Assessment of Groundwater Depletion and quality in western Indian river basins using GIS and Remote Sensing Techniques

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Abstract - To settle water shortage and safeguard water quality, surveying groundwater assets is of most extreme significance, especially in regions encountering developing anthropogenic tensions and ecological changes. In this review, geographic data frameworks (GIS) and remote sensing techniques are joined to examinations groundwater quality and exhaustion in the Western Indian River Basins. There is a developing requirement for groundwater assets in the Western Indian River Basins because of impressive changes in land use, populace increment, and horticultural practices. The production of proficient observing and the executive's frameworks has become essential because of these changes. In this present circumstance, GIS gives areas of strength for a for the review and perception of spatial information, while Remote Sensing gives significant data about changes in land cover and hydrological processes. In view of the coordinated utilization of remote sensing and Geological Data Frameworks (GIS), groundwater research has been finished in the Western Doon valley to characterize the groundwater potential and groundwater quality zones suitable for private purposes. The Western Doon Valley is loaded up with post-Siwalik fluvial and flotsam and jetsam stream stores from the late Quaternary-Holocene and possesses immense synclinal box in the creating fold-push arrangement of the sub-Himalaya.

Keywords - Groundwater, Quality, Western Indian, River Basins, GIS, Remote Sensing

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1. INTRODUCTION

A key natural resource, groundwater is essential for maintaining ecosystems, enabling agriculture, and meeting home and industrial water needs. The evaluation of groundwater depletion and quality has become crucial in areas like the Western Indian River Basins, where population increase, urbanization, and changing agricultural practices place increasing demand on water resources. A thorough and organized approach to comprehending the complex dynamics of groundwater supply and quality is provided by the combination of cutting-edge technology like Geographic Information Systems (GIS) and remote sensing. The Western Indian River Basins, which contain a wide variety of geographies and hydrogeological conditions, have seen significant changes in water demand and land use patterns. Intricate interactions between surface water bodies, aquifers, and human activities have resulted from these changes, demanding a multimodal assessment strategy. Traditional groundwater evaluation techniques frequently fail to adequately account for the complex regional and temporal variations in depletion and quality. Therefore, using GIS and remote sensing techniques has emerged as a viable way to close this gap and give a comprehensive understanding of the dynamics of groundwater.

The integration of diverse geospatial data sets is made possible by the spatial analysis tool GIS, which makes it easier to create precise maps and models. Researchers and decision-makers can better understand the linked nature of geological, hydrological, and anthropogenic processes influencing groundwater supplies thanks to its capacity to visualize, analyze, and interpret complex spatial interactions. Aerial and satellite photography also give real-time and historical data on surface water fluctuations, vegetation dynamics, and changes in land cover, which helps in identifying potential causes of groundwater changes.

1.1 Pressures on resources and water scarcity:

Growing Concerns Worldwide Regarding Water Scarcity:

One of the most important issues of the twenty-first century is water shortage, which has a significant impact on ecosystems, economies, and human well-being. The availability of freshwater resources has decreased as a result of rapid population development, urbanization, industry, and climate change. Regions struggle with declining water supplies, growing competition for water, and the possibility of social, economic, and environmental disruption throughout the world. The Sustainable Development Goal 6 of the United Nations, which aims to ensure access to and sustainable management of water and sanitation for all people, highlights these challenges.

The Western Indian River Basins are significant because they serve as a microcosm of the problem of worldwide water shortage, which is exacerbated by the particular topographical and socioeconomic characteristics of the area. These basins, which include a variety of habitats, including dry and semi-arid areas, are particularly susceptible to changes in the amount of water available. Water scarcity has ramifications for a variety of industries and uses, including agriculture, industry, residential consumption, and environmental preservation. Since water is a vital resource for sustaining life and supporting economic activity in these basins, efficient management and sustainable use are absolutely essential.

1.2 Groundwater Assessment's Importance

Important Function in Maintaining Agriculture, Ecosystems, and Domestic Water Supply:

The water held in aquifers under the Earth's surface, known as groundwater, has a vital and diverse role in supporting a number of components of both natural and human systems.

Ecosystems: Groundwater supports wetlands, springs, and river baseflows, preserving habitat for a variety of plant and animal species. It ensures the vitality of delicate habitats and boosts overall biodiversity by acting as a lifeline for them.

Agriculture: Groundwater is used extensively for agricultural irrigation in several areas, notably the Western Indian River Basins. It offers a steady and dependable supply of water that promotes crop development, assuring food security and permitting agricultural output even during dry spells.

