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Original Article

Groundwater Potential Zones Mapping of Kolhapur District Using Remote Sensing and GIS

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Abstract:

Groundwater is a highly useful and often plentiful resource. However, over-use, over-abstraction or overdraft, can cause major problems to human users and to the environment. The remote sensing data and GIS tools used for the generation of various thematic layers, for lineament map and density, land use and land cover, geomorphology, geology, drainage, drainage density, rainfall, slope, and soil texture. The weightage and rank is assigned to each layer and sub feature and classes of the thematic layers of the layer and weighted overlay technique is used to delineate the groundwater potential zones.

Keywords: Groundwater Potential Zones, Remote Sensing and GIS

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Introduction:

Land and water are the important resources on the earth surface. Without the water living thing cannot possible on the earth surface. The water is key aspect of the animal and plant for the development and growth. We cannot think the life without the water. In the water resource there are two types one is surface water which is found in the glaciers, lake, ocean, and river and another is groundwater. Groundwater is the water present

beneath Earth's surface in soil pore spaces and in the fractures of rock formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. Groundwater is ecologically important and it is having importance of groundwater to ecosystems is often overlooked. Groundwaters maintain rivers, wetlands, and lakes ecosystems, as well as subterranean ecosystems. Groundwater is the major source of irrigation in India which contributes nearly 65% of the irrigation.

The water from rainfall, lakes, rivers, and streams seeps through the porous ground to reach the water table; a level where the ground beneath is saturated with water. Groundwater is usually contained in an aquifer. Groundwater helps grow our food. 64% of groundwater is used for irrigation to agriculture. Groundwater is an important component in many industrial processes and plants. Groundwater is a source of recharge for lakes, rivers, and wetlands resources. Excessive pumping can lower the groundwater table, and cause wells to no longer be able to reach groundwater. There are some of the effects of over utilization of ground water reduction of water in streams and lakes, deterioration of water quality, increased pumping costs, land subsidence. Groundwater is the major source of drinking water in both urban and rural India. Besides, it is an important source of water for the agricultural and the industrial sector.

Therefore, the present study focuses on the delineation and identification of groundwater potential zones in the Kolhapur district.

Study Area:

Kolhapur district is one of the developed district of Maharashtra state and lies between the latitude of 15o43' North and 17o17'North and the longitude of 73o40' East and 74o42' East. The Kolhapur district is surrounded by Sangli district to its north and east, Belgum district of Karnataka state to its south and Sindhudurg district to the west. Administratively the study region is divided into twelve talukas comprising 7,685 sq. km. area.

Database and Methodology:

There are various databases is used for the mapping of groundwater potential zones for Kolhapur district from various different source. The multi criteria are used for the analysis and mapping. For the accuracy and implementation of the groundwater management and usage policy accurate mapping of the source is required. The satellite image for the present work study region is freely downloaded from earth explorer website which is already rectified and georeferenced. The satellite image used for the land use and land cover mapping firstly layer stacked required band of Landsat data which is acquired in the 2018. The supervised classification technique is used to analyze the classification. The signature value for each land use and land cover feature collected manually from signature editor and supervised classification is performed and five classes obtained which are agricultural lands, built up land, fallow and barren land, forest and water bodies.

