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Assessment Of Groundwater Potential Zones In Periyar River Basin Using GIS And AHP Techniques

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ABSTRACT

This study evaluates the groundwater potential for extraction in the piedmont zone of the Periyar River Basin, located in central Kerala, India. Recognised as the longest river in Kerala, the Periyar River is crucial for sustaining the region's ecosystems and meeting the water demands of its population. The assessment involves a comprehensive examination of geological, hydrogeological and hydrological factors using Geographic Information system (GIS) tools and the Analytic Hierarchy Process (AHP) within a Multiple Criteria Decision Analysis framework. Groundwater potential zones are identified based on influential parameters such as drainage density, lineament density, rainfall, topography, soil texture, aquifer geology and land cover patterns. Each parameter is meticulously mapped, reclassified and weighted to create a composite groundwater potential map. The study reveals areas with varying groundwater potential, categorized into moderate, high and very high potential zones. Findings indicate that regions with lower drainage density, higher lineament density and favorable soil and geological conditions exhibit greater groundwater potential. The results underscore the importance of sustainable groundwater management practices, especially in light of increasing water demands and environmental challenges. This study provides critical insights for informed decision-making regarding resource allocation and the implementation of preventive measures to mitigate overexploitation and enhance groundwater recharge. Overall, this research contributes to the sustainable management of groundwater resources in the Periyar River basin, offering a valuable tool for policymakers, environmentalists and water resource managers.

INTRODUCTION

Water is the essence of life, a fundamental resource that sustains ecosystems, supports agriculture, industry and serves a vital component of human existence. Ground water means the water stored beneath the earth's surface. Ground water plays a crucial role in meeting water demands worldwide. It is the primary source of drinking water for billions of people, especially in regions where surface water is scarce or unreliable. Moreover, groundwater sustains ecosystems by maintain base flow in rivers and wetland during dry periods, supporting aquatic life and biodiversity. However, sustainability of groundwater resources is increasingly threatened by overexploitation, pollution and inadequate management practices.

The growing demands on groundwater necessitate a comprehensive understanding of its potential and availability. Hence, the need for groundwater potential studies emerges as a crucial aspect of sustainable water resource management. For prioritizing the protection and preservation of our ground water, we need a detail study about our ground water potential. Groundwater studies provide insights into the quantity and quality of groundwater resources within a particular region. Understanding the spatial distribution and variability of groundwater potential allows for informed decision -making regarding resource allocation. Groundwater potential studies help to identify areas at risk of overexploitation, enabling the implementation of preventive measures such as groundwater recharge, regulation of pumping rates and promotion of water efficient practices. Groundwater potential studies are indispensable tools for sustainable water resource management in the face of growing water demands, environmental degradation and climate change.

Assessing groundwater potential involves a systematic evaluation of geological, hydrogeological and hydrological factors to estimate the presence, quantity and quality of groundwater resources in a given area. There are conventional and advanced methods for exploring groundwater potential. Conventional methods are based on ground surveys. Advanced methods are based on Remote sensing and GIS. Analytical Hierarchical Process (AHP), Weighted Overlay Method (WOM), Frequency Ratio Method (FRM), Weighted Aggregation Method (WAM) are Remote sensing-based methods.

STUDY AREA

The Periyar river basin, spanning latitudes 9°15'30'' N to 10°21'00'' N and longitudes 76°08'38''E to 77°24'32''E, starts from the Western Ghats and flows through central Kerala, India. Periyar is Kerala's longest river with the highest discharge potential, thus known as the lifeline of Kerala. The elevation of the Periyar River Basin varies from 2685 meters to Mean Sea Level (MSL), with Anamudi, the highest peak in South India, marking the highest point of the basin. Periyar river basin exhibits a dendritic drainage pattern.

METHODOLOGY

The study area's potential is being evaluated through the utilization of GIS tools, specifically employing the Analytic Hierarchy Process (AHP) within a Multiple Criteria Decision Method framework. This method facilitates the categorization of the area into various ground water potential zones, predicated upon an influential parameter, utilizing a weighed overlay method in GIS. These parameters are meticulously chosen based on a comprehensive review of existing literature. They encompass Drainage density, Lineament density, Rainfall, Topography, Soil texture, Aquifer geology and Land cover patterns.

