

# Integrated Watershed Management: Identification of Ground Water Potential Zone and Morphometric Analysis using GIS and RS Techniques at Kothamangalam

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**ABSTRACT:** Kothamangalam generally known as the gateway to high range is a region having moderate rainfall each year, even though suffering from insufficient water in the summers. Hence a study about the hydrological details of the area aids the chances of efficient development. The study comprises of two analysis which is the identification of ground water potential zones and morphometric analysis. Various thematic layers were used for the identification of ground water potential zone map such as geology, geomorphology, drainage, lineament, Land Use/Land Cover (LU/LC), soil texture, soil depth and slope, which were used by assigning appropriate weightages found out from MIF technique followed by the analysis using GIS and RS. The drainage layer prepared from the topology sheet were used for finding out the morphometric parameters. Thus the Ground water potential zone map may be used to find out the hotspots with ground water deficiencies and the morphometric parameters can be used for studying the characteristics of study area before planning the suitable measures.

**KEYWORDS:** Ground water potential zone, GIS RS, Morphometric parameters, MIF technique

## I. INTRODUCTION

Kerala state is experiencing a declining trend in ground water levels. Hence the further development of ground water should be done with caution and for which sustainable conservation methods are to be resorted. Analysis and assessment tools like GIS has proven to be very effective and useful for the management of watershed. The scope of the project involves identifying typical watershed in Kothamangalam, Ernakulam, Kerala, preparation of various thematic layers of the proposed watershed, analyzing the maps and data collected on GIS platform. This research helps to plan and implement proper conservation and sustainable water management programme in the study area.

## II. IDENTIFICATION OF GROUND WATER POTENTIAL ZONE

### 1. STUDY AREA

Kothamangalam is a municipality in the eastern part of Ernakulam district in the Indian state of Kerala. The town is in the foothills of westernghats mountain ranges. Kothamangalam is also known as the Gateway of Highrange. The study area comprises of ten watersheds in the eastern part of Kothamangalam sub basin of Muvattupuzha river basin. The watersheds considered are 13M38d, 13M38e, 13M38f, 13M38g, 13M38h, 13M38i, 13M38j, 13M38k, 13M38p, 13M38q. It extends between the coordinates of 76.584087(left), 76.768208(right), 10.132681(top), 9.989665(bottom).



Fig 1: map showing the location of study area

## 2. METHODOLOGY

Sl No	Data	Source Of Data	Methods Used For Analysis
1	Watershed Boundary	KSLUB Trivandrum	Estimation of study area
2	Geology		Rasterisation, Projection and Reclassification
3	Geomorphology		
4	Soil Texture		
5	Soil Thickness		
6	Landuse/Landcover		
7	Lineament Density	KSLUB Trivandrum	Projection, Thematic map creation, Reclassification
8	Drainage Density		
9	DEM	ASTER DEM	Generation Slope

Table1: Sources of Data and Operations Performed

Different data required for various analysis were collected from different sources. The data collected were in different format, size as well as coordinate system. Hence all of them were converted to the projected coordinate system of WGS 1984 UTM ZONE 43N and all of them were subjected to rasterisation. The lineament density and drainage density were also prepared from the lineament and drainage maps. The Slope map was prepared from the DEM. After obtaining the data into the same means, each of them were subjected to reclassification providing them with proper ranks. All the reclassified layers were assigned with proper ranks found out from MIF technique and subjected to the weighted overlay analysis for obtaining the ground water potential zone map.

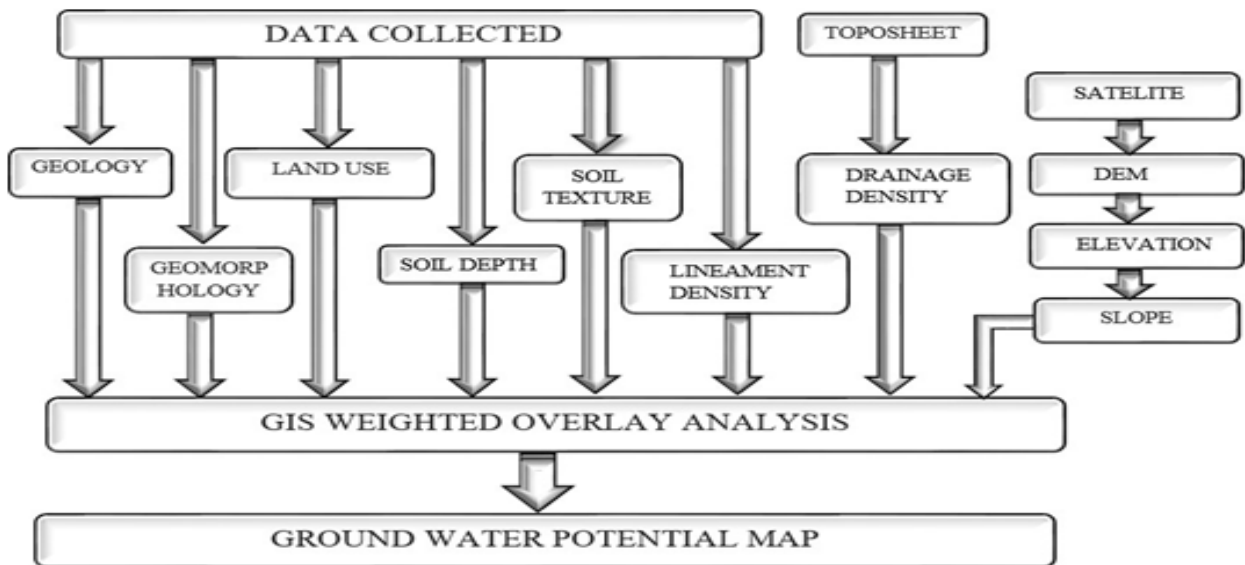


Fig 2 Flow chart of GWPZ methodology

### 3. MIF TECHNIQUE

For obtaining the Ground Water Potential Zones, the effect of various parameters on the ground water has to be analysed. For the purpose a Weightage was assigned to each of the parameters, geology, geomorphology, drainage density, lineament density, landuse, soil texture, soil thickness, slope. A weightage of 1 for major effect and 0.5 for minor effect were assigned. The cumulative weightage of each were found out for obtaining the final weightage of each influencing layer.