Domestic and Municipal Water Supply: In many communities around the world, groundwater is the main supply of drinking water, especially in regions where surface water supplies may be constrained or contaminated. It offers a consistent and frequently excellent water supply for domestic usage, governmental functions, and industrial processes.

2. REVIEW OF LITREATURE

"Assessment of groundwater depletion and quality using remote sensing and GIS in the Thar Desert, India," by Singh and Yadav (2019), was a well-researched paper that was published in Groundwater for Sustainable Development. Their study concentrated on the Thar Desert, which is prone to water scarcity. The authors offered a thorough understanding of groundwater dynamics, depletion trends, and quality variations by merging GIS and remote sensing. The study's conclusions highlighted how crucial these technologies are to improving groundwater management plans.

With their study on "Groundwater quality assessment using GIS and remote sensing in a semi-arid region of Western India," which was published in Modelling Earth Systems and Environment, Kumar, Singh, and Singh (2020) made a contribution to the field. The importance of GIS and remote sensing in assessing groundwater quality indicators was highlighted in this work. These methods were used by the researchers to pinpoint geographic patterns of groundwater quality fluctuations, allowing for informed water use decisions.

Environmental Monitoring and Assessment's article from Sharma and Kansal (2018), "Assessment of groundwater depletion using GIS and remote sensing in an urbanizing region of North India," was examined. Their study focused on the problems that urbanization poses for groundwater supplies. In addition to demonstrating the value of GIS and remote sensing in assessing groundwater depletion, the study also emphasized the urgent need for efficient management measures in areas that are quickly urbanizing.

Joshi and Bhatt (2021) looked into "Spatial and temporal assessment of groundwater depletion using remote sensing and GIS: A case study of Sabarmati River Basin, Gujarat, India," which was written up in Environmental Monitoring and Assessment. The researchers used GIS and remote sensing to examine the temporal trends of groundwater depletion with a focus on the Sabarmati River Basin. The study proved the utility of these technologies in gaining knowledge about how groundwater dynamics change over time.

With their paper on the "Spatiotemporal assessment of groundwater depletion using GIS and remote sensing in Upper Krishna River Basin, South India," published in Groundwater for Sustainable Development, Srinivas and Setty (2017) made a contribution to the field. Their study emphasized how crucial it is to take both time and space into account when evaluating groundwater. The authors presented important details on the regional distribution of groundwater depletion in the Upper Krishna River Basin using GIS and remote sensing.

According to Environmental Earth Sciences, Rao and Kumar (2019) evaluated "groundwater depletion and water quality using GIS and remote sensing techniques in Guntur District, Andhra Pradesh, India." This study brought attention to the importance of both groundwater quantity and quality. The authors provided insights into both depletion trends and fluctuations in groundwater quality metrics by utilising GIS and remote sensing, which improved comprehension of the region's water resource issues.

Using GIS and remote sensing, Patil and Patil (2018) examined "Assessment of groundwater quality and its spatial variation in the semi-arid region of Maharashtra, India," which was published in Environmental Earth Sciences. Their research emphasized how important it is to comprehend groundwater quality in semi-arid areas. The authors conducted a spatial analysis of groundwater quality fluctuations using GIS and remote sensing, which helped in the creation of targeted groundwater management strategies.

In their paper, "Assessment of groundwater quality using remote sensing and GIS techniques: A case study of Lower Tapi Basin, Gujarat, India," Tiwari and Wagle (2018) published their findings in Environmental Monitoring and Assessment. The Lower Tapi Basin groundwater quality characteristics were the subject of their study. The scientists used GIS and remote sensing to identify regional patterns of groundwater quality variations, which helped identify potential sources of pollution.

3. METHODOLOGY

The center topical layers in the GIS climate were made utilizing the remote sensing IRS-1D, (LISS-III) information of October 23, 2002, joined with geographical guides and field information. By outwardly examining satellite symbolism related to the accessible assistant information and ground studies, assessment of the territory and a few topical layers have been arranged, including geography, geomorphology, structure, hydrogeomorphology, waste, and land use/land cover. The SRTM DEM has been utilized to make an incline map utilizing the ERDAS Envision software engineer. The seepage surface guide was made utilizing the Circular segment GIS developer. The dirt surface guide of NBSSLUP, Nagpur, filled in as the reason for making the pressure driven soil bunch map. Spring boundaries and their attributes were found out from siphoning test information assembled during the field study, including (static water table, release, drawdown, explicit limit, and so forth), and well stock of dug wells completed during ground reviews (pre-rainstorm in the period of April-May, 2004, and post-storm in the long stretch of October-November, 2004), including profundity to water table, water table change. To break down the groundwater quality of dug wells and cylinder wells, field estimations of pH, TDS, and EC were made. Also, utilizing regular hadrochemical methods, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and anions including chloride (Cl), sulfate (So4), fluoride (F), nitrate (No3), and silica oxide (Sio2) were analyzed.

