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Research on Shallow Groundwater Enrichment Assessment Based on RS and GIS Arid and Semi-Arid Areas

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Abstract: The area of arid and semi-arid areas in the world is increasing; in order to solve the issues related to the shallow groundwater enrichment assessment of the arid semi-arid areas, take the typical arid and semi-arid area as the research area of Wuwei Citizen Qin County, Gansu, through remote sensing, GF-6, CBERS04 and DEM are used as data sources to use layer analysis to build an evaluation model for hierarchical enrichment results. It has obtained the laws of shallow groundwater distribution in the research zone in the past five years and the next five years. The trend of water level distribution in the past five years is generally consistent, showing from the southwest to the northeast gradually decreases, there are multiple groundwater funnels, and the shallow groundwater content will remain stable and will increase slightly in the next five years. The results of this study evaluate the development trend of shallow groundwater in Wuwei citizens in Gansu; it provides a scientific basis for future shallow groundwater management.

1. Introduction

Groundwater is one of the important water resources and affects soil characteristics and the growth of vegetation. It is the main source of water for arid semi-arid areas, and it plays a vital role in ensuring the production and life of residents and maintaining sustainable socio-economic development [1]. The search and circle of groundwater resources are the main content research of hydrogeological research. The traditional hydrogeological work is mainly field surveys. With the development of remote sensing technology, this method seems time-consuming and laborious. Remote sensing technology has the characteristics of fast and macro geological information that can save a large amount of material and manpower in field survey, make up for the shortcomings of its cycle and a large workload, and it also solves the problem of constraints such as terrain, climate and other conditions faced by the field survey, it is one of the important technical means to find groundwater resources, provide the important hydrological basis for the planning, development and effective use of groundwater resources. With the progress of science and technology, the spectral resolution, spatial resolution, radiation resolution, and time resolution of remote sensing images have continued to improve; the remote sensing band has also developed to visible light, near-infrared, hot infrared, and microwave L, C bands, etc. [2] [3]. Many researchers [4] began to explore and use the "3S" (RS, GIS, GPS) technology quantitatively anti-surface temperature, humidity, vegetation coverage, and other inertia types, etc. to divide the land use type and vegetation type, establish theoretical and statistical models related to groundwater levels, it has been achieved good results. But surveying groundwater resources through remote sensing technology, especially from qualitative description to quantitative extraction, needs a large number of mathematical models and algorithms. Researchers have been working hard for many years; although the accuracy continues to improve, there is still a lot of room for research. The method of groundwater resource survey remote sensing analysis has gradually developed from monocular models (such as soil moisture and water body index) to multi-factor models [5] [6] [7]. Multi-parameter optimization method of hierarchical analysis [8] by decomposing complex problems, establishing an interconnected hierarchical structure model, utilize the weight and sorting of the upper and lower layers to solve the problem. It has the advantages of simple use, high benefits, and a small workload. Compared to the traditional method, it is more convenient and efficient, and the model construction is more accurate.

This article uses data such as GF-6, CBERS-04, and DEM to combine the local hydrogeological data of the research area as the data source and build an evaluation model for enrichment grading results using layer analysis. We can describe the relationship between the index system and evaluation goals through the hierarchical structure. We constructed a hierarchical model with substructures to determine the weights of different evaluation indexes for evaluation goals.

2. Area and Method of Research

2.1 Research Method Introduction

This article uses RS and GIS-based hierarchical analysis methods to evaluate groundwater potential, and the specific process is shown in Figure 1. For the characteristics of the research zone in the text and the selection results of the evaluation index factors, the hierarchical structure analysis, its index factor layer is the result of data countermeasures is important data in the model evaluation, there are seven indexs, extract it through remote sensing technology. Then the linear weighted model was used for the comprehensive weighted average to obtain evaluation results.

