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Exploring the Potential of GIS: Exploratory Spatial Data Analysis of Groundwater Quality and Quantity over Parts of YSR District, Andhra Pradesh, India

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Abstract

Groundwater is one of the important sources on which life on terrestrial habitat survived since centuries. Though impervious to pollutants of the air or any surface phenomena, this precious water source is prone to be affected by its major stakeholders such as humans. Knowingly and by virtue of education and exposure to this fact, humans are changing for a better now and future. Nevertheless, how to know the status of the groundwater prospectus? Moreover, where should we concentrate? In both space and time dimensions is a million dollar question. Exploratory Spatial Data Analysis provides us an opportunity to understand and prepare maps to serve the agencies to act appropriately as far as groundwater quality and quantity is concerned. Through this part of the research, an attempt has been made to study the spatial distribution of groundwater quality and quantity using GIS banked with geostatistics as effective tools. Data was collected all over parts of YSR district and the spatial structure was developed. The key parameters such as TDS, TH, Na, Mg, SAR, EC, pH etc were analyzed. After systematic analysis, the prediction maps were prepared.

Keywords: *geostatistics, GIS, groundwater, interpolation, prediction maps*

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INTRODUCTION

Groundwater is merchandise which is proposed to be utilized wisely whilst ensuring its serenity and sacredness as far as quality and amount. Universal usage in segments, for example, streamlined, metropolitan, commercial, agricultural and private makes groundwater polluted and changing over it as a powerless element. Populace development is on the cutting edge to make an upgraded water request because of everlasting lack of surface water and overweening industrialization. Geographic Data Systems launched a helpful harmonious relationship with ecological concerns and regular assets lately. Vacuity amidst GIS examination and geostatistics are viably connected by ArcGIS Geostatistics analyst module. A few studies were endeavoring utilizing interpolation strategies without Geostatistical analyst and alongside it. Hu et al led a study in which spatial variability existed in groundwater quality in Central North China was adequately resolved utilizing ordinary kriging [1]. Zhu et al readied a spatial conveyance guide of radon by utilizing GIS strategies and kriging in Belgium [2]. D'agostino et al analyzed ordinary kriging and co-kriging procedures whilst concentrating on the spatial dissemination of nitrate concentrations in an aquifer in the central segment of Italy [3]. Istok and Cooper demonstrated that the circular model was the best-fitted model for testing variograms of sulphate, Chloride and EC [4–6]. The points of this examination are to give a diagram of ebb and flow groundwater quality for key parameters, for example, pH, TH, Sodium Absorption Ratio (SAR), Na^{+}, $Mg^{2+,}$ $Ca^{2+,}$ Cl^{-}, HCO_3, total Dissolved Solids (TDS), Electrical Conductivity (EC), Groundwater level (GWL) and to speak to the spatial circulation of key parameters of the study zone utilizing Geostatistical apparatuses and GIS methods.

MATERIALS AND METHODS

The study territory is one of the regions in Rayalaseema district stretching out from 78^0 to 79^0 longitudes and 14^0 to 15^0 latitudes. The study is thrived with timberland and water assets everywhere. The range is honored with awesome gods of Lord Venkateswara and Lord Rama who are prominent in all parts of the world. The water specimens were gathered from bore wells everywhere throughout the locale throughout January 2009 and January 2010. The topo sheets of YSR district was acquired at 1: 50000 scales and were digitized with UTM coordinate framework through on-screen digitization. The products utilized for the whole study were ArcGIS Geostatistical Analyst and ArcGIS alongside kriging strategies for interpolation.

