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Agricultural Suitability and Static Modelling: A GIS Approach

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ABSTRACT

Agriculture with its allied sector is largest livelihood providing sector in India. It also contributes to the employment. 54.6 % of the workforce is involved in the agricultural sector alone. Ramganjmandi is a tehsil situated in the south-eastern part of Rajasthan. The region undergoes limestone, popularly known as Kota stone mining. The region faces serious threat in terms of air soil, noise, and water pollution. Irrigated supply when impacted by the economic activity induce toxic chemicals in the food chain. The objective of the paper is to assess the irrigational suitability of water in Ramganjmandi tehsil of Kota in Rajasthan. The suitability will be assessed using sodium absorption ratio SAR, Sodium percent, Kelley's ratio KR and Electrical Conductivity. The static modelling of these irrigational parameters is executed in Arc GIS using Interpolation through inverse distance weightage method. The value of Electrical conductivity lies between 367 µS to 939µS, SAR values lies between 0.98 to 11.16, sodium percent values lie between 11.43 to 60.14% and Kelley's index values lie between 0.12 to 1.35.

Key words : *Irrigational suitability, SAR, Sodium percent, Kelley's Ratio, Electrical conductivity, Interpolation*

Introduction

The development today is expected to be sustainable in nature. The industry boosts the economy but ultimately ends up creating a negative impact over the natural resources and also the health of residential population. Farmers facing crop loss have faced a major change in their social and economic life. India has always been a farmer's economy, any threat to agriculture, strikes the country's GDP. Agriculture largest sector of livelihood of country's population and accounts for 16% of GDP.

Hydro chemical analysis of water in is indicative climatic and environmental conditions in any region. Zhang *et al.* (2019) worked on the surface hydrochemistry of Syr Darya river in Kazakhstan at 39 locations and analysed regional hydro chemical characteristics and evaluate irrigational suitability of the regions. The cations studied were $Na^{+,}$ Ca^{2+}, and Mg^{2+} and anions studied were SO_4^{2-}. The main hydro chemical type is Ca-Mg- SO_4 – Cl. The industrial and agricultural production and domestic sewage generation imposed the study of the river. The irrigation suitability is based on Sodium absorption ratio, Na%, Kelly's index. Most of the water sites are suitable for irrigation and TDS content analysis is also considered. The pH value of the study ranges from 7.95 to 9.31 and the mean value of dissolved oxygen is 8.96. the salinity of the surface water varied from 342 mg/l to 4014 mg/l. 94.87% of samples were above the limit of 500 mg/l. As depicted by the correlational matrix, the correlational coefficients between all the parameters are more than 0.8. chloride, magnesium, sodium, and potassium show high concentration. The combination of these ions can easily produce insoluble salts such as $CaSO_4$ and

$MgSO_4$. The correlational coefficients of TDS with Cl^-, SO_4^{2-} Na^+, Ca^{2+}, and Mg^{2+} are all greater than 0.8. The water chemistry of *syrdarya* when analysed through Gibbs Diagram. No samples were under the atmospheric precipitation, some samples were in the rock weathering area and another portion of the sample is in the rock weathering area (Zhang *et al.,* 2019).

Hwang *et al* (2017), worked in terms of cations and anions for ground water quality assessment by using SAR, Percent Sodium, RSC residual sodium carbonate, PI permeability index, SSP soluble sodium percentage, Magnesium ratio, Kelly's Ratio, Magnesium Hazard, PI. 100 % samples were classified as excellent after applying SAR, 98% lied in the category of permissible and good after applying sodium percent, 95 % was classified as safe after applying RSC, 99.6% were classified as excellent / good after applying PI, 99.2% as excellent/good after applying SSP, 93.2 % as permissible according to Kelly's ratio (Hwang *et al.,* 2017)

Quality assessment of Nalgonda district, Telangana region was done for testing the groundwater for irrigational and drinking water purpose. 78 ground water samples were taken from the region and compared to WHO and BIS standards, 72.5 % samples are suitable for drinking and 86 % were suitable for irrigational purpose. Wilcox, United States Salinity Laboratory diagrams (USSL diagram) and Doneen's chart states that most of the samples are suitable for irrigation purposes. The irrigation suitability of the water increases in the post monsoon season. The major portion of the region shows contamination of NO_3^-, F^-. NO_3^- concentration varies from 3.3 to 236 mg/L (Roy *et al.,* 2018).