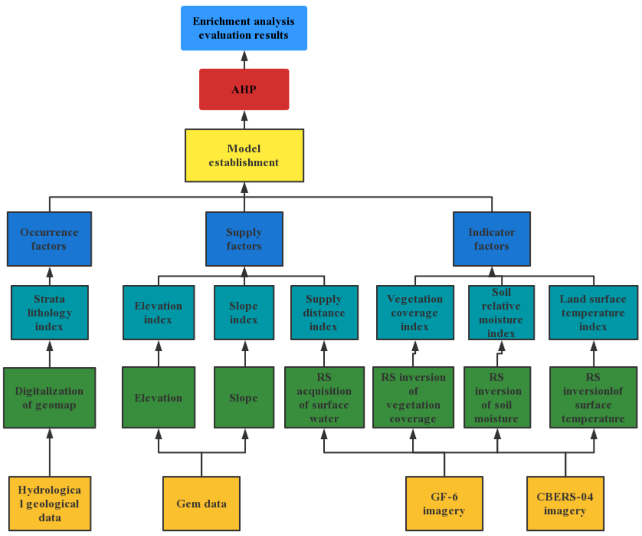


Figure 1: The specific process of RS and GIS-based hierarchical analysis methods to evaluate groundwater potential

2.2 Introduction to the Research Area and Data Source

The research zone is located in Minqin County, Wuwei City, Gansu Province. It belongs to the typical arid desert climate and is a typical climate-sensitive area. The geographical location is shown in the figure. The water content in the north is thin, and the water content in the south is mainly based on the gravel of the accumulation phase; there is a small amount of sub-sand layer in the middle. The overall direction of the shallow groundwater runoff of the research area is the southwest to the northeast, and the hydraulic slope also dropped from 1 ‰ ~ 3 ‰ to 0.7 ‰ ~ 0.8 ‰. Data sources are shown in Table 1.The geographical location is shown in the Figure 2.

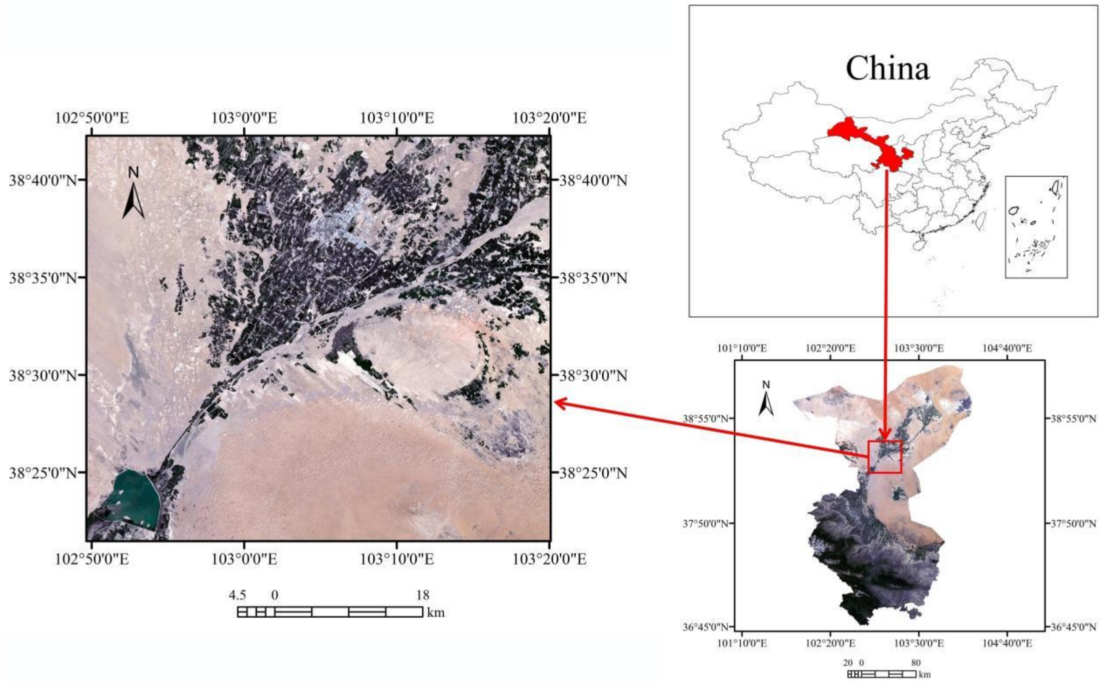


Figure 2: Schematic map of the geographical location of the study area

Table 1: Data sources

Data	Coverage of cloud cover	Image resolution （m）	Scene identifier	Time	Web
GF-6 (WFV)	<10%	16	1119857026 1119839105 1119866193 252203	2019-03-16 2019-01-03 2018-09-05 2018-06-05	http://www.cresda.cn
DEM	<=5%	30	ASTGTMV003_ N38E103	2019-01--2019-04	http://www.gscloud.cn