Kriging strategy is the ideal straight forecast of processes, which are spatially connected. This system is utilized within natural screening, hydrology, topography and collaborated extensions for interjection of spatial data. The factual and numerical properties of the samples are dealt with Geostatistical methods, for example, kriging. Inverse Distance Weighting (IDW) is a brisk deterministic interpolator that is accurate. There are not many choices to make in regards to model parameters. It might be a great approach to examine an interpolated surface. On the other hand, there is no appraisal of the prediction errors, and IDW can prepare "bulls eyes" around data areas. There are no presumptions needed by the data. Global Polynomial (GP) is a snappy deterministic interpolator that is smooth. There are not many choices to make in regards to model parameters. It is best utilized for surfaces that change gradually and progressively. Notwithstanding, there is no evaluation of prediction errors and it may be excessively smooth. Locations at the edge of the data can have a vast impact on the surface. There are no assumptions needed by the data. Local Polynomial (LP) is a reasonably fast deterministic interpolator that is smooth. It is more adaptable than the Global polynomial strategy; however, there are more parameter choices. There is no evaluation of prediction errors. The strategy gives expectation surfaces that are tantamount to kriging with estimation lapses. Local polynomial interpolation does not permit you to explore the autocorrelation of the data, making it less adaptable and more programmed than kriging. There are no assumptions needed by the data. Radial Basis Functions (RBF) are decently snappy deterministic interpolators that are careful. They are significantly more adaptable than IDW, yet there are more parameter choices. There is no evaluation of prediction errors. The strategy gives prediction surfaces that are tantamount to the careful manifestation of kriging. Radial Basis Functions do not permit you to explore the autocorrelation of the information, making it less adaptable and more programmed than kriging. Radial Basis Functions make no presumptions about the data. Kriging is a reasonably fast interpolator that could be correct or smoothed relying upon the estimation error model. It is extremely adaptable and permits you to examine graphs of spatial autocorrelation. Kriging utilizes statistical models that yield predictions, prediction standard errors, probability, and so on. The adaptability of kriging can oblige a considerable measure of choice making. Kriging accepts the information generated from stationary stochastic processes, and a few routines accept normally distributed information. The samples collected were physico chemically analyzed and the values obtained were subjected to the aforementioned interpolation methods. After systematic analysis, prediction maps were prepared. The method which exhibits low RMS error was considered fit for producing maps.

RESULTS AND DISCUSSION

The results exhibited relatively less root mean square error (RMSE) whilst using kriging for total hardness (TH), Sodium, Magnesium, Calcium, total dissolved solids, Electrical conductivity (EC) and groundwater levels (GWL). Relatively less RMSE was observed for pH when Inverse Distance Weighted (IDW) method of interpolation is applied. Global polynomial Interpolation (GPI) yielded less RMSE when compared with other interpolation methods for SAR, Sulphates and Chlorides. Local polynomial interpolation resulted with a relatively less RMSE when applied for bicarbonates. The maps were represented in (Figure 1–12).