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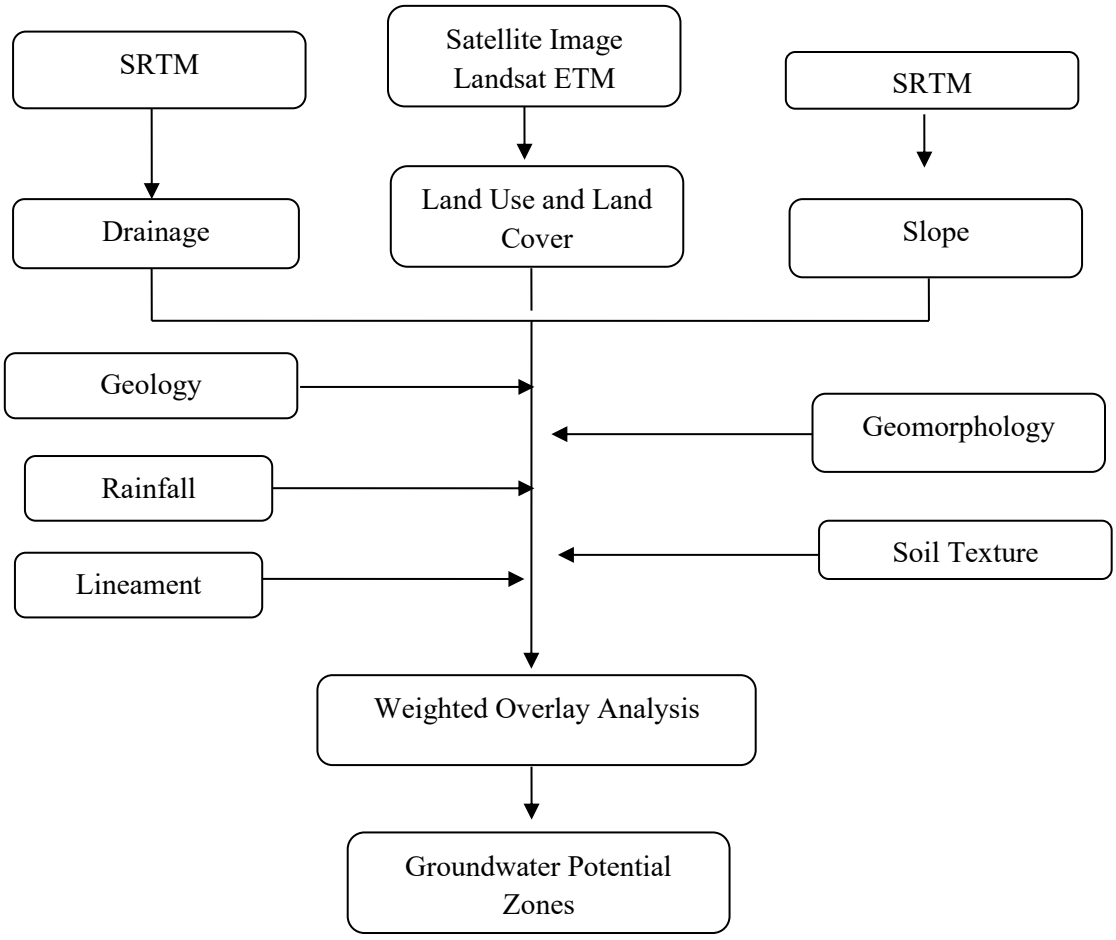

Flow Chart of Methodology of Groundwater Potential Zone

The drainage network is derived from SRTM data which is obtained from earth explorer and drainage is generated in the GIS environment. Drainage density is used for the analysis so; it is prepared using line density tool in the GIS environment. The geology data obtained from the Geological Survey of India (GSI) resource map and prepared vector layer in ArcGIS and converted into raster for analysis. The lineament data used from the GSI map and lineament density is calculated using line density tool in GIS environment. Rainfall data received from IMD, Pune and average rainfall is taken into consideration for the groundwater potential mapping. Slope is derived from SRTM data and prepared using spatial analyst tool from ArcGIS. Soil data is obtained from soil department. The geomorphology data obtained from the Geological Survey of India (GSI) resource map and prepared vector layer in ArcGIS and converted into raster for analysis.The weightage was assigned to each feature on knowledge-based method and influencing factor of the feature. Each thematic layer assigned appropriate weights to each feature according to the impact of the feature and each class assigned the rank. The weigthage overlay analysis tool used to perform groundwater potential mapping in the GIS environment.