3. Exclusions Based on Remote Sensing Technology

3.1 Research Zone Stratigraphic Lithology Index

Input different rocky-rich weight information input to a digital geological diagram as a table assignment, and use a heavy sampling method to adjust the spatial resolution to 16 meters; the grades are displayed and drawn by the results of wealthy water evaluation, the rocky stratigraphic index on the weighing weight of the water richness is shown in Figure 3 (A). (See table 2)

Table 2: Research zone stratigraphic lithology index

Serial number	Rock symbol	The main component of rock	Weights
1.	Q4eol	Windy sand	0.3
2	Q41	Sandy clay	0.5
3	Q31	Sandy clay, clay	0.3
4	Q2j	Gravel and sand	0.9
5	Zad3	Phyllite with limestone, Limestone mixed with phyllite	/

3.2 Research Zone Elevation Index

The high program mainly affects the flow of ground runoff and groundwater under gravity; under the influence of high-end influences, it flows from high places to low places. It is believed that the water richness is relatively good in places with low -end values, and the water richness is relatively poor in places with high -end values,as a result, it is determined that the high range is a cost-type indicator. As shown in Figure 3 (B), the topography of the research area shows the trend of the north high and south lows. There is a relatively low-lying area in the southeast and southwest direction. Among them, the low-lying areas in the southeast are large, which is conducive to groundwater enrichment.

3.3 Research Zone Slope Index

The analysis shows that the smaller the slope and the flat the terrain, the more conducive to the gathering of surface runoff and groundwater, and the richness of the shallow groundwater may be better. Therefore, the slope is a cost index. The digital image of the extracted area slope index is shown in Figure 3 (C). It can be seen from the figure that the slope change range of the research area is 0 ~ 75.05 degrees. The total distribution of pixels with a slope of more than 20 degrees accounts for less than 1.4%. The proportion of meta -distribution in the pixels with a slope greater than 25 degrees is less than 0.01%per degree. Although the range of the slope is large, the distribution of different slopes is extremely uneven; most of the slope value is below 20 degrees.

3.4 Research Zone Supply Distance Index

The study of Jha [9] believes that the water supply to the shallow groundwater is limited; the shallow groundwater supply distance in the clay area is around 75m. The stratigraphy of the research zone is mainly the fourth series of loose accumulation, such as gravel, sub-sand soil, etc.; the pore rate is better than the clay, the trainability is also higher than the clay, the difference in pore rate also causes the difference in soil water conduction rates. Essence Figure 3 (D) shows there are two larger areas in the southwest to northeast; the depth of the groundwater buried is shallow and has good potential for groundwater.

3.5 Research Zone Vegetation Coverage Index

To a certain extent, vegetation changes in a region can reflect the changes in local groundwater. The vegetation coverage index extracted by NDVI is shown in Figure 3 (E). Vegetation coverage information with high NDVI values is strong, and the lack of vegetation coverage information in research areas with low NDVI values is unevenly distributed. The sporadic distribution of vegetation coverage information with strong. Most areas of vegetation coverage are low and basically mainly desert. The comparison of vegetation coverage information in the desert area and farmland is very obvious.

3.6 Research Zone Soil Humidity Index

The results of the FTVDI soil humidity grading of the research area are shown in Figure 3 (F). In the anti-discovery results, the Tengger Desert and Badan Jilin Desert are all designated as arid and particularly arid areas. The regional level near Hongya Mountain Reservoir and View Lake is moist or very humid.

3.7 The Temperature Index on the Surface of the Research Zone

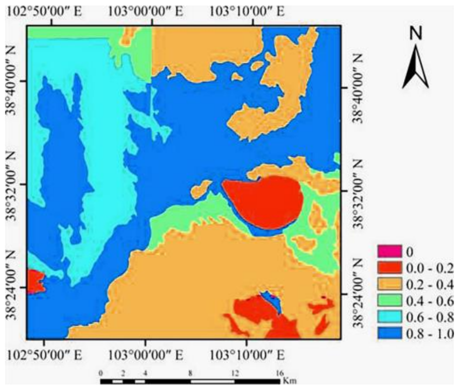
Surface temperature for shallow groundwater and integrating evaluation is a cost-type index; the results of the standardized processing method are used, as shown in Figure 3 (G). Different water content in the ground will also cause different surface temperatures; as a result, the rich area of the shallow groundwater, the greater the water contained in the type of ground, and the slower the temperature on the surface of the day. This also means that the higher the surface temperature, the less likely the possibility of shallow groundwater. Conversely, the lower the surface temperature, the more likely the shallow groundwater is enriched.