Each parameter undergoes individual mapping within GIS tools for the study area and is subsequently reclassified to fit within a scale of 1-5. Through weighted overlay analysis, these reclassified parameter maps are amalgamated to generate a groundwater potential map, also ranging from 1-5 indicative of potential levels varying from very low to very high (as illustrated in Table 1). To ensure accuracy and relevance, each reclassified parameter map is assigned an influence percentage. These percentages are calculated utilizing an Automatic AHP excel sheet calculator, facilitating overlay analysis depicted in Table 2.

Table1: Scale index values

Scale	Index
1	Very Low
2	Low
3	Moderate
4	High
5	Very High

AHP CRITERIA

The analytic Hierarchy Process (AHP) is a design making method that systematically evaluates the influence of parameters or the weights assigned to those parameters in a given study. In this study, an AHP Excel sheet is utilized to automatically compute the influence of parameters through matrix calculations. In this AHP technique, a hierarchy structure is first identified, followed by pairwise comparison matrices (utilizing a scale of relative importance) and subsequent verification of consistency checks to derive weighting values for each parameter.

Table 2: Parameters and influence per percentage

Parameter	% of influence
Drainage Density	10
Lineament Density	13
Rainfall	19
Aquifer Geology	39
Soil	8
Topography	6
Land cover	5

SURFACE PARAMETERS

The estimation of groundwater potential areas in the Periyar River Basin involves the analysis, classification and reclassification of various parameters

1. Drainage Density

In sloping or mountainous regions, where the terrain is rugged, drainage density tends to be higher, resulting in swift surface water flow and increased runoff. This limits the likelihood of water accumulation and decreases infiltration, rendering such areas less conductive to groundwater potential. Consequently, there exits an inverse relationship between drainage density and groundwater potential occurrence. As drainage density rises, the likelihood of groundwater potential diminishes due to heightened runoff, which impedes water infiltration. Conversely, area with lower drainage density may greater potential for groundwater resources as infiltration rates are higher.

In this study, drainage emanates from Western Ghats and exhibiting a dendritic pattern. Drainage density was determined using cartographic Digital Elevation Model (DEM) data processed with ArcGIS. The drainage density was classified into five categories: very low, low, moderate, high and very high. Notably, areas with low drainage density received higher ranking due to their greater potential for ground water, attributed to higher rates of infiltration.

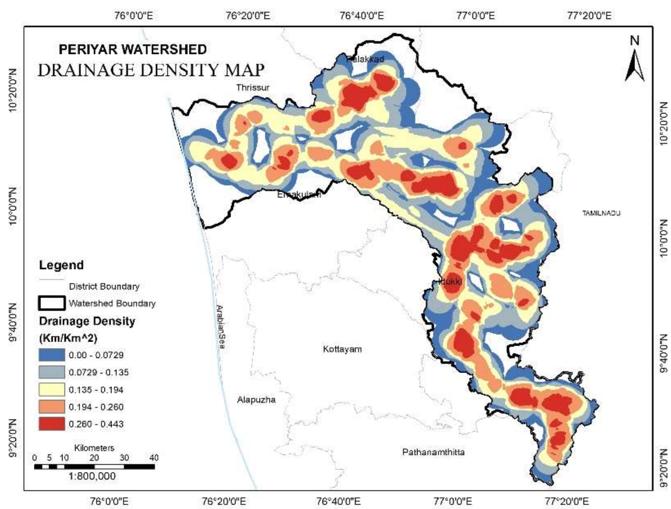

Fig.2: Drainage density map of Periyar River basin

2. Lineament Density

Higher lineament density areas exhibit greater potential for groundwater extraction due to increased infiltration, thus rating values are directly proportional to the scaled values.