Pure water is a poor conductor of electricity. Acids, basis, and salts make it a better conductor. Such substances are termed as electrolytes. The one with poor solubility are known as weak electrolytes and the one with higher solubility are known as strong electrolytes. Thus, higher the concentration of electrolytes more is the electrical conductance. conductance of a distilled water is 1 to 5 µS. Water up to 20 µS are considered suitable for irrigation. Since the conductivity varies with temperature it is reports at 25°C (Saxena, 1990).

Water containing high concentrations of Na^+ poses greater hazards when used for irrigation because Na^+ is absorbed into the soil, causing soil polymer dispersion and leading to a decrease in permeability. SAR signifies the relative activity of Na^+ in soil exchange reactions and is used to calculate the degree of alkalization of irrigation water (Ayers and Westcot, 1985).

The measurements taken from the environment of soil, rock, soil, water bodies are made on smaller elements on whole which are relatively farther away from each other. The people who make measurements and their clients would require knowing the values in the intervening spaces. The main objective is to get a spatial sense from a spatial data and to map these spatial distributions of these variables. Herein the concept of interpolation occurs. Interpolation is the process of predicting unknown values for the non-sampled locations from the known values of sampled locations. Most attempts at spatial predictions are mathematical in nature based on the geometry and some attention to the physical nature of the phenomenon (Webster and Oliver, 2007).

The study of Ishfahan in Iran, 66 samples of groundwater have been tested and analysed through Gibbs diagram. The pH value ranged from 7.05 to 8.95. irrigational suitability and risk assessment are evaluated through EC, % Na, SAR, RSC. The SAR values ranges from 0.47 to 39 meq/L. RSC values vary from -18.2 to 4.7in the study area (Rezaei and Hassanni, 2018).

Balaji *et al.* (2017) studied the ground water quality of Tirupati region in Chittor district of Andhra Pradesh. The groundwater parameters have been analysed according to Chaddha's diagram including calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulphate chloride, fluoride, TDS, calcium hardness, alkalinity, pH, Electrical conductivity, SAR, PS, RSC, PI, Kelly's ratio, indices of base exchange, Gibbs ratio I, Gibbs Ratio II. The major ions in most of the locations were to be found within the permissible limit, and the groundwater is capable of drinking and irrigational purpose except for few samples. sodium is the most dominant ion, few of the samples cross the sample limit, which was because of the interaction of the ground water with sewage and intensive agricultural practices.

Ramganjmandi is a tehsil of the district of Kota in the state of Rajasthan, in which lies the Ramganjmandi city. It is known as a stone city and coriander city. It is 73 km away towards south of Kota on the Delhi-Mumbai broad gauze railway line. The latitudinal extension is 24° 08´00´´N to 24° 11′ 10″N and the longitudinal extension is 75° 13´

04″ E to 76° 01′ 57″ E. Ramganjmandi once famous for coriander cultivation is now famous for mines, extraction, poor air quality, water unfit for drinking, loss of agricultural land, deforestation, and massive solid waste disposal. The heaps of scrap contributing to land degradation; the slurry on soil affecting the soil quality; the continuous grinding; extraction of mineral making the air polluted; the dumpage Fig 1: Locational aspect, Ramganjmandi of waste in the surface water and long-term impact on groundwater; health dilapidation because of the combined effect of ecosystem imbalance are sufficient reasons to make this research problem significant (Rana and Sharma, 2020).