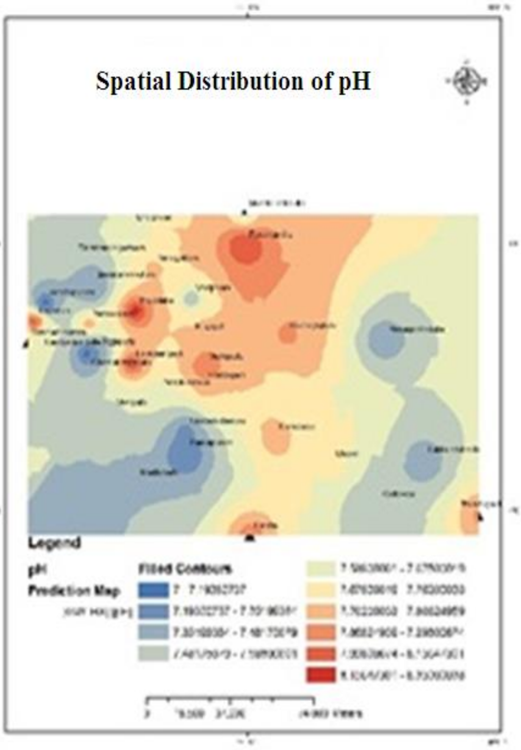

Fig.1: *Spatial Distribution of pH.*

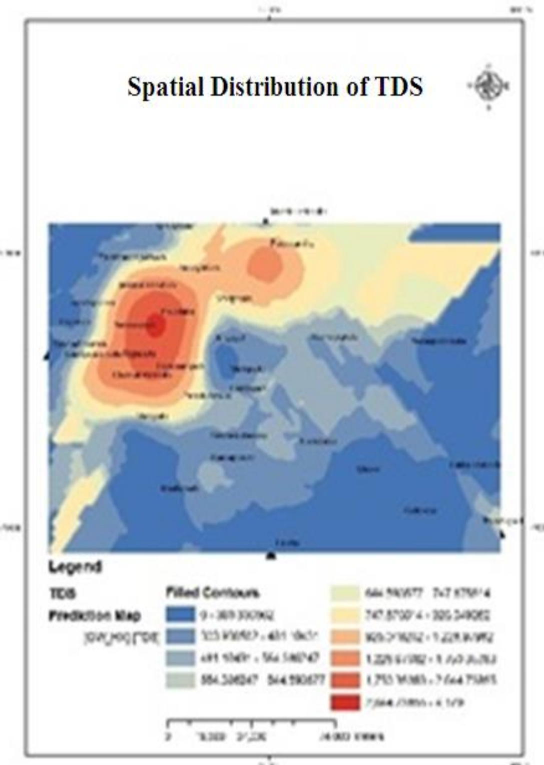

Fig.2: *Spatial Distribution of TDS.*

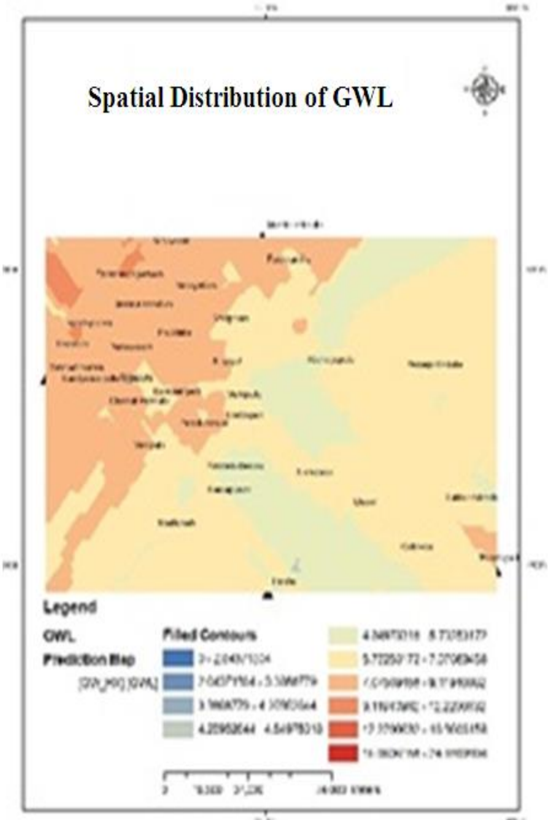

Fig.3: *Spatial Distribution of GWL.*

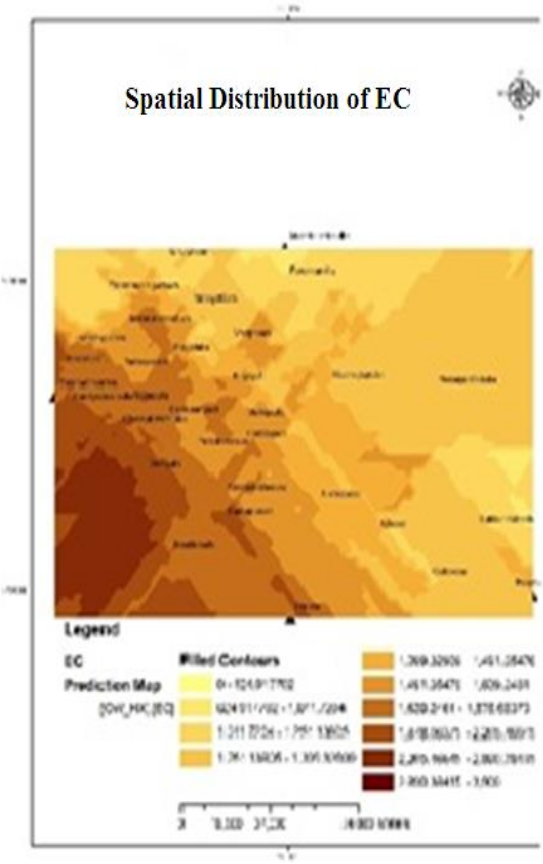

