Delineation of Groundwater Potential Zones in Koyna River Watershed, Maharashtra using Remote Sensing and GIS.

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Abstract:. Groundwater is considered as only source which provides water for meeting domestic, industrial and agricultural requirement. Continuous uses of water without any conservation cause lowering of Ground water level and thus living forms are facing many problems now-a-days. In current situation some existing wells getting dried up because of depletion of groundwater table as the natural groundwater recharge is not sufficient for requirements. As a result, the access to resources and their demand allows individuals to pick favorable locations for population increase. As the world's population grows, so does urbanization and groundwater exploration. As a rising metropolitan region, it is critical to analyze the present groundwater scenario of the Koyna River watershed. This study is simple to do with the use of remote sensing and geographical information systems (GIS) by cost-effectively incorporating factors impacting groundwater potential. We will combine numerous data sets and maps in this study, including satellite imaging, drainage, groundwater level, precipitation, LULC, slope, and its existing geological map. After including the groundwater potential, it was divided into five distinct zones: extremely poor, poor, moderate, good, and very excellent [1].

Keywords- Groundwater potential, GIS, RS, LULC, Koyna River, Thematic Layers.

1. Introduction

The Western Ghats are a hilly terrain that runs along the western border of the Indian Peninsula (hills) [4]. The Koyna River basin is located east of the primary ridge, which is locally known as the Sahyadri Hill Range (portion of the Krishna River basin). Mahabaleshwar,
Satara district, Western Maharashtra, India is the source of the Krishna River [7]. It emerges near Mahabaleshwar, a well-known Western Ghats hill station. Four tributaries feed the Koyna River [2]. All tributaries flow from the Western Ghats [mpcb.gov.in]. Unlike other Maharashtra rivers, the Koyna River flows north-south. This river basin is 2,036 km² in size and is located in the Deccan region of Maharashtra State, India. Geologist became concerned in this river basin after the 1967 Koyna earthquake. Despite these efforts, there have been few groundwater storage zone analyses in the river basin. The goal of this study is to define the river basin's hydrogeologic framework, including aquifers, underground water occurrence, well efficiency, and aquatic habitat [2].

The physiography of the Koyna River basin is typical of the Deccan Plateau, with elevations ranging from 550 to 1,460 metres above sea level features a sub-dendritic drainage system with a lot of baseflow and steep slopes, therefore groundwater recharge is negligible. The river basin is well-drained, with a lot of surface runoff and a high gradient, as well as low absorption rate. [2].

The Koyna Dam, built on the Koyna River, is a significant supply of water for Maharashtra. It's a crumbled concrete dam with a height of 103.02 metres above the deep footings and 85.35 metres above the riverbed. It is 807.22 metres long in total.

A subtropical monsoon climate characterizes the Koyna River watershed. Rainfall averages more than 5000 mm in the River Course's watershed up to Helwak. The catchment area is 891.78 square kilometers from Koyna Dam to the mouth of the river. 120 TMC is the mean annual production with 75% reliability [2].

A number of techniques have been used for mapping groundwater potential zones. But recently, remote sensing along with Geographic Information System plays a vital role in order to provide information about potentiality, occurrence, mapping, problems regarding exploitation of groundwater. Exploration of groundwater with the help of remote sensing data leads to discover new information about inaccessible or remote areas. Remote sensing and GIS technique are not only accurate, cost-effective, time-saving but also, they provide reliability as well as detail interpretation of data. GIS refers to a set of technologies for gathering, storing, retrieving, processing, and presenting geographical data from the actual world [1].

The main application of using this advance technology to know; (i) amplifying the efficacy of planning and decision making that help in data distribution and controlling unwanted data base (ii) reducing replication ability to amalgamate information derived from many resources (iii) complex interpretation of geographical referenced data in order to create new information.

2. Study area

The Konya River Basin is located between 17.54 and 17.16 N and 73.42 and 74.06 E. The Konya River runs north-south for 65 kilometres, approximately parallel to the continental divide (Fig. 1). It runs from Mahabaleshwar to the hamlet of Helwak, passing via King Shivaji's fort of Pratagpah. It swings steeply eastwards near Helwak, runs for approximately 56 kilometres, and meets the Krishna River at Karad. It's an odd confluence where two rivers meet head on. Preeti Sangam is the common name for this confluence.

