A Combined Entropy-FR Weightage Formulation Model for Delineation of Groundwater Potential Zones .

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Abstract One of the most valuable natural resources on the planet, groundwater is essential to the continuation of human activity. Water shortage has an impact on a region's environmental and developmental activities, however this issue may be partially solved by locating groundwater potential zones and examining the water quality of that region during its useable season, which is from post-monsoon to pre-monsoon. This aids in the even distribution of the water demand load to make the best use possible of the local water resources. Due to their ability to recognise different ground features that could be utilised as a sign of the existence of groundwater, GIS tools and satellite photos are frequently employed for groundwater investigation. Study and analysis of remote sensing data is a fast and economical way of finding and exploring the ground water resources in study area. Also, the quality checks of ground water ensure its usability for various purpose during its usable period.

DEM and Satellite imageries are used for preparing various thematic maps. For getting the groundwater potential zones, each thematic layer was computed statistically. These maps were transformed to raster class data using feature to raster converter tool in ArcGIS. All the raster maps were allocated to a fixed percentage of influence and weighted.The primary goal of this study is to develop the weightage calculation using the combined theory of FR and Entropy. The generated data were then combined with the various themed maps on the GIS platform. To create a composite groundwater potential zones map, all the thematic maps are combined using the overlay analysis tool in ArcGIS software. This projected groundwater information will be useful for efficiently identifying suitable places for the process of groundwater extraction.

***Keywords*: Groundwater, FrequencyRatio,Shannon's Entropy,Model Formulation,FR-Entropy.**

1.INTRODUCTION

1.1 General

One can attempt to make judgments using traditional optimization techniques when the game's rules are clear, the context in which one operates is predictable, the opposition is known, the actors behave deterministically, costs vary within a small, narrow range, and linear relations are the norm. The idea of optimization for decision-making will not be very helpful, though, when the rewards of actions are unpredictable and when correlations between variables may not only be non-linear and stochastic but also actually unknown. Exactly this is the circumstance that exists in the modern world.The absolute necessity is strategic, operational, and tactical agility in quickly absorbing a situation and responding with maximal concentration of effort when needed. In the more organised world of the past, conventional optimization strategies for decision-making have somewhat aided at the tactical and operational level in various large-scale enterprises. These strategies haven't been able to have a bigger impact, though, at the strategic level. A decision can be thought of as the selection of one alternative from a group of possibilities based on some premise or criterion. In some situations, it may be essential to base a judgement on more than one criterion. To determine the relative ranking of the alternatives with regard to the problem, it is necessary to assess multiple criteria, evaluate alternatives in light of each criterion, and then combine these evaluations. When there are three or more specialists whose perspectives must be considered in the decision-making, the issue is exacerbated. Lack of sufficient quantitative data causes a reliance on the expertise, experience, and judgement of qualified people, or experts.

2. LITERATURE & METHODOLOGY:

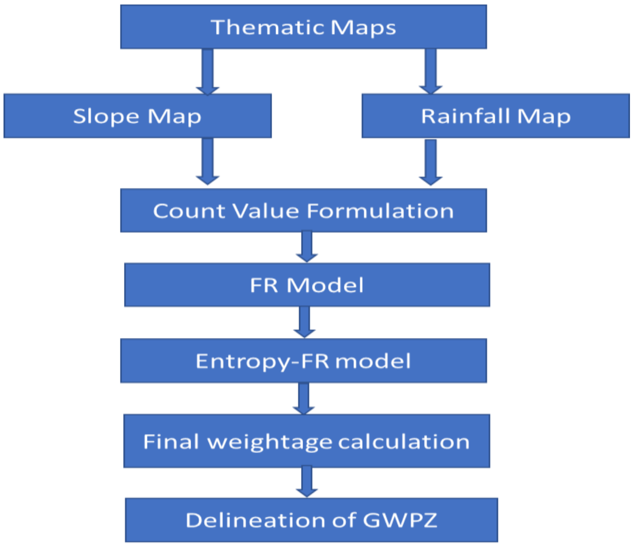

Fig.1 Flow chart for Methodology to be followed to Identify Groundwater Potential Zones

2.1 Literature Review

The literature on the Entropy and FR technique that researchers have explored is examined in this section. Information theory, which was initially used to evaluate the uncertainty of hydrological models, is the source of information entropy. The results of the studies demonstrate how the entropy information considerably raises the algorithm's robustness and recognition rate. use techniques like the entropy weight approach to analyse the coordinating relationship between economic progress and investment potential. The goal of this study is to choose appropriate suppliers in a green market utilising FR and using entropy weight data to calculate criteria weights.

The research methodologies for building models and solving problems were presented based on the aforementioned literatures.

2.2 Data Collection:

Table No.1 Data collection and software used.