Fig.4: *Spatial Distribution of EC.*

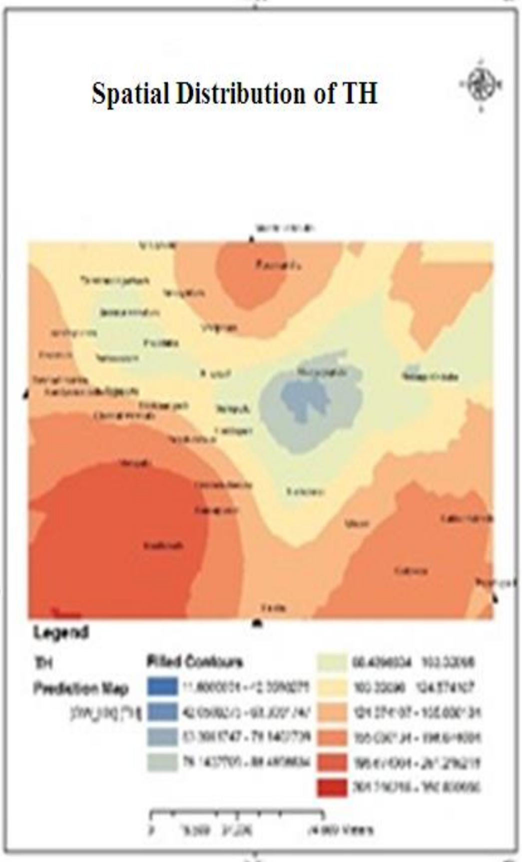

Fig.5: *Spatial Distribution of TH.*

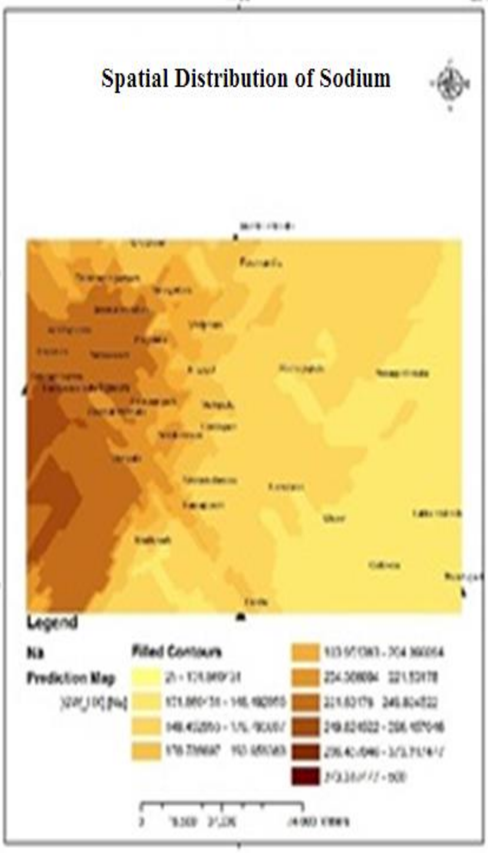

Fig.7: *Spatial Distribution of Sodium.*

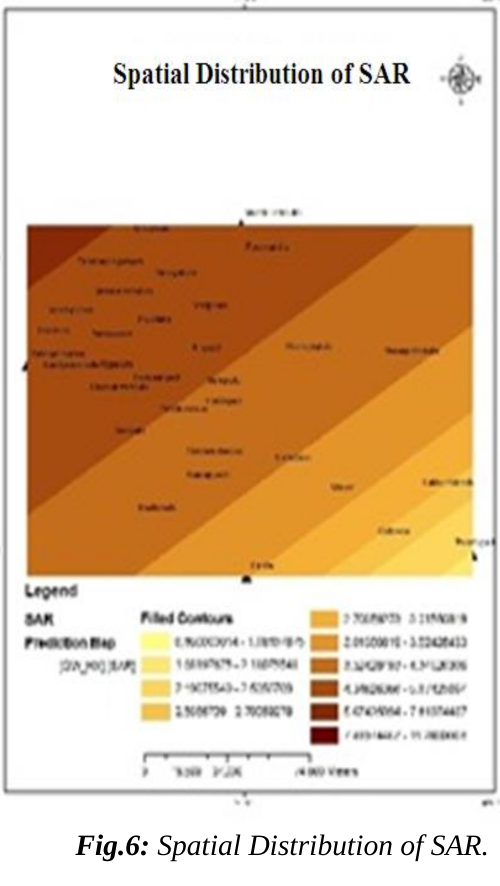

Fig.6: *Spatial Distribution of SAR.*