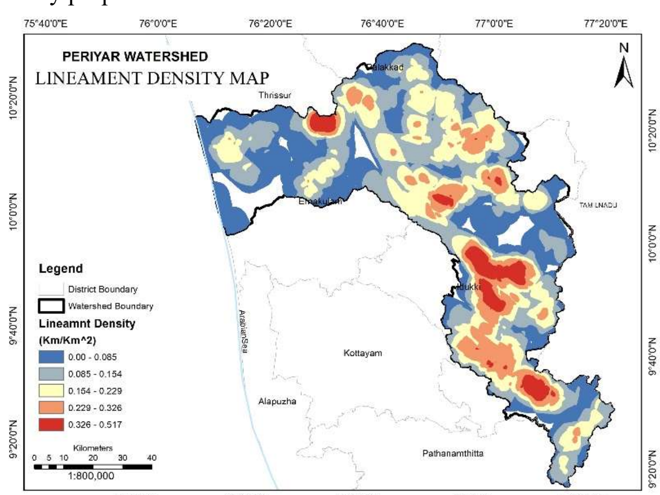

Fig.3: Lineament density map of Periyar River basin

3. Rainfall

The primary source of groundwater in the study area is rainfall. Consequently, regions experiencing high rainfall have a greater likelihood of infiltration, influenced by soil characteristics. As this parameter directly influences groundwater potential, scaled values also maintain a proportional relationship.

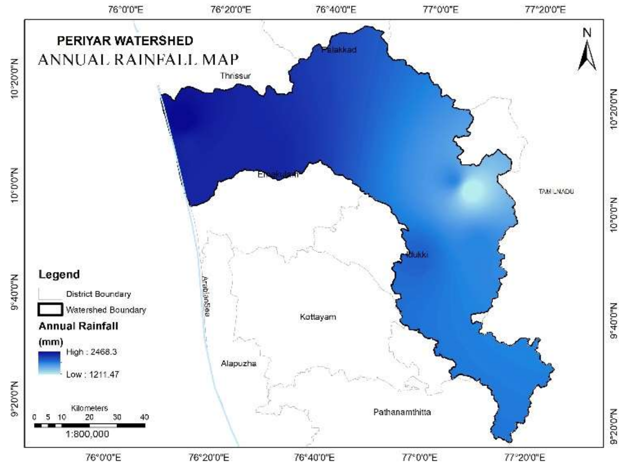

Fig.4: Rainfall map of Periyar River basin

4.Slope

Flat and gently sloping areas possess greater potential for groundwater due to reduced runoff and increased opportunities for infiltration, often leading to waterlogging. Therefore, the lowest slope class receives the highest rank, as it facilitates optimal groundwater retention and recharge.

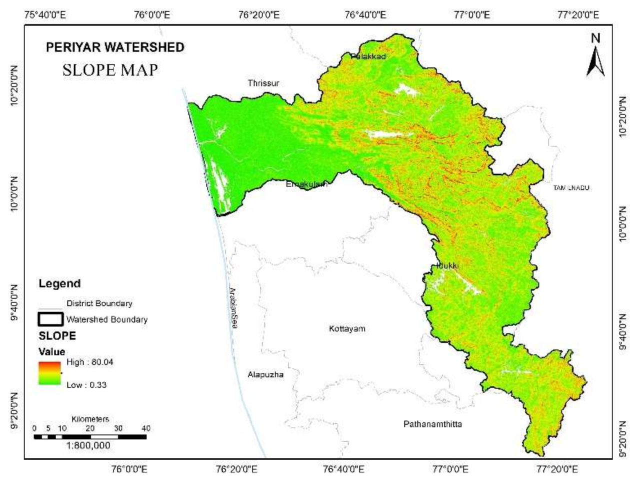

Fig.5: Slope map of Periyar River basin

5. Soil Type

In this study area, commonly three type of soils such as clay loam, sandy clay loam and loam. Clay loam soils, with their moderate permeability, allow for some water infiltration but feature slower drainage compared to sandy soils. This moderate drainage capacity can contribute to moderate groundwater recharge rates. Sandy clay loam soils exhibit moderate permeability, enabling some infiltration and drainage, albeit at a slower pace than sandy soils. Loam soils generally offer good permeability and infiltration capacity, making them favorable for groundwater recharge and storge.

