool. All the parameters has been prepared using the line density analysis tool in ArcGIS. Satellite images from LANDSAT 8 on a scale of 1:50,000 (geo-coded, with UTM projection, spheroid and datum WGS 84, Zone 42 North) have been used for delineation of thematic layers such as land-use land-cover and soil types. These thematic layers were converted into a raster format (30 m resolution) before they were brought into GIS environment (Gazioğlu et al., 2014). The groundwater potential zones were obtained by overlaying all the thematic maps in terms of weighted overlay methods using the spatial analysis tool in ArcGIS. During weighted overlay analysis, the ranking was given for each individual parameter of each thematic map, and weights were assigned according to the Analytical Hierarchy Process (AHP), multi influencing factor (MIF) of that particular feature on the hydro-geological environment of the study area

Database:

The study was initiated through the collection of geological map, topographic maps and satellite image to extract basic information of the study area. Nandurbar district (46 K/3,,46 k/4, 46K/7, and 46 K/11,46k/12), are used for present study. The primary and secondary data were compiled to form GIS database. Development of thematic layers involves digital image processing of remote sensing data, digitization of existing maps and field data for extraction of relevant information. To identify the groundwater potential zone in the study area, thematic layers of geology, geomorphology, soil, slope, drainage density, rainfall and land use were generated and integrated in GIS environment. The study of ground water quality based on primary as secondary sources of data. Secondary data will be collected from BIS (bureau of Indian standards) while primary data will be collecting through sample survey. Some Secondary data also collected. The Geological Survey of India (GSI), Geomorphology Bhuvan Portal, Geomorphology Atlas of Maharashtra (SAC), Soil Data National Bureau Soil Survey (NBSS), Landsat 8, SOI sheets etc. The present study is mainly concerned with The ARC/INFO GIS software package and satellite date will be used for the project.

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Fig1. Flow chart showing the proposed methodology.