The river runs through Patan and Karad talukas. The River Course's catchment area extends up to Helwak and has an average rainfall of more than 5000m. The river's catchment area up to Konya Dam is 891.78 square kilometres.
Table 1: date used in preparation of different maps

| SL. No. | Layer Name                       | Source                 | Sites                               |
|--------|----------------------------------|------------------------|-------------------------------------|
| 1      | Geology                          | Bhukosh                | www.bhukosh.gsi.gov.in              |
| 2      | Geomorphology- Landforms          | Bhukosh                | www.bhukosh.gsi.gov.in              |
| 3      | Geomorphology- Units              | Bhukosh                | www.bhukosh.gsi.gov.in              |
| 4      | Lithology                        | Bhukosh                | www.bhukosh.gsi.gov.in              |
| 5      | Drainage pattern                 | DEM                    | www.earthexplorer.usgs.gov          |
| 6      | Lineament Density                | Bhuvan                 | www.bhuvan.nrsc.gov.in              |
| 7      | Precipitation                    | India-WRIS             | www.indiawris.gov.in                |
| 8      | Groundwater level                | India-WRIS             | www.indiawris.gov.in                |
| 9      | Land Use and Land Cover          | Sentinel-2             | www.earthexplorer.usgs.gov          |
| 10     | Slope                            | DEM                    | www.earthexplorer.usgs.gov          |
3. Methodology

Systematic methodology adopted in the present study (Fig. 2). The identification and extensive research of groundwater potential zones in the Koyna basin was accomplished through the use of GIS technology to analyze a variety of remote sensing data and numerous thematic maps. Some layers were created and used to identify recharging locations in our present investigation. SRTM data was used to create the drainage layer [1]. A proportion of the slope map was created in addition. Bhuvan.gov.in provided the geomorphology theme map. The Geological Survey of India provided this geology map. For ease of use in GIS settings, all of these data were geo-rectified and projected in WGS 1984 with UTM Zone 45 N [3]. Geology, geomorphology, LULC, gradient, drainage/water bodies, post-monsoon water level, and worn thickness & cracks occurring near the surface all determine the best site for groundwater recharge. By combining geographical data from the research region and utilizing an index overlay model in a GIS context, the best zone for groundwater recharge was discovered. In this paradigm, weightage for the theme was assigned on a scale of 1–10, while subclasses of the theme were assigned on a scale of 1–5. The map was then divided into five categories: very high, high, moderate, extremely poor, and poor.

4. Climate

The climate of the Koyna River basin is subtropical monsoon. The Indian rainy season, the most significant of India’s three seasons, runs from June to September and accounts for around 88 percent of yearly rainfall. The winter months are November to February, while the summer months are March to May the Western Ghats’ orographic influence has resulted in a wide variation of rainfall distribution in the region. Annual rainfall decreases steadily from the

Figure. 2 Adopted Methodology Flow Chart
western to the eastern parts of the state. In the north, Mahabaleswar has the highest annual precipitation (6,024 mm), while in the southeast, Karad has the lowest (745 mm). The contribution of rainfall is just 8% in the winter and 4% in the summer [2].

5. **Thematic Layers**

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

5.1 **Lithology**

Basaltic lava flows make up the lithology of the Koyna River basin. It was mostly discovered between the Cretaceous and the Lower Eocene epochs. Groundwater in this region is mainly unconfined in shallow aquifers, but semi-confined to confined in deeper aquifers. It is mostly related with Basalt. The Basaltic flow is divided into two trap units: a bottom massive unit and an upper vesicular unit. Containing 60 to 85 percent of the Basaltic flows, the enormous unit is the major trap unit. It's primarily fine-grained, thick, and compact, and the color ranges from greenish grey to dark grey [4]. It also behaves as an impermeable bed with negligible porosity and permeability (Fig. 3).

The vesicular trap unit is found at the top of each flow and accounts for 15–40% of the total basaltic flow volume. These are soft, fine-grained, and range in hue from greenish to brownish. The lava flows are porphyritic to varying degrees and are tholeiitic in nature (Geological Survey of India 1974). Laterites produce flat plateaus and tablelands at altitudes ranging from 975 to 1,400 meters above sea level as cap rocks over basalts. In the eastern and northern regions, the lateritic profiles are 12–30 m thick, whereas in the southern parts, they are 2–5 m thick. The color of laterites is often reddish-brown [2].

5.2 **Geomorphology**

In study of geomorphology of a particular area we mainly cover its landforms, topography and different geological features. But this is not always accessible to study these features of a particular area. So, the recent advancement in remote sensing and GIS helps to understand these features in a very effective way and by using this advanced technology, it is very easy to detect ground water potential zone of concerned area (Fig. 4). Various available features of an area can indicate good site for groundwater availability [9]. We know that there are many geomorphic features are controlling factor for groundwater storage and its movements. We are focusing the detailed study of groundwater potential zone of (GWPZ) of koyna river.