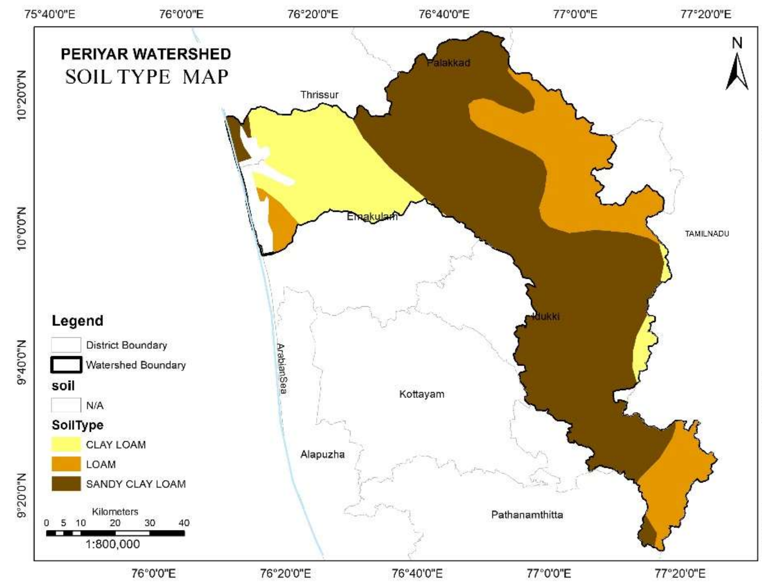

Fig.6: Soil map of Periyar River basin

6. Geology

Charnokite and migmatite gneissic complexes generally exhibit low permeability, limiting their contribution to groundwater potential. In contrast, undifferentiated fluvial, aeolian, coastal and glacial sediments typically possess higher permeability, making them more favorable for groundwater storage and extraction. The dense and crystalline nature of the gneissic complexes restricts significant groundwater movement, whereas sedimentary formations offer greater opportunities for groundwater storage and movement.

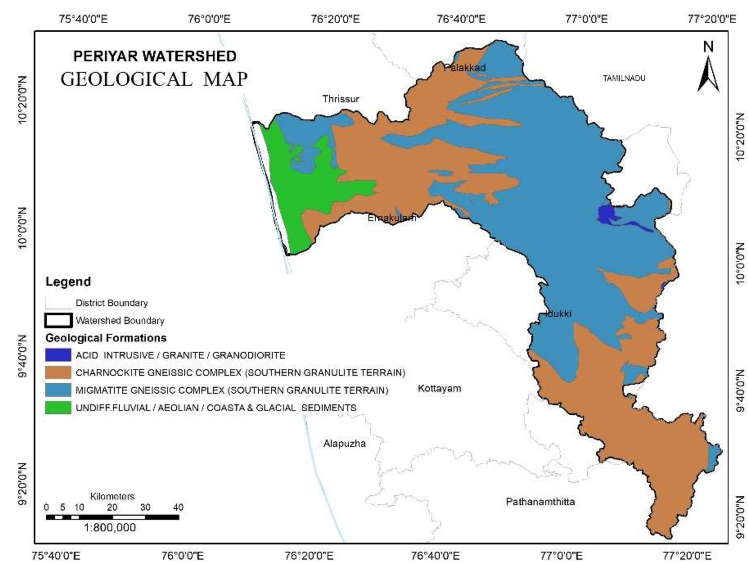

Fig.7: Geology map of Periyar River basin

7. Land use land cover

Groundwater potential is typically higher in agricultural and forested regions as well as areas with abundant water bodies, owing to increased infiltration rates. Conversely, bare lands and urban areas tend to exhibit lower groundwater potential due to reduced infiltration and increased surface sealing.