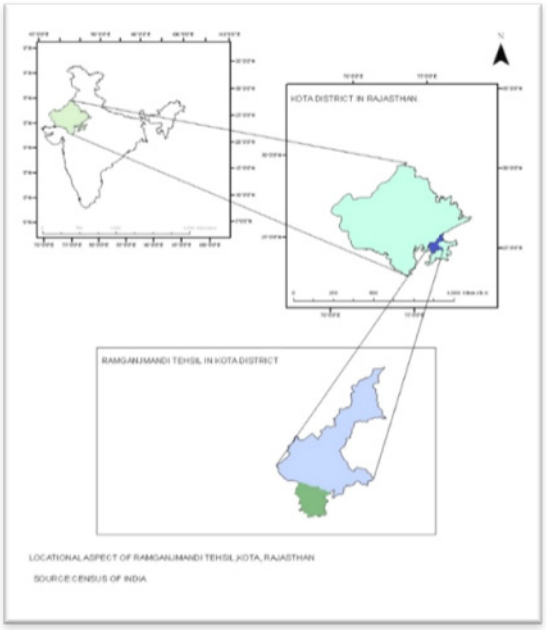

Fig. 1. Locational aspect, Ramganjmandi

Materials and Methods

The samples are taken from 25 different locations focussing primarily on the mining belt, henceforth a purposive Random Sampling.

1 l of the sample are collected in dark coloured bottles which are washed with the help of distilled water beforehand. Multi parameter kit PC5 TEST R 35 series kit is used to measure the electrical conductivity. The estimation of Na^+ and K^+ is based on Spectroscopy using Flame Photometer. The cations studied were Na^+, Ca^{2+}, and Mg^{2+} and K^+. The irrigation suitability will be calculated using sodium ab-

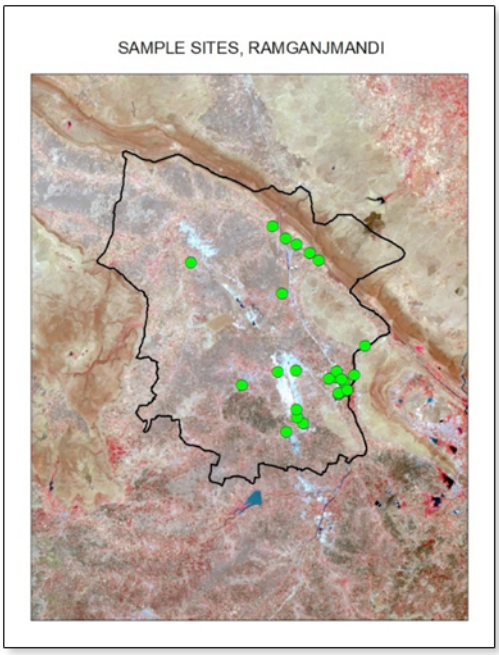

Fig. 2. Sampled sites

sorption ratio SAR (Wilcox, 1955), Sodium percent (Ayers and Westcot, 1985) Kelley's ratio KR (Kelley, 1963) and Electrical Conductivity (Richards, 1954).

$$SAR = \frac{Na+}{\sqrt{Ca^{2+}+Mg^{2+}/2}}$$ ——Equation (1)

$$Na\% = \frac{Na^{+}+K^{+}}{Ca^{2+}+Mg^{2+}+Na^{+}+K^{+}} \times 100$$ ——Equation (2)

$KR = Na^{+}"(Ca^{2+} + Mg^{2+})$ —Equation (3)

Interpolation is the estimation of a most likely estimate in given conditions. The technique of estimating a past figure is termed as interpolation. Interpolation is the art of reading between the lines of the table. Inverse distance Weightage method is used as the interpolation method.

The output value for a cell using inverse distance weighting (IDW) is limited to the range of the values used to interpolate. Because IDW is a weighted distance average, the average cannot be greater than the highest or less than the lowest input. Therefore, it cannot create ridges or valleys if these extremes have not already been sampled. The influence of an input point on an interpolated value is isotropic. Since the influence of an input point on an interpolated value is distance related, IDW is not "ridge

preserving" (Philip and Watson, 1982).