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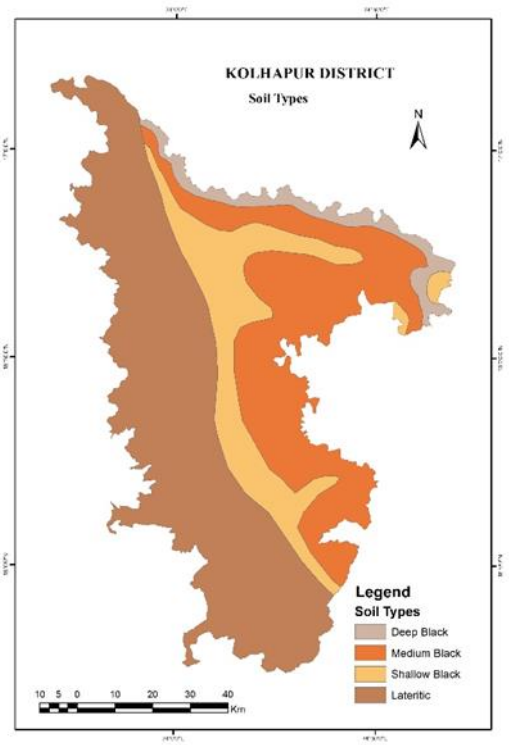
Thematic Layers for Groundwater Potential Zones:

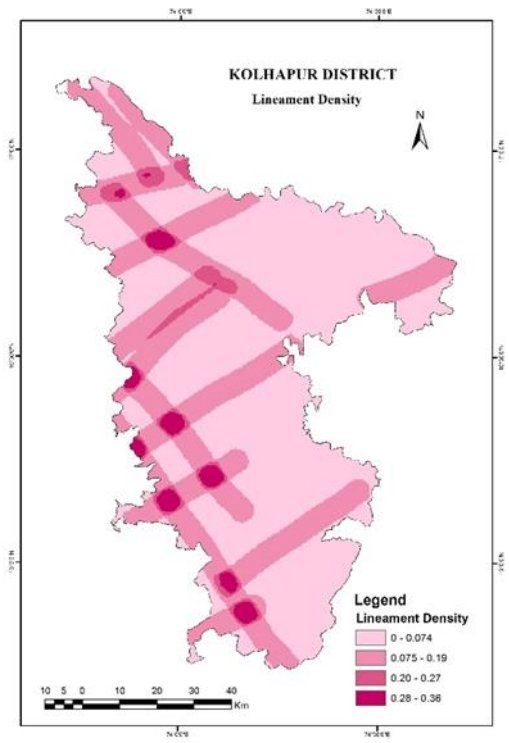
Soil:

Soil type controls and having impact on the rate of infiltration. Clay, deep black soil is having low infiltration and resulting into the low groundwater potential. In the Kolhapur four types of soil found. The soil map of study region is obtained from the Geological Survey of India. The deep black, medium black, shallow black and lateritic are soil group found in the Kolhapur district. Lateritic soil type found in the hilly track of Western Ghat which is porous and low water holding capacity, so this area facing water shortage during summer season. Major part of the Kolhapur district covered by the lateritic soil type and deep black soil in the eastern side and in the river flood plain area of the study region and nearly 30 per cent area covered by shallow black soil which is favorable for the groundwater potential.

Rainfall:

Rainfall is main source water on the earth surface and rainfall is a good indicator of the groundwater availability. Higher rainfall area is having good potential of groundwater and low rainfall area resulting drought condition and scarcity of water resources in that region. The Kolhapur district receives rainfall from the south-west monsoon and distribution of the rainfall is uneven in the study region. In the study region rainfall is decrease from west to east. Western Ghat area is receiving highest rainfall which above 5000 mm and lowest in the eastern region which is below 600 mm.





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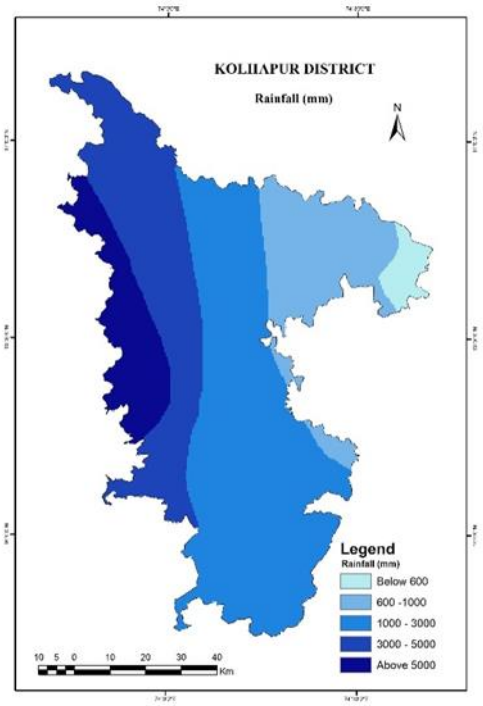