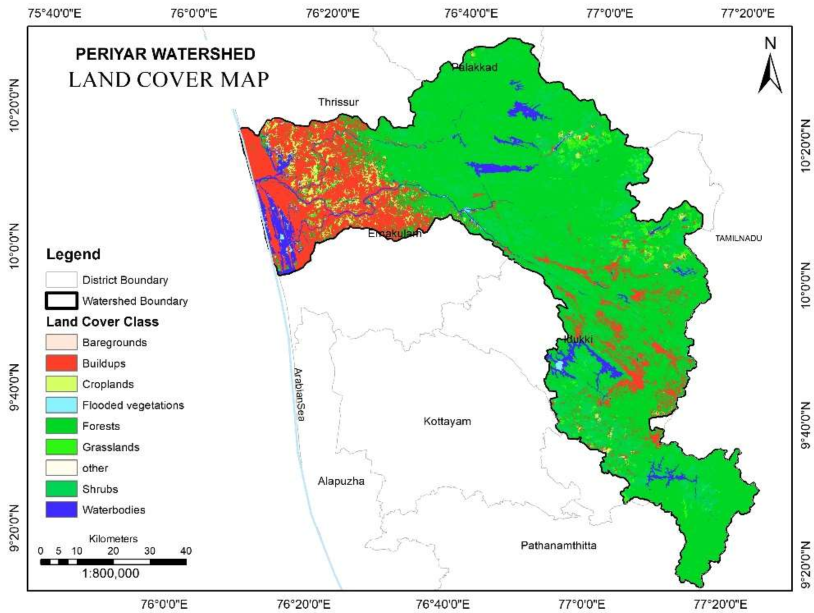

Fig.8: Land use land cover map of Periyar River basin

RESULTS AND DISCUSSIONS

The parameter layers undergo reclassification, with each being assigned a rating from 1 to 5, representing low to high potential. These reclassified layers are further assigned percentage influence values through the Analytic Hierarchy process (AHP) criteria. Subsequently, a weighted overlay analysis is conducted to generate a groundwater potential map for the Periyar River basin (refer to Table 3)

Table 3: Weighted overlay values of parameters of Groundwater Potential mapping

Sl.No.	Influencing Parameters	Weight (From AHP)	Classes	Reclassified Scale	Ranks allotted (1-5)	Groundwater Potentiality
1	Geology	39	CHARNOCKITE GNEISSIC COMPLEX (SOUTHERN GRANULITE TERRAIN)1	1	4	High
			MIGMATITE GNEISSIC COMPLEX (SOUTHERN GRANULITE TERRAIN)	2	4	High
			UNDIFF.FLUVIAL / AEOLIAN / COASTA & GLACIAL SEDIMENTS	3	3	Moderate
			ACID INTRUSIVE/GRANITE/ GRANODIORITE	4	3	Moderate
2	Rainfall (Annual average) (mm)	19	1,211.47 - 1,635.34	1	3	Moderate
			1,635.34- 1,842.34	2	3	Moderate
			1,842.34 - 2,009.92	3	4	High
			2,009.92- 2,207.07	4	4	High
			2,207.07- 2,468.29	5	5	Very High
3	Drainage Density Km/km²	10	0 - 0.04	1	5	Very High
			0.04- 0.11	2	4	High
			0.11 - 0.17	3	3	Moderate
			0.17- 0.25	4	2	Low
			0.25- 0.44	5	1	Very Low

4	Lineament Density Km/km²	13	0 - 0.07	1	1	Very Low
			0.07- 0.14	2	2	Low
			0.14 - 0.22	3	3	Moderate
			0.22- 0.32	4	4	High
			0.32 - 0.51	5	5	Very High
5	Soil Texture	8	CLAY LOAM	1	4	High
			SANDY CLAY LOAM	2	4	High
			LOAM	3	3	Moderate
6	Topography Degrees	6	0 - 6.90	1	5	Very High
			6.90- 14.43	2	4	High
			14.43- 22.914	3	3	Moderate
			22.91 - 33.27	4	2	Low
			33.27 - 80.04	5	1	Very Low
7	Land Use Land Cover Unique Values	5	1 (Water)	1	3	Moderate
			2(Dense Vegetation)	2	5	Very High
			3(Grass)	3	5	Very High
			4(Flooded Vegetation like mangroves)	4	4	High
			5(crops)	5	5	Very High
			6(Scrublands)	6	4	High
			7(Built-up)	7	1	Very Low
			8(Bare ground)	8	3	Moderate
			10(Clods)	10	1	Very Low

Using the overlay technique, a groundwater potential map for the Periyar River basin is created, ranging from 1 to 5, indicating very low to very high potential for groundwater extraction. However, the output map only displays ranges 3 (Moderate Potential), 4 (High Potential) and 5 (Very High Potential). This is because the values for ranges 1 (Very Low Potential) and 2 (Low Potential) are deemed negligible and are automatically excluded from the map during the GIS processing.