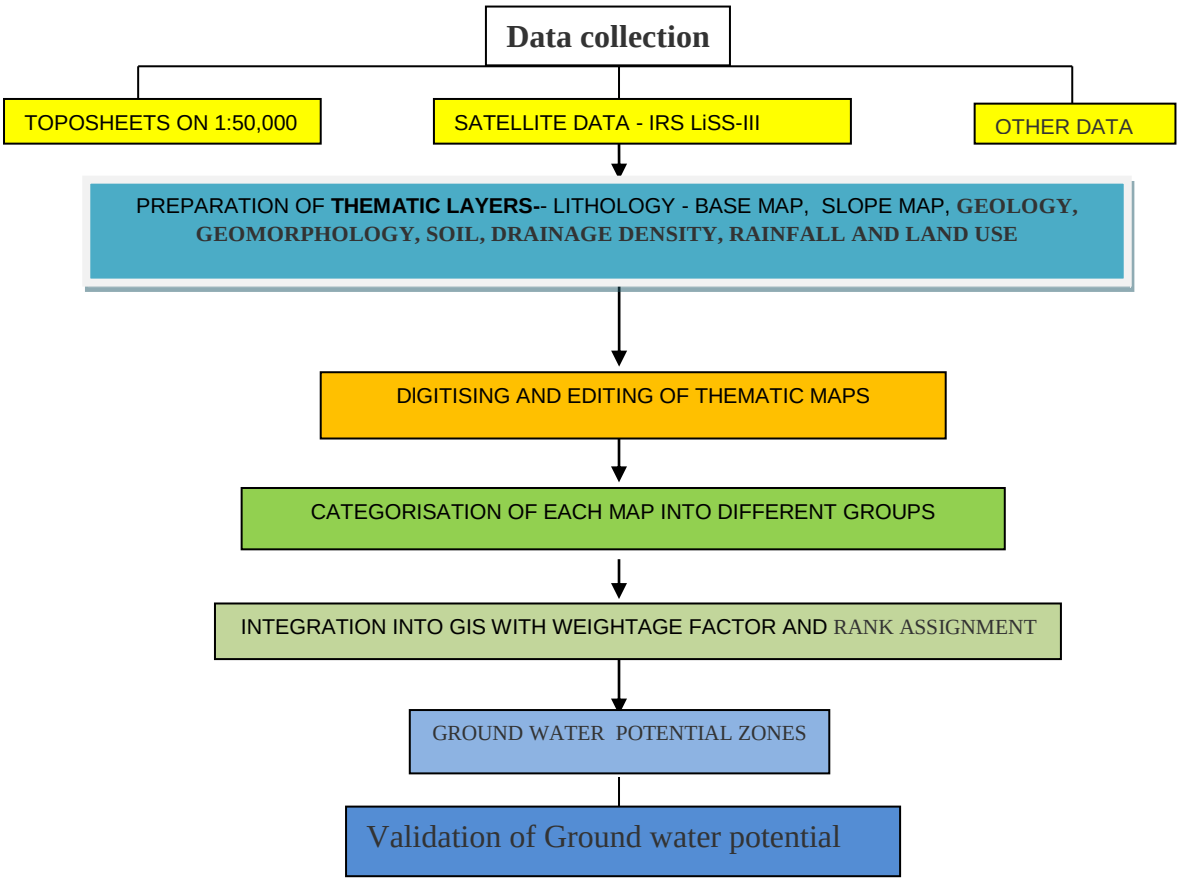

Fig 1 : Flowchart for **Demarcation** GW potential zone

3.1 Results and Discussion

A. Factor Maps for Groundwater Occurrence

i) Geology:

Geological study covering the study area has been carried out by many authors. The study area consists of two sequence, Satpura Hilly Region, Tapi River Valley proper, Region of the dykes and residual hills of the Sahyadri Spurs with eastward trending streams in between and Nawapur and Western Nandurbar Region with a westerly aspect below the Sahyadri Scarps. The geological formations are interpreted to lithological units to ease the groundwater occurrence in the study area. Based on the hydrogeological characteristics of different rock types, weightage was assigned to various groundwater potential categories and are reclassified in terms of their groundwater potential suitability

ii) Geomorphology:

Geomorphology of an area depends upon the structural evolution of geological formation. The landform plays a vital role for the occurrence and distribution of groundwater. Geomorphology is a study of earth structures and also depicts the various landforms relating to the ground water potential zones and also structural features with affinity for potential zones Pediments which are gently sloping rock surface having moderate relief, Pediplains in the

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Northern part of the Tapi basin which is a low leveled extensive spread of rock sediments and are most favorable to groundwater and meander, concave mark on the face of a bluff or valley wall, meandering stream which undercut the bluff, and indicating the abandoned root of the stream . The landforms present here includes Pediment- Pediment complex, while most of the area is covered by Pedi plain followed by moderately dissected hills and valleys, alluvium adjoining river banks, suggesting erosion prone area.

iii) Soil:

It is the one of the primary factor which controls the amount of groundwater. The movement of ground water and infiltration of surface water into ground is based on the porosity and permeability of soil. The soils of the district are basically derived from Deccan Trap Basalt to the south of Tapi River. Mainly three types of soils are observed in the district i.e., coarse shallow soils, medium deep soils and deep black soils.. North of Tapi River the soils are from Deccan Trap Basalt as well as from Alluvial formations. The northern part of the district has dark brown to yellowish brown coarse shallow to medium deep soils, with clayey loamy deep soils of Tapi River.

iv) Drainage Network:

Drainage Network: The drainage system of an Tapi basin is determined by the nature and structure of the bedrock, kind of vegetation, rainfall absorption capacity of soils, infiltration, and slope gradient. It is an inverse function of permeability A low-drainage-density region causes more infiltration and decreased surface runoff i.e. areas having low drainage density are suitable for groundwater development. The Drainage lines in the Tapi basin were derived by digitizing topographic map overlaying by satellite image (figure 4) so that the existing and non-existing streams can be detected precisely. The drainage patterns that were observed in the study area were dendritic, sub-dendritic and sub parallel.

v) Drainage Density:

Drainage density is another important parameter for the groundwater occurrence. The drainage system of an area is determined by the nature and structure of the bedrock, kind of vegetation, rainfall absorption capacity of soils, infiltration, and slope gradient. It is an inverse function of permeability A low-drainage-density region causes more infiltration and decreased surface runoff i.e. areas having low drainage density are suitable for groundwater development (Fig.1.2). The suitability of groundwater potential zones is indirectly related to drainage density because of its relationship with surface runoff and permeability. With higher the drainage density, there is lesser the infiltration of water to the subsurface, which in turn leads to higher runoff and vice versa.The study area is divided in to three classes, low (41.71%) drainage density (Figure 2d). Lineaments are the linear features that express the zones of weakness in the surface of the earth.