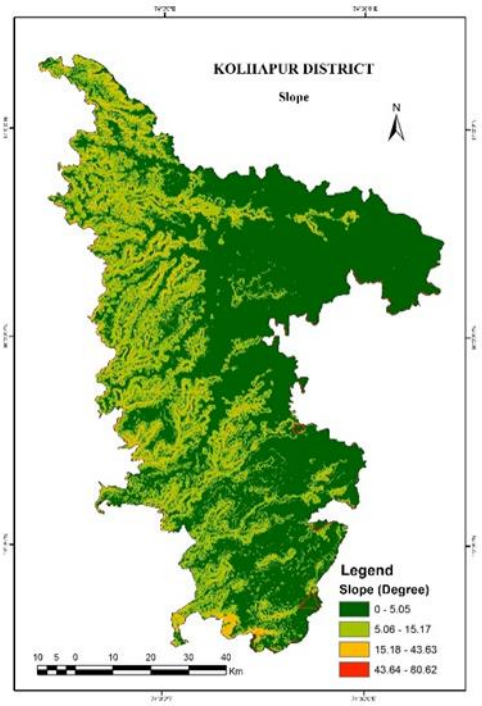

Geology:

Geology is one of the major factors which play an important role in the distribution and occurrence of groundwater. The Kolhapur district is generally formed by ingenious rocks in Deccan trap formation. The Deccan trap rock formation and basalt rock having hard rock structure in the region and it is having impact on the groundwater potential in Kolhapur District. The hilly area is having patches of lateritic rock formation and water infiltrate from it and this area facing water shortage during summer season when this area is receiving highest rainfall during rainy season.

Slope:

Slope is very important and potential determining factor. The slope of the area is derived from the SRTM data and in the GIS environment. Steep slope area having highest runoff and low infiltration rate and this area is having low potential of ground water. Plain surface and gentle slope area is having low surface runoff resulting into higher the rate of infiltration and this area having good potential of groundwater. In Kolhapur district Sahyadri hill area giving steep slope and heavy rainfall and surface runoff also high so all rivers originate in this area. The eastern part of the Kolhapur district is having plain surface and less slope this area is having good potential of groundwater.

Lineament Density:

Lineaments are indicators of subsurface faults and fractures influencing the occurrence of ground water. Geological features that give rise to lineaments include faults, shear zones, fractures, dykes and veins as well as bedding planes and stratigraphic contacts Higher lineament density found in the hilly western area of the district and low in the eastern part of the Kolhapur district. The area with very high lineament density is having good groundwater potential where as area with very low lineament density having poor groundwater potential.

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Drainage Density:

The density of drainage is one of the factors which play important role in the mapping of groundwater potential zones. In the higher density area surface runoff is high and resulting infiltration rate is low so it is indicate the low groundwater potential. In the area of low drainage density the surface runoff of water is low and resulting into the high rate of groundwater infiltration and this area is good for the groundwater potential. For the Kolhapur district the drainage stream network is derived from the SRTM data which is provided by NASA mission of elevation data and the stream network is generated in the GIS environment. The GIS environment is best for the mapping of drainage network from the elevation data which is accurate and reliable for the drainage density analysis. The line density method is used to calculate the drainage density of the Kolhapur district.

Geomorphology:

Geomorphology is the study of origin and development of the landforms on the earth surface. Geomorphological landforms are the outcome of surface, rock structure, and agents of denudation. It is having impact of geological structure on the distribution and formation of landforms. Kolhapur district having different types of landform and distributed in the all part of the region which are denudational hills and valleys, high level plateau, middle level plateau, denudational plateau and denudational slope.