We discovered inselberg, mesa, pediment, pediplain, plateau top, scarp, and butte morphological characteristics. Approximately 31% of the territory is made up of fragmented plateaus with steep slopes, whereas the remainder 28percent is somewhat low and residence to the general populace. Almost 6percent of the basin's water-spread area is covered by the Koyna reservoir. The western half of Mahabaleshwar is primarily wooded. The shattered plateau and hillsides, but from the other side, have a scant layer of soil and a limited vegetation, largely comprising of shrub, steppe, and a few distributed trees. The main valley is mostly cultivated and has deep soils and regolith. Lands that have been eroded are also common, especially where the fragmented plateau meets the main valley [2].

5.3 **Slope**

A Slope is the rise or fall of the land surface. It is proportional to the amount of water flowing through it. The Western half of the research region has the largest slope angles, according to the Koyna River basin's slope map [1]. This location (Fig. 5) has a slope angle of more than 15°.
According to the investigation, high slopes may be found in upstream regions, while very low slope ratios can be found in downstream areas. In general, slopes range from the direction is northwest to southeast. As a result, all of the streams are determined to be flowing in these orientations.
5.4 Rainfall

Our groundwater is recharged only by rainfall. The orographic effects of the Western Ghats causes a large variance in rainfall distribution in the Koyna River basin. Annual rainfall decreases steadily from the western to the eastern part of the state. Northern Mahabaleswar (6024 mm) receives the greatest annual average rainfall, while the southeast’s Karad (745 mm) receives the least. In the winter, rainfall contributes just 8%, whereas in the summer it contributes 4% [2].

The rainfall map has been categorized into five classes in millimeters (Fig. 6), such as

- Class 1: 989.56 to 1262.73
- Class 2: 1262.73 to 1535.90
- Class 3: 1535.90 to 1809.07
- Class 4: 1809.07 to 2082.24
- Class 5: 2082.24 to 2395.40

5.5 Water Level

As per the map, groundwater may be found at both surface and subsurface depths in the Koyna River basin. Aquifers are divided into two types, shallow aquifers and deeper aquifers. Dug wells seldom reach depths of more than 15 meters, and the majority arc between two and eight meters. The diameter ranged from 2-10 meters, with 50% and diameter of 2-4 meters. Bore wells typically have a diameter of 150mm and are 30-80 meter deep, seldom going deeper than 90-100 meter; the majority are 50-70m deep (Fig. 7). Dug wells are used to access the lower aquifers whereas borewells are used to access the deeper water resources [2]. The major part of the area is located near Koyna River, so any further groundwater development to meet drinking water requirements can be suitable on a village-to-village basis.

5.6 Lineament

Usually, lineament-controlled terrains that are underlain by the zone of increased porosity and permeability. The lineament density of lineament map is closely related with groundwater occurrences and its distribution (Fig. 8). The surface interpretation of the underpinning geologic structure is lineament, which is a linear feature existing in the earth’s surface. The presence of lineament implies favorable groundwater prospects since they operate as possible pathways for groundwater circulation [1].

5.7 Land Use Land Cover (LULC)

LULC is a significant indicator of human impact on groundwater resources. Groundwater storage and outflow, as well as infiltration, are influenced by land use patterns [5]. Forest land, nonagricultural land, and cultivable land are the three basic categories of land use. The Koyna River basin covers 280671 acres of territory from the two talukas of Patan and Karad in the Satara district. 38322 hectares are covered in forest, 21804 hectares are utilised for non-agricultural activities, and 220545 hectares are cultivable land (Fig. 9).

According to our observations, trees cover the majority of the land, whereas bareground constitutes a relatively small percentage of the total surface of the region.

5.8 Drainage Density

The DD of the Koyna River and its tributaries reveals that the drainage basin's general trend is from northwest to southeast. This corresponds to the altitude of the land surface, which maintains the same trend as inferred from the DEM data [12]. Because the waterways in the research region run from west to east, almost all of them meet on the right bank of the Krishna River (Fig. 10). Streams and rivers flow into the major river Krishna from the western mountainous region. The drainage
density in the research region was divided into five categories. The maximum density was discovered at the edge of the catchment area, with a value of 40.83-190.82, and the lowest density was found in the heart of our catchment region, with a value of 640.78-790.77.