Table 1 .1 Drainage density

Drainage Density	Area (sq.km)	Area (%)
Low	1806.364	41.71
Moderate	2293.079	52.95

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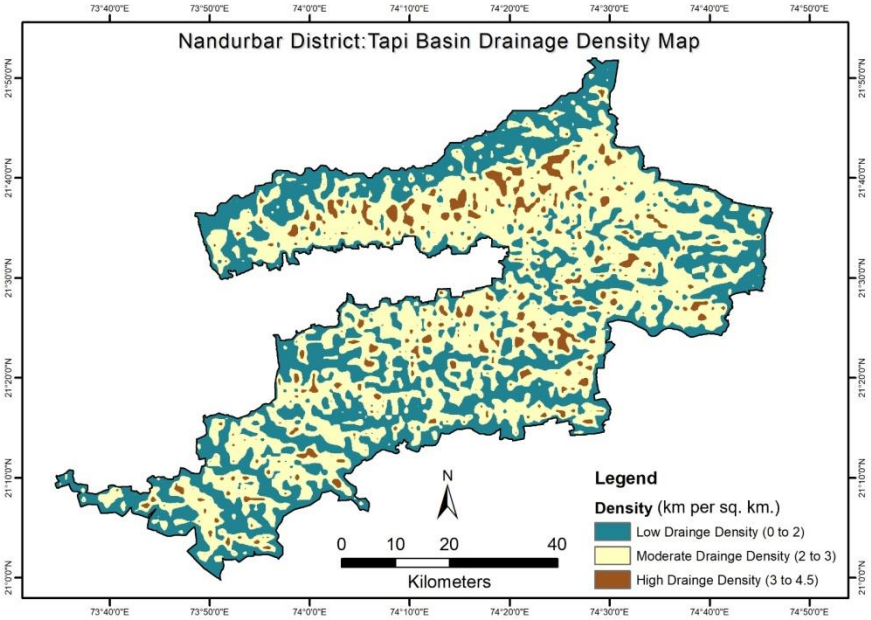
High	231.557	5.35
	4331	100



Map1.2 Drainage density Map

1.4 Groundwater Potential Zone:

Potential Zones for Groundwater Recharge In this study, seven parameters are used for evaluation, and weight accumulation was applied AHP to get a recharge potential score. The total weights of the different raster's in the integrated layer were computed using a weighted and ranking method to integrated all layers in using raster calculator in ArcGIS 10.1. Each thematic layer consisted of a grid cell. The grid cell in each of the thematic layers was categorized, depending on the contribution to groundwater potential

Table 1 Ground water potential Zones of Tapi basin.

Groundwater Potential	Area (sq.km)	Area (%)
Low	1554.123	35.88
Moderate	1514.745	34.97
High	1262.133	29.14
	4331	100

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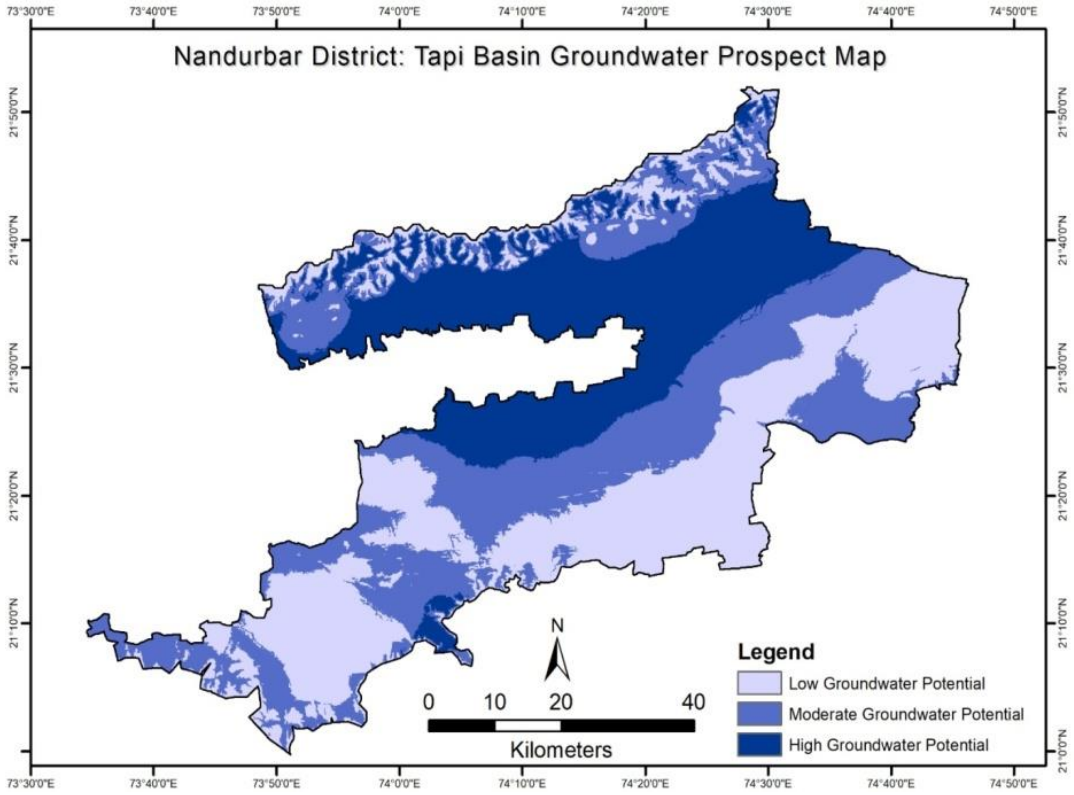