Results

Table 1. Irrigational Suitability Assessment- Na%, Kelley's Ratio, SAR, EC

Sample No	Sodium Absorption Ratio (SAR)	Sodium Percent (%)	Kelly Index	Electrical Conductivity (µs)
1	1.34	16.12	0.18	661
2	1.46	19.38	0.22	568
3	11.16	60.14	1.35	846.15
4	2.09	21.89	0.26	861.53
5	1.90	20.04	0.23	761.5
6	1.83	18.97	0.22	692.3
7	1.75	17.96	0.20	753.84
8	1.71	17.64	0.20	692.3
9	2.04	23.00	0.27	661.5
10	1.87	21.68	0.25	601
11	2.06	23.08	0.28	672
12	1.58	23.63	0.28	367
13	1.90	21.47	0.25	876
14	1.86	21.02	0.24	815.38
15	1.75	17.04	0.19	692.3
16	0.98	11.43	0.12	707.69
17	1.11	13.48	0.14	747.69
18	3.32	16.99	0.16	384.3
19	5.03	28.62	0.34	600
20	5.41	22.48	0.25	569.23
21	5.44	19.32	0.21	523
22	4.84	17.80	0.19	598.46
23	2.25	26.63	0.34	568
24	1.68	15.49	0.18	939
25	1.43	14.49	0.15	723.07

As per Table 2, the values show high degree of variability depicted by the standard deviation. The mean values are impacted by extreme high values in the mining belt and low value sin the sensitive zone.

Predictive Mapping of Irrigational Parameters- Inverse Distance Weightage Interpolation

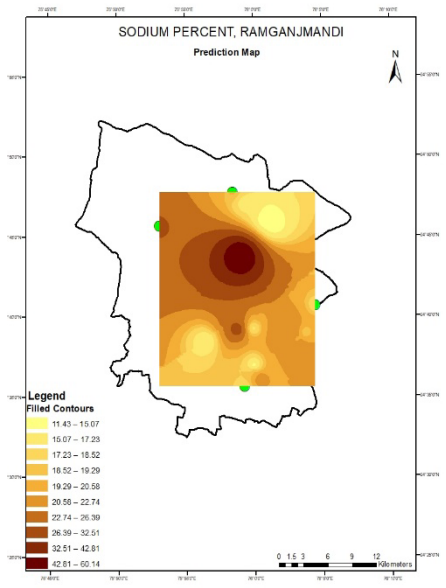

Fig. 3. Sodium Percent Predictive Mapping

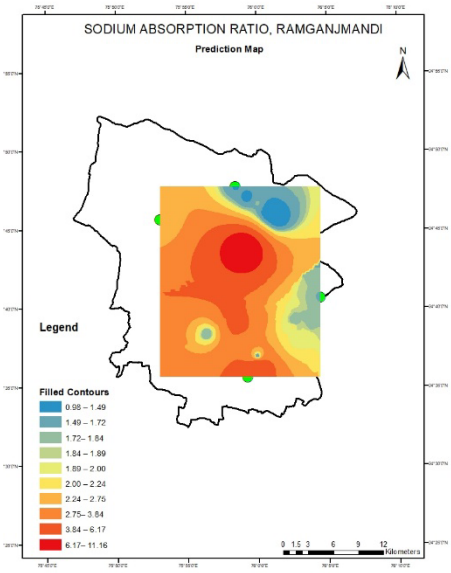

Fig. 4. SAR Predictive Mapping

Table 2. Irrigational Suitability Assessment

Parameters	Minimum	Maximum	St Deviation	Median	Mean
EC (µS)	367	939	140.1	692.3	675.29
Kelly's Index	0.12	1.35	0.23	0.22	0.27
Sodium Absorption Ratio	0.98	11.16	2.21	1.87	2.71
%Na	11.43	60.14	9.03	19.38	21.19