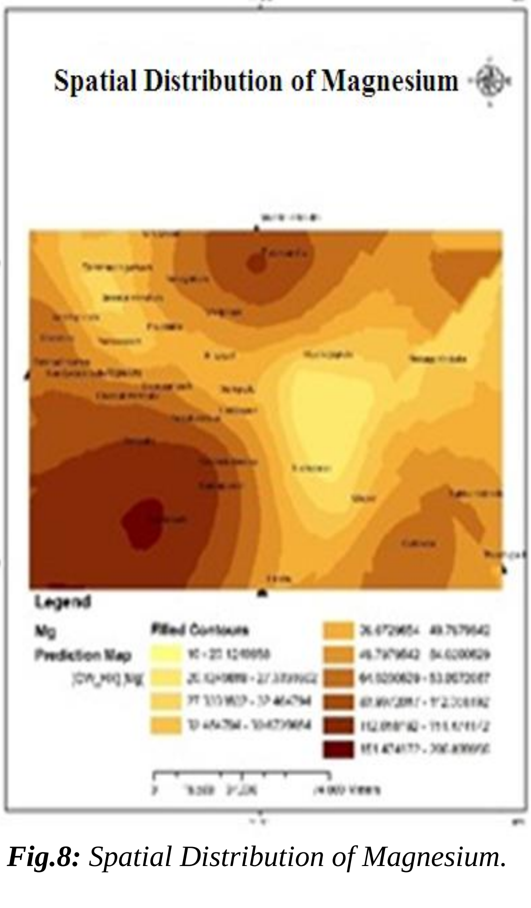

Fig.8: *Spatial Distribution of Magnesium.*

Fig.9: Spatial Distribution of Calcium.

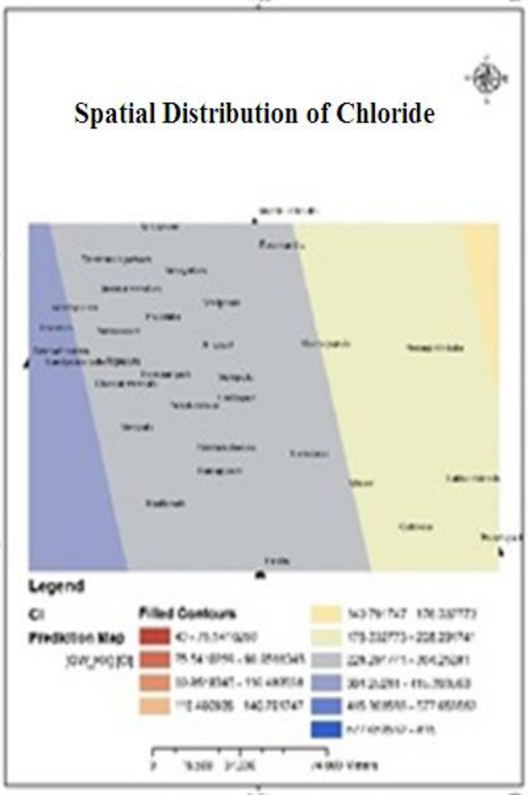

Fig.11: Spatial Distribution of Chloride.

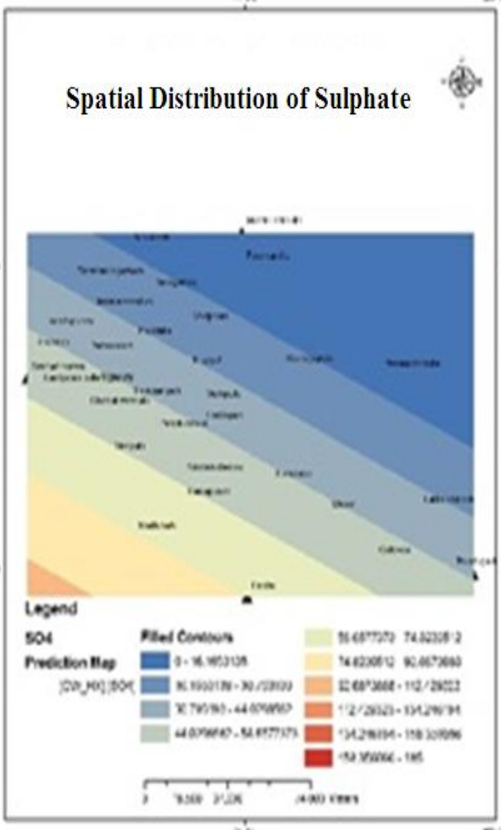

Fig.10: Spatial Distribution of Sulphate.