Map1.3: **Ground water potential Zones of Tapi basin**

Weighted overlay method was carried out to integrate the factor maps to demarcate groundwater prospect zones and the resulting output map was further classified into three classes namely, low, moderate and high prospect zones using equal interval method. Finally, the AHP combines the criteria weights and the options scores, thus determining a global score for each option, and a consequent ranking. The global score for a given option is a weighted sum of the scores it obtained with respect to all the criteria.

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Table1: Weight and rank assignment thematic layers (Factor maps).

S.N.	Parameter	Classes	Weight	Rank
1	Geology	**Graphitic schist**	25	**1**
		Calcquarzite and marble		3
		Calcquartzite andschist		1
		Calc-metas and stone and marble		2
		Psammitics chist		1
		Gneiss		2
2	Drainage density	Low	15	3
		Moderate		2
		High		1
3	Land use	Forest	10	3
		Bushes		2
		Cultivation		3
		Water body		3
		Settlement		1
4	Slope	Gentle (<15o)	10	3
		Moderate(15o-35o)		2
		Steep(>35o)		1
6	Geomorphology	Low dissected	25	3
		Moderately dissected		2
		Highly dissected		1
7	Lineament Density	Low	15	1
		Medium		2
		High		3
Total			100	

The Overlay Analysis is the final step after reclassification of raster datasets. The overlay analysis was done in ArcMap by using Overlay tool from spatial analyst tool. The function of this tool is to integrate all the input raster dataset. Different authors have used different combinations of factor maps. Some authors have used five thematic layers of drainage density, lineament density, slope, land use/land cover and lithology In the present study seven factors Geology, drainage density, slope, land use, geomorphology, and lineament density that have pronounced control on the occurrence of groundwater in the area have been considered. Likewise, there are various methods for assessing groundwater prospect zones, like quantitative, semi-quantitative and knowledge driven.

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CONCLUSION

Conclusion The integration of RS andGIS provides a quick and inexpensive approach to groundwater surveying and play an important role in maintaining sustainable development. The study area consists of Tapi alluvial plain Compared to conventional technique of groundwater inquiry remote sensing data which provide accurate spatial information can be utilize cost effectively. Satty's AHP is one of the appropriate methods for assigning the weightages for the groundwater study. The multi-parameter approach carried out by means of GIS and an AHP technique was economical work method.Lithology, land use, geomorphology, drainage density, lineament density and slope were considered as the controlling factors for groundwater occurrence in the study area. The factor maps were assigned weight and rank values to obtain score of each map then integrated to obtain groundwater prospect map for the study area. The high prospect zone consists of near tapi river in Shahada and Nandurbar tahsil , moderate prospect zone consists of Taloda northern and Nandurbar southern part and low prospect zone consists of outer boundary of Tapi basin. The groundwater prospect zones demarcated in the present study reasonably represents the field condition of groundwater occurrence and the map can be used for detailed exploration at specific site for groundwater exploitation to meet the growing demand of water in the area. This is specifically important in view of climate change that is supposed to change the future precipitation pattern and depletion of groundwater table thereby limiting the water availability through natural springs and streams.

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