Sr.No	Data	Purpose	Source
1	12.5 m resolution DEM	To extract elevation data of the study area	https://asf.alaska.edu/
	Software used	**Purpose**	**Source**
1	ArcGIS Pro	Identification of groundwater zones	SIG,Pune

2.2.1 DEM

Digital elevation model file is downloaded from Alaska sentimental facility. DEM file is downloaded to create the slope map of study area. According to elevation of study area slope changes as slope changes ground water potential contribution also changes in Penganga River sub-basin. Digital elevation model file is shown below.

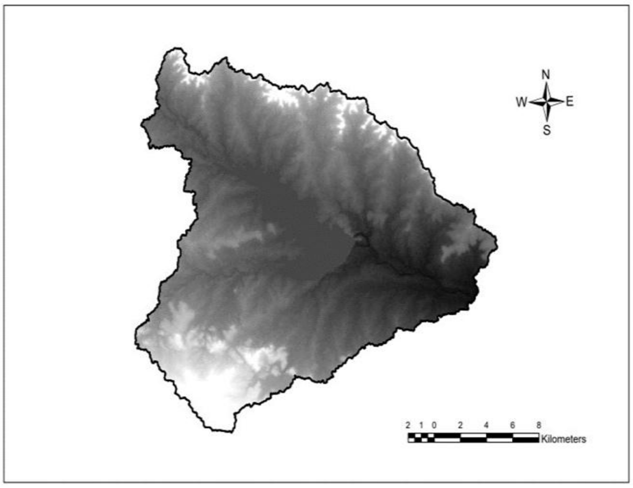

Fig.2 DEM for Numerical Execution.

2.3 Entropy Weightage Method

A well-known method for determining the weights for a MADM problem is Shannon's entropy, particularly when it is unable to conduct DM experiments or find an appropriate weight based on preferences. Shannon's entropy, a term used to describe a broad measure of uncertainty, plays a significant role in information theory. Entropy is used in transportation modelling to represent the dispersion of journeys between origin and destination. Entropy is a key fundamental concept in physics and refers to how "disorderly" a system is. Also, the entropy associated with an event is"a measure of the degree of randomness in the event. Entropy has also been concerned as a measure of fuzziness. Entropy in statistical thermodynamics and information theory is comparable. The analogy occurs when the values of the random variable identify the energies of microstates, and as a result, the Gibbs formula for entropy and Shannon's formula are formal equivalents.

2.3.1 Entropy Weight Principle

German physicist R. Clausius first suggested the idea of entropy in 1865. It is a state parameter of matter and describes the disorder or chaos of a thermodynamic system. Information entropy, a term established by Shannon in 1948, is a measurement of the signal uncertainty in information sources.The entropy weight technique assesses the ability of each evaluation attribute to pass decision information and determines the relative weight amongst attributes. It primarily uses the size of the entropy value in information theory to represent the uncertainty of the message. The judgement matrix can be used to derive the entropy weight, which states that "the evaluated information criterion's weight increases with decreasing entropy." This is only accurate if the fundamental presumptions that underlie it are correct. The unique multi-criteria decision-making approach put out in this research is, of course, no exception.

2.3.2 Significance and nature of Entropy Weight Method

The entropy weight approach involves calculating the indicator's information entropy and using the indicator's degree of difference to compute the effective information and indicator weight contained in the known data. The importance coefficient of the each indicator with in competition under the circumstances of a specific evaluation object and evaluation index when formulating a decision or evaluation plan is indicated by the entropy weight, but it does not indicate the practical importance coefficient of the indicator.These are its attributes:

a. The maximum entropy and entropy weight are both 1, respectively, if all of the elements in a column have the same values. If the data for each evaluation object for an indicator are the same, the indicator does not include any useful information.

b. The entropy value of the elements in a column decreases and the entropy weight increases in proportion to the size of the difference between the values of the elements in the column. It suggests that the indicator has important data. On the other hand, if the indicator's entropy value is higher, its entropy weight is lower and it is therefore less significant.

2.4 Frequency Ratio

The frequency ratio model is based on the statistical correlation between groundwater occurrence in a region and the sites of productive boreholes, flowing wells, and springs. The ratio of the study area to the area where boreholes were found is known as the FR. Using the following formula, the FR is determined.

$$FR = \frac{Percentage\ Area\ for\ class(b)}{Percentage\ Area\ for\ entire\ Domain(a)}$$

b is the percentage for area with respect to a class for the factor

a is the percentage for the entire domain.