3.8 Evaluation of Shallow Groundwater-rich Integrated Results

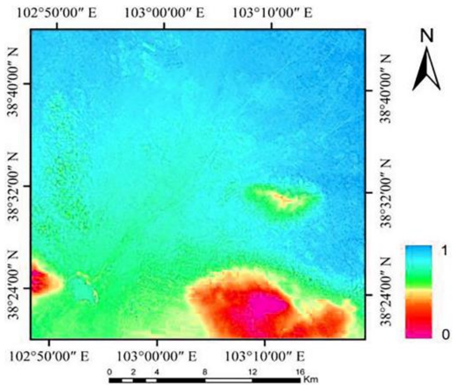
According to the field situation of the research zone, the constructor of the judgment matrix is shown in Table 3. From this, to judge the proportion weight of each index, the consistency test is performed, and the calculation evaluation results are shown in Figure 3 (H). Among the rich assessment results based on hierarchical analysis methods, groundwater enrichment assessment is high -level region mainly located around the Hongya Mountain Reservoir, the ring-shaped area centered on the county and oasis. In the southwest of Suwu Mountain, the enrichment assessment of the Tengger Desert area is low; most places in the Badan Jilin Desert are rated as medium or high.

Table 3: Judgment Matrix

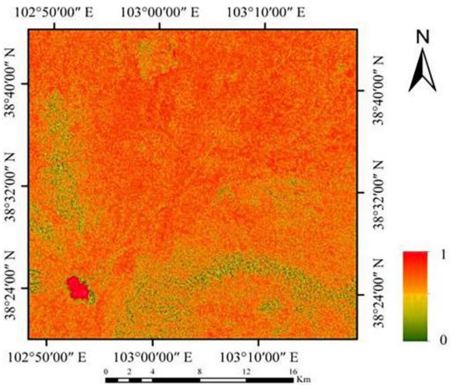
	Dependent factor	Supply factor	Instruct factor	Weights
Dependent factor	1	1/5	1/3	0.1047
Supply factor	5	1	3	0.6370
Instruct factor	3	1/3	1	0.2583