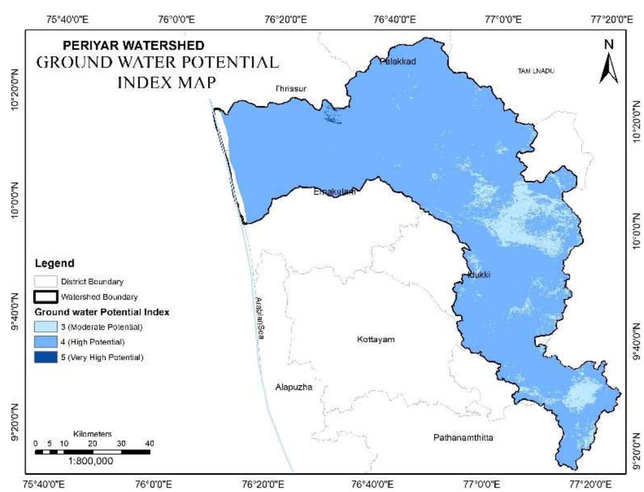

Fig.9: Groundwater Potential zoning map of Periyar River Basin

CONCLUSION

This study on the groundwater potential of the Periyar River Basin provides a comprehensive evaluation of the region's groundwater resources. Utilizing advanced GIS tools and the Analytic Hierarchy Process (AHP), successfully identified zones with varying groundwater potential based on critical parameters such as drainage density, lineament density, rainfall, topography, soil texture, geology and land cover patterns.

The findings indicate that areas with favorable geological conditions, lower drainage density and higher lineament density have higher groundwater potential. These insights are crucial for developing sustainable groundwater management practices in the basin. The generated groundwater potential map, which categorizes the region into moderate, high and very high potential zones, serves as a valuable tool for policymakers, environmentalists and water resource managers. Effective management of these groundwater resources is essential to meet the growing water demands, prevent overexploitation and mitigate the impacts of climate change. Implementing strategies such as groundwater recharge, regulation of pumping rates and promotion of water efficient practices will help preserve this vital resource. This study underscores the importance of integrating scientific methodologies with practical applications to ensure the sustainable use of groundwater in the Periyar River Basin

REFERENCES

1. Arhun B Doke, Rajendra B Zolekar, Hemlata Patel Sumit Das (2021) Geospatial mapping of groundwater potential zones using multi-criteria decision making AHP approach in a hardrock basaltic terrain In India. Ecological Indicators, Volume 127, August 2021 107685.
2. P. Arulbalaji, D. Panmalal, K. Sreelash (2019), GIS and AHP Techniques Based Delineation of Groundwater Potential Zones: A case study from Southern western Gahats, India, www.nature.com/scientificreports.https://doi.org/10.1038/s41598-019-38567-x.
3. Ritambhara K. Upadhyay, Gaurav Tripathi, Bojan Durin, Sanja Samanovi, Vlado Cetl (2023) Groundwater Potential zone Mapping in the Ghaggar River Basin, North-West India, Using Integrated Remote Sensing and GIS Techniques. Water 2023,15,961. https://doi.org/10.3390/w15050961.
4. Saket Raja, Kishan Singh Rawata, Sudhir Kumar Singh, Anil Kumar Mishr (2024), Groundwater potential zones identification and validation in Peninsular India. Geology, Ecology and Landscapes 2024, Vol.8, No.1,86-100.
5. Y. Yaswanth Kumar, D.V Satyanarayana Moorthy, G. Shanmuka Srinivas (2017) Identification of Groundwater Potential Zones using Remote Sensing and Geographical Information System, International Journal of Civil Engineering and Technology (IJCIET)Vol.8 Issue 3 2017 pp 01-10.