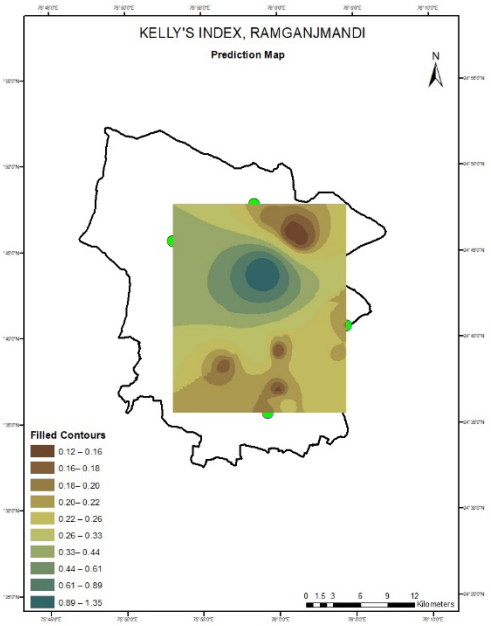

Fig. 5. Kelley's Index Predictive Mapping

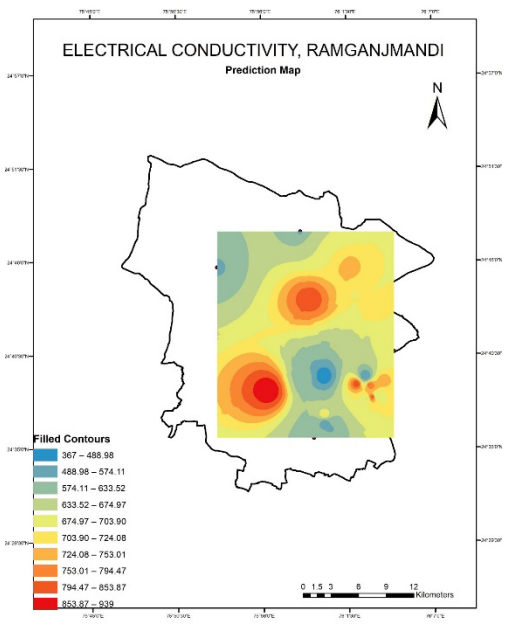

Fig. 6. Electrical Conductivity(µS) Predictive Mapping

Discussion

Table 3. Sodium Percent and Irrigational Suitability

Sodium Percent (wilcox, 1955)	Category	Percent of Samples
20	EXCELLENT	52%
20-40	GOOD	44%
40-60	PERMISSIBLE	NIL
60-80	DOUBTFUL	4%
>80	UNSUITABLE	NIL

1. Sodium Percent : The values of sodium percent lies between 11.43 to 60.41. The standard deviation is 9.03 depicting variability which is caused due to extremely high values at the mining sites and low values in the sensitive zone in the north of the tehsil, Mukundara National Park. 52% of the samples lie in the Excellent Category as suggested by Wilcox, (1955). 44% of the samples lie in the Good category and rest 4% of the samples lie in a doubtful category as depicted in the predictive map, which is an active mining region, Chechat (Fig. 3).

2. Sodium Absorption Ratio, SAR- The SAR values lie between 0.98 to 11.16. The region shows low SAR values in the north of the tehsil and high SAR values in the central and southern part which is an active mining belt (Fig. 4). 96% of the samples lie in the excellent category and rest 4% of the samples lie in the Good category as suggested by Richards, (1954).

3. Kelley's Index- The values of Kelley's index lie between 0.12 to 1.35 with a high variability depicted by the standard deviation as 0.23. High values can be seen towards the active mining belt of Chechat region towards North-west of the tehsil (Fig. 5). 96% of the samples lie in the suitable category and rest 4% lie in the marginally suitable category (Table 5).

4. Electrical Conductivity- The values of Electrical

Table 4. Sodium Absorption Ratio and Irrigational Suitability

Water Suitability for Irrigation Based on Sar Values (Richards, 1954)	Category	Percent of Sample
0-10	Excellent	96%
10-18	Good	4%
18-26	Fair	NIL
>26	Poor	NIL

Table 5. Kelley's Index and Irrigational Suitability

Water Suitability According to Kelley's Index (1963)	Category	Percent of Samples
<1	Suitable	96%
1-2	Marginally Suitable	4%
>2	Unsuitable	Nil

Table 6. Electrical Conductivity and Irrigational Suitability

Water Suitability for Irrigation Based on Ec Values (Richards 1954)	Category	Percent of Sample
<250	Excellent	NIL
250-750	Good	72%
750-2000	Permissible	28%
2000-3000	Doubtful	NIL
Above 3000	Unsuitable	NIL

Conductivity lie between 367 µS to 939µS. 72%of the samples lie in the Good category and rest 28% of the samples lie in the Permissible category according to Richards, 1954 (Table 6).

Acknowledgement

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