Groundwater quality guides for water system and drinking designs were made in light of the cations and anions information referenced previously.

In the ebb and flow study, a record overlay technique has been utilized to coordinate different topical layers into the GIS climate for groundwater prospect zones, including hydrogeomorphology, land use/landcover, soil surface, slant, seepage thickness, pre-storm and post-rainstorm water tables, water table variance, static water levels (tube wells), lineament distance, release, drawdown, and explicit limit.

The WHO (1984) and BIS (1991) principles were utilized to analyze the drinking water quality of the groundwater, and it was found that a few examples had Ca, Mg, TH (complete hardness), and NO3 levels that were higher than the best reach. Guides of the examination region's water quality have been made, showing where TH, Ca, Mg, and NO3 fall into alluring and awful classes.

Alloted loads for groundwater investigation went from 1 to 10, and those for groundwater quality (fitting or inadmissible) went from 1 to 2. The class with the most noteworthy weight is awesome for both the quality and capability of the groundwater. For positive or attractive, the least class is granted. The total subject layer was coordinated to make the groundwater expected zones, which were then ordered in light of the weight factors tracked down all through the exploration. The opportunities for fitting and unacceptable groundwater quality was additionally recognized. The cycle is portrayed in the flowchart (Fig. 1).

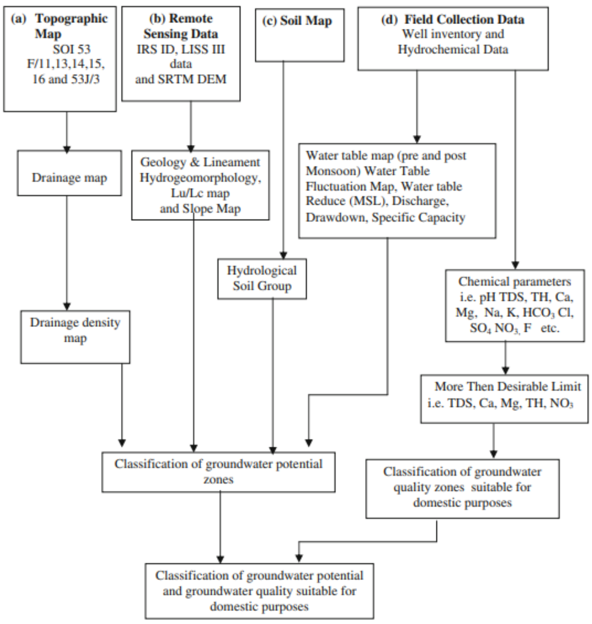

Figure 1: Diagram of the methodology

On the two sides of the Asan River, piedmonts are found, making around 451.93 km2 (57.25%) of the all out region. On the two banks of the Asan River, the more seasoned and more youthful porches cover 110.41 km2 (13.98%) of the absolute region, while the flood plain covers 57.19 km2 (7.24%), as demonstrated in Table 1.

3.1 Slope

For groundwork for slant classes including almost level, exceptionally gentle, delicate, moderate, respectably steep to soak, and extremely steep, the SRTM Advanced Height Model (DEM) was utilized. 77% of the examination region (610.41 km2) is basically level, 20% (153.58 km2) has an extremely gentle to medium slant, and the leftover 25% (25.08 km2) has a moderate to exceptionally high incline. The incredibly delicate, medium, and moderate slant groupings all have low help. The slants that are decently steep to soak and very steep have moderate alleviation. The weight 6 has been assigned as the evidential topic for the incline class.