Figure 7: Groundwater Level Map

Figure 8: Lineament Map

Figure 9: LULC Map

Figure 10: Drainage Density Map
| Table 2. Weightage Table | Influencing Factors | Category (Classes) | Groundwater Potentiality | Rating | Weightage |
|--------------------------|--------------------|--------------------|--------------------------|--------|-----------|
| Geology                  | Basalt             | Poor               | 2                        |        | 5         |
|                          | Laterite           | Good               | 4                        |        |           |
| Geomorphology            | Pediment           | Good               | 4                        |        |           |
|                          | Pedi Plain         | Poor               | 2                        |        |           |
|                          | Mesa               | Very poor          | 1                        |        |           |
|                          | Inselberg          | Good               | 4                        |        |           |
|                          | Bench              | Poor               | 2                        |        |           |
|                          | Butte              | Very Poor          | 1                        |        |           |
|                          | Dam and Reservoir  | Poor               | 2                        |        |           |
|                          | Lake               | very Good          | 5                        |        |           |
|                          | Pond               | Moderate           | 3                        |        |           |
|                          | River              | very Good          | 5                        |        |           |
| Lineament Density        | <50m               | Very Poor          | 1                        |        | 5         |
|                          | 50-100m            | Poor               | 2                        |        |           |
|                          | 100-150m           | Moderate           | 3                        |        |           |
|                          | 150-200m           | Good               | 4                        |        |           |
|                          | >200m              | Very Good          | 5                        |        |           |
| Slope                    | >2*                | Very Good          | 5                        |        |           |
|                          | 2-8*               | Good               | 4                        |        |           |
|                          | 8-15*              | Moderate           | 3                        |        |           |
|                          | 15-30*             | Poor               | 2                        |        |           |
|                          | 2.700-4.179bgl     | Very Good          | 5                        |        |           |
|                          | 4.179-5.659bgl     | Good               | 4                        |        |           |
|                          | 5.659-7.139bgl     | Moderate           | 3                        |        |           |
| Groundwater Depth | Range          | Category  | Value |
|-------------------|----------------|-----------|-------|
| 7.139-8.619 bgl   | Poor           | 2         |
| 8.619-10.099 bgl  | Very Poor      | 1         |

| Rainfall (mm)     | Range          | Category  | Value |
|-------------------|----------------|-----------|-------|
| 1289.03-1539.95   | Moderate       | 3         |
| 1539.95-1790.88   | Good           | 4         |
| 1790.88-2041.81   | Moderate       | 3         |

| LULC              | Category  | Value |
|-------------------|-----------|-------|
| Scrub lands       | Good      | 4     |
| Bare ground       | Very Poor | 1     |
| Flooded Vegetation| Very Poor | 1     |
| Trees             | Very Good | 5     |
| Grass             | Poor      | 2     |
| Build-ups         | Poor      | 2     |

| Drainage Density (Km/ Km²) | Category  | Value |
|---------------------------|-----------|-------|
| 40.83-190.82              | Very Good | 5     |
| 190.82-340.81             | Good      | 4     |
| 340.81-490.79             | Moderate  | 3     |
| 490.79-640.78             | Poor      | 2     |
| 640.78-790.77             | Very Poor | 1     |
6. **Groundwater Potential Zone Map:**

The relative importance of multiple themed layers and their relevant classes were used to develop the groundwater potential zone. The weighted sum technique was used to produce the groundwater prospecting zone study area. The potential zones were created using a weighted total with five distinct zones. Very poor, poor, moderate, good, and very good are the zones. According to the findings, the researched region has a significant groundwater potential zone (Fig. 11). According to a research of the groundwater potential map, the distribution of groundwater potential is influenced by rainfall, drainage density, slope, LULC, and other geomorphologic and geological factors [6].

![Figure 11: Groundwater Potential Map Of Koyna Watershed](image)

7. **Discussion**

The Koyna watershed's final groundwater recharge zone shows extremely poor, poor, moderate, good, and very good. The presence of a very excellent recharging zone may be detected in a major section of the northern half of the research region, but it declines as one moves southern [11]. As a result, the majority of the northern and central parts of the Koyna River watershed have a good groundwater potential zone. Basalts cover the majority of our research region, with some Laterite thrown in for good measure. The intermediate groundwater potential zone is situated in the middle of the research region, whereas the poor zone is found in the southern section (Fig. 11).
8. Conclusion

The purpose of this study was to create a groundwater potential map for the Koyna River basin. The findings suggest that the most effective groundwater potential zone is located in the research area's northern half. Around here the dam, reservoir and crop land have high infiltration capacity and the area is gaining moderate to low rainfall and having lower lineament density. Because of its lithology and low lineament density, moderate rainfall, and inadequate drainage density, the northern half of the research region is most effective for groundwater potential. Geomorphology, rainfall, lithology, LU/LC, drainage density, lineament density, and slope (percent) all have a role in the presence and potential of groundwater in the research region, according to GIS analysis. To map the groundwater occurrence map, movement, and management, remote sensing and GIS techniques were utilized to merge distinct theme maps. From the above study, the utilization of RS and GIS techniques gives amazing tool to consider groundwater resources and represent a reasonable exploration plan for recharge of groundwater around there, and which can be utilized for improvement in the groundwater potential and holding for the study area. So, by doing this, results can be used to advancement of groundwater management for future.

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