2.4.2 Application of FR:

For the purpose of calculating the frequency ratio, the area ratio for the area occurrence and non-occurrence for each class or type of factor was computed, as well as the area ratio for each class or type of factor to the total area. Therefore, frequency ratios were derived by dividing the area occurrence ratio by the area ratio to determine the class or type of each factor. The area occurrence ratio was then divided by the area ratio to determine frequency ratios for each factor type or range. If the ratio is more than 1, there is a strong correlation between the areas and the given factor; if it is lower than 1, there is a weak correlation between the flooded areas and each type or range of factors. The ratios were further used for calculating the entropy.

$$FR = \frac{A/B}{C/D}$$

Where,

A is the area of a class for the groundwater factor;

B is the total area of the factor;

C is the number of pixels in the class area of the factor;

D is the number of total pixels in the study area

3. Numerical Execution Example of Delineation of Groundwater potential zones.

The count values of the study area is calculated with the help of tabulated tool in ArcGIS.The count values gives the area of pixels of the study area which is “b”.The count values of the conditioning factor viz. Lineament,soil which is divided by the pixel sixe of dem which is 12.5m which gives the value of “a”. Once percentage values of the area is calculated the FR of the study area is calculated which is further used in the calculation of weight using Entropy-FR as shown in the following steps:

Step 1: Two thematic maps viz. slope and rainfall are taken for the calculation.The maps are further divided in equal interval values in five classes.The count values of the area are calculated in ArcGIS as shown in the table below

Classes	Count values	Percentage area of domain(a)	Percentage area of class(b)
1	6347500	689617	40624
2	2780156	534576	17793
3	2036406	737930	13033
4	831719	568627	5323
5	285156	116365	1825

Table No.2 Calculations for slope map

Classes	Count values	Percentage area of domain(a)	Percentage area of class(b)
1	2623120	279784	16788
2	2467910	216834	15794
3	2298005	190220	14707
4	2546340	210340	16297
5	2455180	199545	15713

Table No.3 Calculations for rainfall map

Step 2: Probablity density is calculated followed by FR calculation.

$$FR = b/a$$

Classes	Slope	Rainfall
1	0.058	0.060
2	0.033	0.072
3	0.017	0.077
4	0.009	0.008
5	0.015	0.078

Table No.3 Calculations for FR

Step 3: Probablity density is calculated followed by FR calculation,

$$E_{ij} = FR / \sum_{j=1}^{M_j} (FR)$$

Step 4: Entropy is calculated,

$$H_j = -\sum_{j=1}^{M_j} E_{ij} ⁡\log(E_{ij})$$

Step 5: Maximum entropy is calculated,

$$H_{jmax} = -\log(M_j)$$

Step 6: Information coefficient is calculated,

$$I_j = (H_{jmax} - H_j / H_{jmax})$$

Step 7: Final achieved weightage is calculated,

$$V_j = I_j ⁡ FR$$

where Hj and Hjmax are the value of entropy, Ij is the information coefficient, Mj is the number of classes in each conditioning factor and Vj is the achieved weight value for the given parameter. The range is between 0 and 1. Values close to 1 show greater inconsistency and imbalance. With the help of steps shown above final weightage for each class for each thematic maps are calculated as shoen in the table below,

Classes	Slope Weightage	Rainfall Weightage
1	36.05%	17.53%
2	24.79%	19.52%
3	15.55%	20.86%
4	9.65%	20.94%
5	13.96%	21.15%
Overall Weightage	26.81%	73.19%

Table No.4 Final weightage calculated

4. Results and discussion.

A analysis must be carried out at the very end of the multi-criteria evaluation technique to examine how the weights of the alternatives relate to one another. It is possible to derive the entropy-FR weight value, which can effectively replace the arbitrary weight value set by decision-makers in the conventional technique. Wi = (wi1, wi2,..., wi5) = is the obtained entropy-FR weight for slope (0.3605, 0.2479, 0.1555, 0.0965, 0.13.96).This indicates that each criterion has a 36.09 percent, 24.79 percent, 15.55 percent, 9.65 percent, and 13.96 percent individual impact on alternatives. The individual weighting for the slope map and rainfall map for the thematic maps is 26.81 percent and 73.19 percent, respectively. The bias of subjective weights can be reduced and the current situation can be accurately reflected when objective weight (entropy) and subjective weight (FR) are combined. The entropy-FR weight is added to the technique, and a model that is weighted according to entropy-FR is created.

5. Conclusion:

The aim of this research is to construct an entropy-FR weighted model that will evaluate the definition of the groundwater zone from a theoretical and practical perspective. This article provides a thorough and rigorous explanation of how to design an entropy-FR weighted strategy. To accomplish the research objectives from the stated approaches, entropy and FR are applied.The research's findings and particular benefits point to the following:

- In place of the weight value chosen arbitrary by decision makers in the other traditional techniques, the entropy-FR weight value can be an appropriate replacement. Decision-makers can evaluate potential suppliers more thoroughly and scientifically by combining the objective and subjective weights of the FR and Entropy.
- Separate calculations must be made to combine the weights of the various levels of FR and entropy. The total weight value is then calculated by multiplying the weights of all the layers after merging the weights of each layer (entropy-fr weight).
- Compared to the FR-based methodology, this evaluation model
- 's selection output is more consistent, efficient, and reliable.
- to create an appropriate MCDM solution by combining the FR and entropy weight approaches. When decision-makers are confronted with a lack of information and a strong subjective consciousness, they should be given useful information.

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