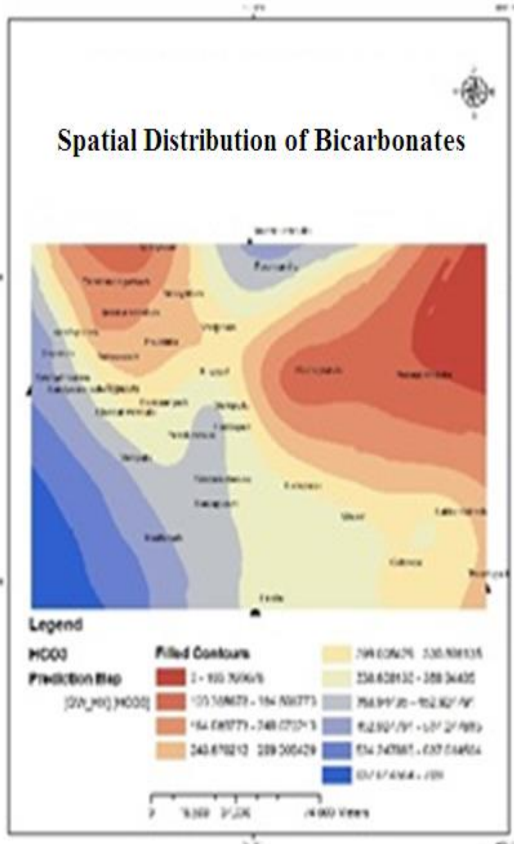

Fig.12: Spatial Distribution of Bicarbonates.

Table 1: *Comparison of Different Interpolation Methods.*

S. No	Parameter	Interpolation Method									
		Inverse Distance Weighing		Global Polynomial		Local Polynomial		Radial Basis Function		KRIGING	
		Prediction Errors		Prediction Errors		Prediction Errors		Prediction Errors		Prediction Errors	
		RMS	MEAN	RMS	MEAN	RMS	MEAN	RMS	MEAN	RMS	MEAN
1	PH	0.3948*	-0.002	0.4032	-0.00190	0.4543	-0.05	0.395	0.0015	0.3962	-0.0147
2	TH	92.32	-1.445	96.24	-1.155	106.4	21.46	92.59	-1.002	90.19*	1.069
3	SAR	2.676	0.3122	2.634*	0.04533	2.659	-0.30	2.81	0.170	2.708	0.1697
4	NA	120.5	14.72	114.4	0.9533	115.7	-8.38	130.9	6.715	108.6*	0.0295
5	MG	50.26	2.112	56.7	-0.7062	56.98	11.81	50.03	0.3696	48.53*	1.686
6	CA	47.55	-2.964	47.53	-0.447	54.41	8.834	48.24	-1.31	47.19*	-0.4131
7	SO4	60.75	*3.503	57.97*	-0.6117	66.16	7.507	62.84	-1.909	60.16	-2.689
8	CL	241.4	6.389	231.4*	0.0356	261.9	15.79	254.6	4.987	247	15.67
9	HCO3	182.8	4.582	183.6	-2.046	176*	19.35	184.6	0.9752	187.2	-3.73
10	TDS	964.8	113.4	975.7	12.02	974.1	-185	954.4	48.98	949.1*	57.36
11	EC	1232	39.35	1221	-9.918	1283	147.4	1268	15.49	1194*	-35.61
12	GWL	5.798	0.0499	5.701	-0.0355	5.746	-0.19	6.017	-0.060	5.588*	0.1525

CONCLUSIONS

Groundwater is quintessential substance in the study region, which includes urban and peri-urban areas. Since the expectation for everyday comforts is low, the vast majority of the populace relies on upon groundwater wells since two to three decades. The target of the present study is assessing the groundwater nature of Y.S.R district, Andhra Pradesh, India, and produce prediction maps. This map reflects the need of a sustainable framework so that the precious groundwater resource would be well protected and so the positive progress of the society well flourished.

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