3.2 Land Use/Land Cover

Significant marks of how much groundwater is required and utilized are given via land use and land cover. The land use/land cover classes, for example, rivers, ranch fields, thick woodlands, settlements, debased backwoods, and open timberlands, have been characterized in light of FCC of the IRS-LISS III satellite information by regulated advanced order in the ERDAS Envision programming. The weight 8 is the evidential topic alloted by the land use/land cover class. Rivers make up 8.69% (68.62 km2) of the concentrated-on region. 8.91% (70.38 km2) of the exploration region is populated. 24.67% (194.76 km2) of the land is covered by agribusiness, which is practically in the center of the exploration region. 6.49% of the examination region, or 51.30 km2, is covered with open backwoods. This region is situated in the review region's south and north. On the southern and northern sides of the exploration region, separately, thick timberland and debased woodland cover 35.71% (281.88 km2) and 15.49% (122.32 km2) of the domain, which is basically uneven.

4. RESULTS AND DISCUSSION

4.1 Potential Groundwater Zones

Critical signs of how much groundwater is required and used are given by means of land use and land cover. The land use/land cover classes, for instance, rivers, farm fields, thick forests, settlements, corrupted woodlands, and open forest areas, have been portrayed considering FCC of the IRS-LISS III satellite data by managed progressed request in the ERDAS Imagine programming. The weight 8 is the evidential subject alloted by the land use/land cover class. Rivers make up 8.69% (68.62 km2) of the focused on district. 8.91% (70.38 km2) of the investigation district is populated. 24.67% (194.76 km2) of the land is covered by agribusiness, which is basically in the focal point of the investigation district. 6.49% of the assessment area, or 51.30 km2, is covered with open woodlands. This area is arranged in the audit district's south and north. On the southern and northern sides of the investigation area, independently, thick forest area and degraded forest cover 35.71% (281.88 km2) and 15.49% (122.32 km2) of the space, which is essentially lopsided.

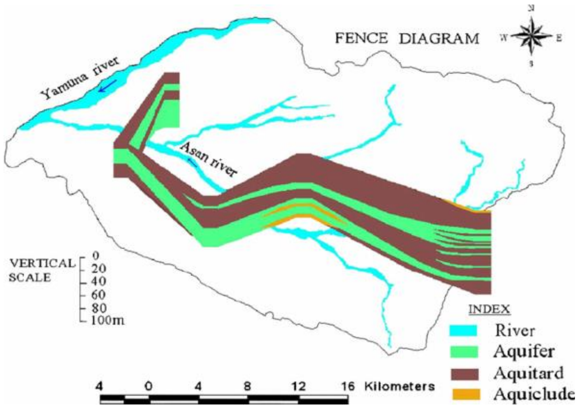

Figure 2: Chart of a wall demonstrating the horizontal and vertical situation of a spring

Table 1: Examination of study region groundwater quality boundaries to WHO (1984) and BIS (1991) norms

Parameters	Units	WHO (1984)	BIS (1991)	Concentration in Study Area	Highest Desirable Limit	Maximum Permissible Limit
pH		9.3	8.2	8.9–9.5	9.7	9.5
TDS (Mg/l)		612		90–400	1500	3120
Calcium (Mg/l)		75	75	10–89	200	400
Magnesium Mg/l)		30	30	0.97–32.4	212	200
Potassium (Mg/l)		-	-	0.03–7.2	-	-
Sodium (Mg/l)		-	-	4.5-30	320	-
Bicarbonate (Mg/l)		-	-	61–300	-	-
Chloride (Mg/l)		300	412	6.3-75	70	1523
Sulphate (Mg/l)		352	300	6-91	500	500
Nitrate (Mg/l)		52	52	1.6–63	-	200
Fluoride (Mg/l)		-	1.0	0.008–0.24	-	3.2
Total Hardness (CaCO3)		200	400	60–300	400	700

Table 2: Different attributes of groundwater quality are classified for home use.

Class Criteria	Total Dissolved Solids (mg/l)	Total Hardness (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Nitrite (mg/l)
Very Low	<300	-	52.20 (758.69)	-	92.57 (685.85)
Low	312–620	-	20.91 (135.80)	-	1.25 (5.62)
Moderate	600–952	-	-	-	-
High	800–2000	-	-	-	-
Very High	>2000	-	-	-	-

Soft Water	-	<89	-	-	-
Moderately Hard-Hard Water	-	80–185	-	-	-
Hard Water	-	200-400	-	-	-
Very Hard Water	-	>400	-	-	-
Low Concentration	-	-	70.15 (615.05)	-	-
Medium Concentration	-	-	40.65 (312.33)	-	-
Low Concentration	-	-	-	99.85 (685.98)	-
Medium Concentration	-	-	-	5.45 (56.30)	-
Low Concentration	-	-	-	-	98.51 (788.69)
Medium Concentration	-	-	-	-	1.28(5.64)