Denudational plateau is having in patches in the southern part of the region. Most of the part of the district is covered by the middle level plateau.

Land Use / Land Cover:

Land use is coming land under the land used for the man made activities. Man uses land for the various development purposes. The agricultural fields, canal, other irrigation structures, road and other transport network, building are falling in the classes of land use. Land cover is natural features such as forest, hills, valley, and natural water bodies. The land use and land cover prepared from the Landsat ETM satellite imagewhich was downloaded from the earth explorer website. The map was prepared using ERDAS Imagine software and using supervised classification method. Kolhapur district is having different classes such as agricultural land, forest, barren land, built-up area, and water body.

Assigning Weightage to Feature:

The influence of the multi criteria factor was used for mapping the groundwater potential zones of Kolhapur district these are rainfall, land use and land cover, geology, geomorphology, soil types, lineament density, slope, and drainage density. Each were examined and assigned appropriate weights to each feature according to the impact of the feature and class for occurrence, storage and accumulation of groundwater. The Weightage was assigned to each feature on knowledge-based method and influencing factor of the feature. The value one is assigned to the less potential and five and in some layer four is high potential.

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Table 1: Classification of Weightage

Sr. No.	Thematic Layer	Weightage	Feature	Rank
1	Soil Type	12	Deep Black	1
			Medium Black	3
			Shallow Black	4
			Lateritic	2
2	Geology	13	Recent Cainozoic	2
			Deccan Trap	1
			Kaladgu Super Group	3
			Dhawar Super Group	4
3	Slope	12	0 - 5.05	4
			5.06 - 15.17	3
			15.18 - 43.63	2
			43.64 - 80.62	1
4	Drainage Density	13	0 - 0.8	5
			0.8 - 1.6	4
			1.6 - 2.9	3
			2.9 -3.4	2
			3.4 - 4. 9	1
5	Geomorphology	10	Denudational Slope	1
			Denudational Hills and Valley	2
			High Level Plateau	3
			Middle Level Plateau	5
			Denudational Plateau	4
6	Rainfall	15	Below 600	1
			600 - 1000	2
			1000 - 3000	3
			3000 - 5000	4
			Above 5000	5
7	Land Use and Land Cover	14	Agricultural Land	4
			Fallow and Barren land	2
			Built-up	1
			Forest	3
			Water body	5
8	Lineament Density	11	0 - 0.074	1
			0.075 - 0.19	2
			0.20 - 0.27	3
			0.28 - 0.36	4