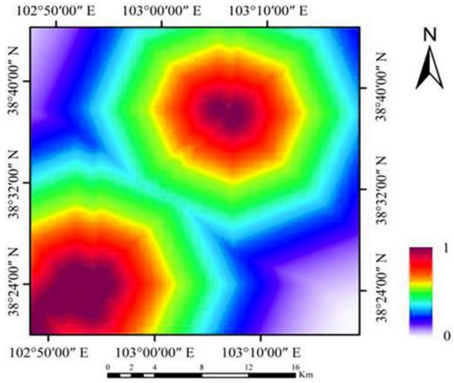


A. Stratigraphic lithology index

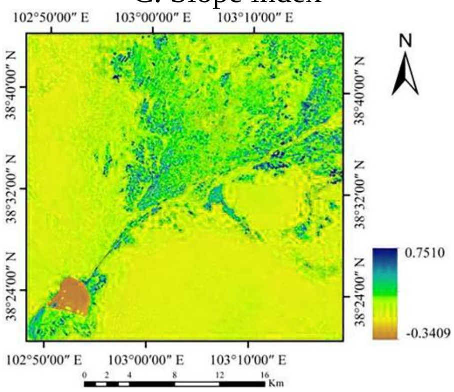


B. Elevation index

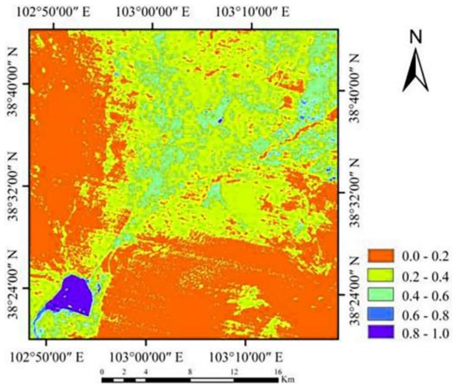




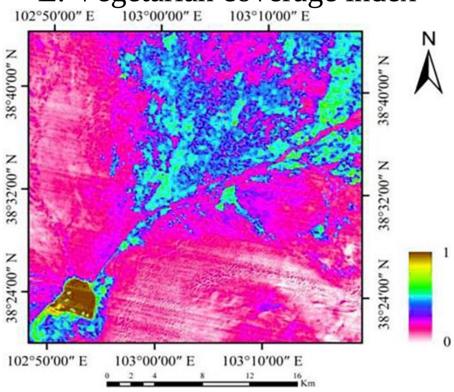
C. Slope index



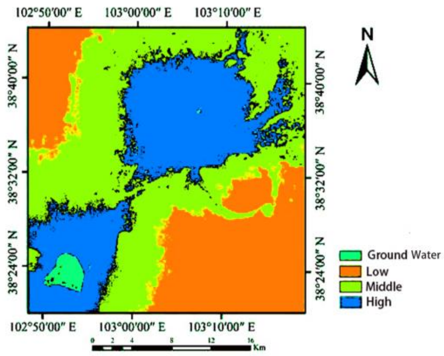
E. Vegetarian coverage index



F. Stranger soil humidity index



G. Surface temperature index



H. AHP evaluation grading diagram

Figure 3: Evaluation of shallow groundwater-rich integrated results

4. The Characteristics of Groundwater Level Distribution and Dynamic Changes

The use of hierarchical analysis methods combined with the remote sensing data obtains the groundwater enrichment assessment of the research area, as shown in Figure 2 H. To test the accuracy of the evaluation method, some sites were selected for field visits to investigate and choose ten areas of water wells to record the maximum rising water. Create geological maps according to hydrological standards, and compare them with the hierarchical results in the model evaluation results. Compare the results of the local survey and evaluation model, as shown in Table 4.

Table 4: The results of the local survey and evaluation model

Serial number	Survey location	Water volume （m3 /d）	Corresponding level Hydrogeological map	AHP
1	Four Clubs in Chongxing Town	About 1200	high	high
2	Hongqi Village, Chongxing Town	About 1200	high	high
3	Hongya Landscape	About 1200	high	high
4	Suwu Temple	About 500	middle	middle
5	Suwu Manor	About 1000	high	high
6	Heihe Farm	About 1000	high	high
7	Erdan Water Pipe Office	About 800	middle	middle
8	Qinfeng Farm	About 900	middle	high
9	Suwu Town Longyi Village	About 1200	high	high
10	Xuebaixiang Xingou Farm	About 600	middle	high

It can be seen in the table that the model based on the surveyed single-well water volume correctly predicts 8 points based on the model-based model, the evaluation results are in line with the actuality, and the evaluation effect is accurate.

4.1 Applicability Analysis of Rich Assessment Results

In this article, the index factors of the groundwater enrichment assessment research, DEM data, and hydrogeological data will not change significantly over time, and the location of the surface water body will not change; therefore, the four index factors of high-end, slope, strata rock, and surface water supply distance will not change significantly over time. Vegetation coverage, surface temperature, and soil humidity based on remote sensing data are closely related to the water content of shallow groundwater and the change in water level at the time of extraction, factors such as seasons, climate, and acquisition time have been fully considered. Analysis of influencing factors through water levels and dynamic changes, the water content state in different areas in the research area has maintained a stable and slightly improved state in the past five years; therefore, the extraction result of the surface index factors will not have a fundamental impact. Although the remote sensing data used in this study came from 2018 and 2019, the shallow groundwater enrichment evaluation methods and rich assessment conclusions of this article can still be applicable to the research zone in 2019 for nearly five years.

5. Conclusion

This article takes the typical arid and semi-arid areas of the northwest of our country -Gansu Minqin Desert Oasis Region; the construction of shallow groundwater enrichment evaluation index systems in arid and semi-arid areas is proposed. Focusing on the index system, stratigraphic, high, slope, water body supply distance, vegetation coverage, surface temperature, and soil humidity are selected from the perspective of generalization and acquisition, the correlation between different index factors, and shallow groundwater. The index factors extracted in the article are based on the layer analysis method shallow groundwater enrichment evaluation models, evaluate the shallow groundwater in the Minqin area, and formulate hierarchical standards. Using the verification set data for accuracy inspection proves that model evaluation based on the hierarchical analysis method can better and more accurately reflect the law of shallow groundwater enrichment.

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