4.2 Groundwater Quality Zones

Amount of groundwater is reliant upon groundwater re-energize from many sources. In the event that there is a lot of groundwater release and there is a more noteworthy re-energize from the surface water, the toxins in the surface water from different sources might influence the quality of the groundwater. The surface water that straightforwardly enters the groundwater has countless pollutants because of human exercises as well as because of spills or removal of pesticides, manures, petrol hydrocarbons, modern synthetic substances, and side-effects. Groundwater quality will be harmed when the review locale is created and farming area is moved to non-horticultural purposes. The land use and land cover, or modern turn of events, various anthropogenic exercises, geographical circumstances, and soil conditions, are the elements directing the groundwater quality of the concentrated-on locale. We can gather that the quality of groundwater is geogenic in light of the previously mentioned managing factor.

The hadrochemical results have been evaluated to decide if groundwater is reasonable for drinking and general wellbeing targets. These hadrochemical attributes of the examination region's groundwater (Table 2) were contrasted with the necessities laid out by the WHO (1984) and the Department of Indian Guidelines (1991).

The water's pH goes from 6.5 to 7.9, demonstrating a somewhat acidic to somewhat basic structure.

The water is sufficient for domesticated animals since the absolute broken up solids (TDS) ranges somewhere in the range of 90 and 400 mg/l inside the most suggested limit, with 84.19% (664.52 km2) of the exploration region being under 250 ppm and the excess region being somewhere in the range of 250 and 500 ppm (Table 3). The Ca2+ and TH (Ca2+plus Mg2+) 10-89 mg/l and 40-300 mg/l are more than as far as possible as per WHO (1984) and Department Indian Norm (1991), proposing decently difficult to hard water in certain areas, which is a super durable condition welcomed on by the transcendence of solid acids (TA TH). As per the hydrochemistry of the ground water in the review region, feeble corrosive (HCO3-) beats solid acids (Chloride, Sulfate, and Nitrate), basic earths (calcium and magnesium) dwarf alkalies (sodium and potassium), carbonate hardness (optional alkalinity) surpasses half, and powerless corrosive outflanks alkalies (sodium and potassium).

As indicated by Sawyer and McCarty's (1967) arrangement for hardness, tests can be categorized as one of three classes: delicate, modestly hard, or hard (Table 4). A TH fixation that is too high makes no adverse consequences, yet there is some proof that it adds to coronary illness. Inadmissible for private use is hard water. Bubbling water can only with significant effort wipe out the enduring hardness.

Table 3: Water hardness grouping by Sawyer and McCarty (1967)

Hardness (as CaCO3)	Water Class	Pre-monsoon Samples	Post-monsoon Samples
0–75	Soft	18	5
75–150	Moderately Hard	31	30
150–3000	Hard	15	20
>3000	Very Hard	-	-

Bubbling water can only with significant effort wipe out the tireless hardness. With a couple of exemptions, the degrees of nitrate, fluoride, sulfate, and chloride are inside the best reach. Since the TH is inside the most extreme ideal cutoff and different cations and anions are likewise inside the most noteworthy beneficial breaking point, the groundwater is appropriate for drinking and keeping up with general wellbeing (Table 3).

A few examples of groundwater for drinking water have been found to have Ca, Mg, TH, and NO3 fixations over the greatest suggested range (Table3). The straightforward methodology of triangulation and addition procedures were utilized to make forms, which were then plotted in the areas of the particular examples. Water quality guides for the exploration region's TDS, TH, Ca, Mg, and NO3 that fall among alluring and unwanted cutoff points were made.

5. CONCLUSION

Groundwater is a significant asset with a restricted stockpile. A careful assessment is important to guarantee the insightful utilization of groundwater, and this examination requires a lot of multidisciplinary information from various sources. The right stage for concurrent examination of different informational indexes for decision-production in groundwater the executives and arranging is given by coordinated remote sensing (RS) and GIS draws near. Utilizing the file overlay technique in a GIS climate, a guide of groundwater potential zones was made by coordinating different topical layers, including hydro geomorphologic, land use/land cover, slant, soil, seepage thickness, profundity to the water table of the pre-rainstorm and post-storm periods, water table change, static water level, explicit limit, release, and drawdown maps. From the hadrochemical information, a guide of the groundwater quality zones OK for family use has been made. Guides of the groundwater expected zones and quality zones were overlaid, and the zones were partitioned into alluring and inadmissible quality zones.

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