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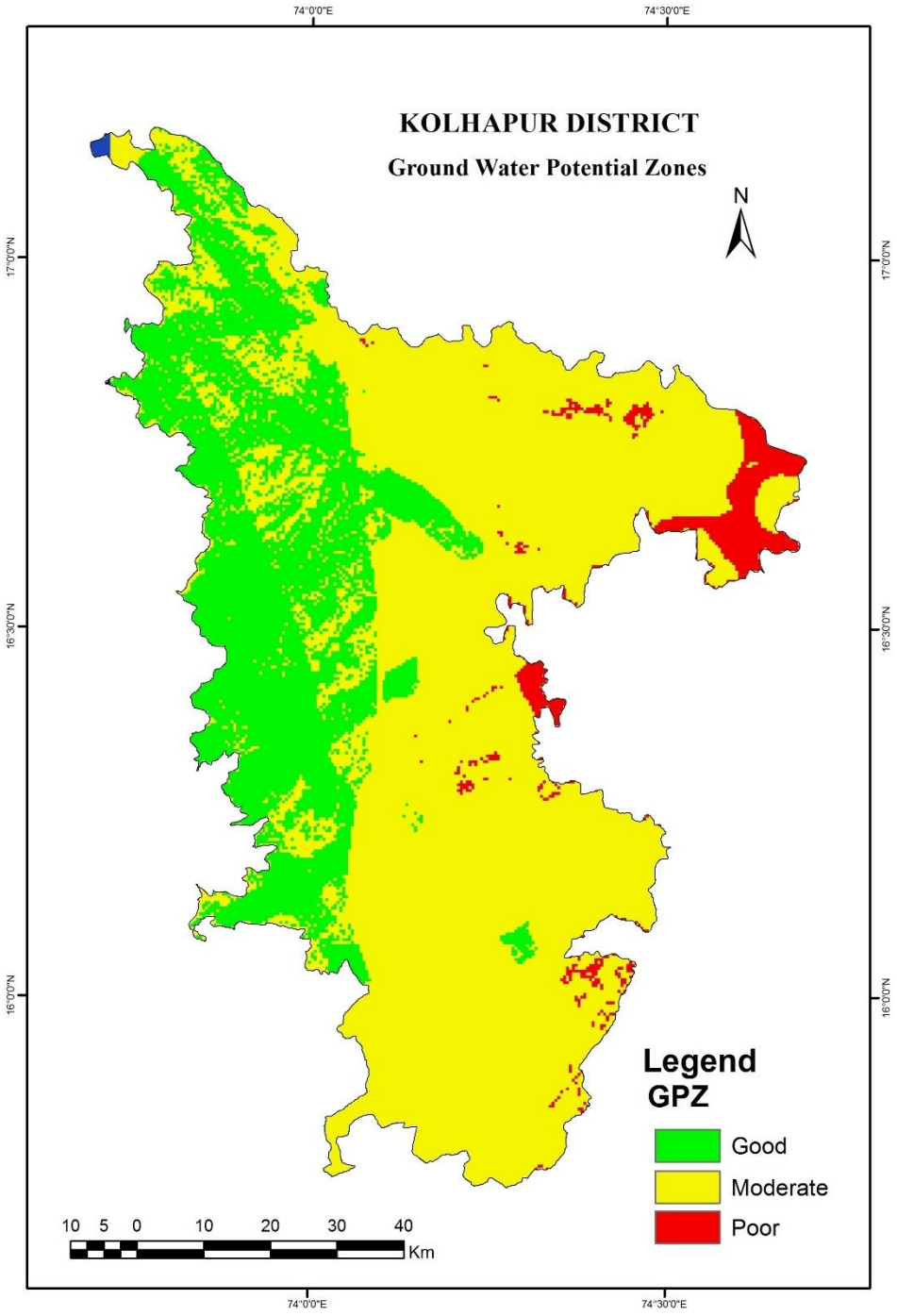

Results and Discussion:

Groundwater potential zone mapping analyzed for the Kolhapur district for the better planning and management of groundwater resources. For the sustainable management of resources, the planning more important and for that purpose mapping of available groundwater resource is key aspect. For the mapping multi criteria, different influencing factors which are having direct relationship with the groundwater potential are used for the analysis. Rainfall, soil type, geomorphology, geology, drainage density, slope, land use and land cover, and lineament density. The weightage is assigned to each parameter and rank is assigned to

each feature class of that parameter and Weighted Overlay analysis tool from the Spatial Analyst toolset of ArcGIS Software, used to perform overlay analysis in GIS environment. Groundwater potential analysis has been classified into three classes such as good, moderate, and low potential. The good potential zones found in the area of high rainfall and higher density of lineament. Moderate potential area covered major part of the district and middle part of the district is found moderate groundwater potential. Low potential is found in small patches of deep soil, low density of lineament, and in low rainfall area.

Conclusion:

Multi criteria thematic layers and parameters with proper weightage and working in the GIS environment using weighted overlay analysis is an effective tool for the accuracy of the results in groundwater studies of the region.The thematic layers such as land use / land cover, geology, soil types, lineament, drainage network, slope, and rainfall of the Kolhapur district was used for the mapping groundwater potential zones. Spatial data, remote sensing satellite images, and GIS environment is effective and very accurate tools for the analysis and proper mapping of groundwater resources. Advanced remote sensing and GIS technologies are found to efficient in minimizing cost of work, and time. Kolhapur district was classified into three classes as good, moderate and poor potential on the basis of analysis for groundwater resources. Over utilization of the groundwater indicate that there is need to give attention towards the artificial recharge of groundwater to increase the potential of water resources for sustainable development and proper management of groundwater resources.

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