$$\frac{(a+b)}{\Sigma(a+b)} \times 100$$

Where 'a' and 'b' are the major and minor influencing factor respectively between two parameters.

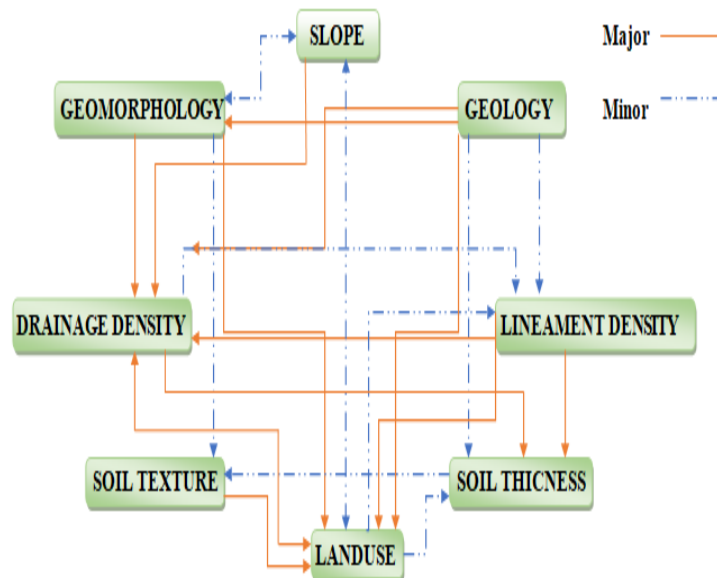


Fig 3: Major effects and Minor effects of MIF Technique

FACTOR	Major Effect (a)	Minor Effect (b)	Relative Rate (a+b)	Proposed score
Geology	1 + 1 + 1	0.5 + 0.5	4	22
Geomorphology	1 + 1	0.5 + 0.5	3	16
Lineament	1 + 1 + 1	0	3	16
Landuse/ Landcover	1	0.5 + 0.5 + 0.5	2.5	14
Drainage Density	1 + 1	0.5	2.5	13
Slope	1	0.5 + 0.5	2	11
Soil Texture	1	0	1	5
Soil Depth	0	0.5	0.5	3
			$\Sigma$ 18.5	$\Sigma$ 100

Table2: MIF Technique weightages.

#### 4. GROUND WATER POTENTIAL ZONE MAP

After the analysis using different parameters in the GIS platform has helped to acquire the Ground Water Potential Zone map of the study area. By the reclassification of the resultant map, it was able for the classification of the area into different zones namely very low, low, medium, high.

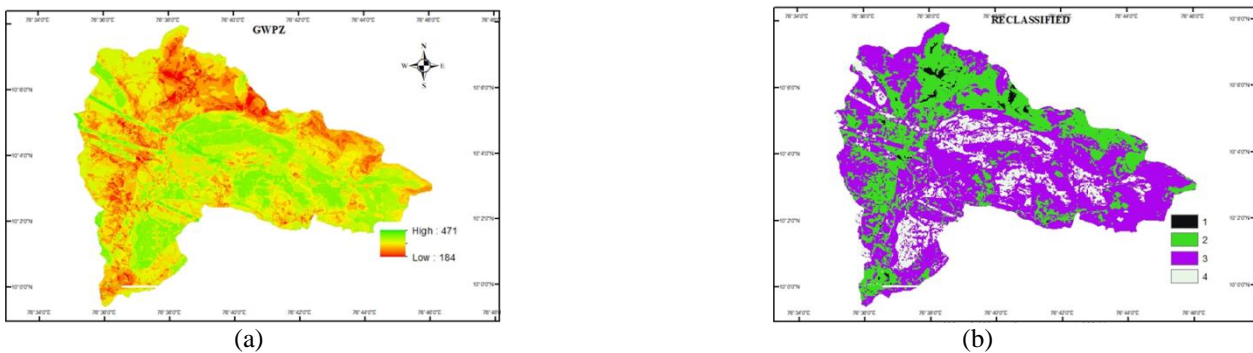


Fig 4: Ground water potential zone Map and Reclassified Map

About 12.172 % of the total area is in the highly ground water available zone (4 in Fig 3-b), 57.075 % of area is in the medium ground water available zone(3 in Fig 3-b), 29.595 % of area is in the low ground water availability zone(2 in Fig 3-b) and the remaining 1.158 % of area is very low ground water availability zone(1 in Fig 3-b).

### III. MORPHOMETRIC ANALYSIS

#### 1. STUDY AREA

The study area was chosen to be the kothamangalam subbasin which lies in the eastern part of Ernakulam district. It is a part of Muvattupuzha river basin. The study area lies between the coordinates 10.132681 in the top, 9.969295 in the bottom, 76.584087 in the left, 76.877179 in the right. It has a total area of 202.3 km<sup>2</sup> and perimeter of 99.333 km.

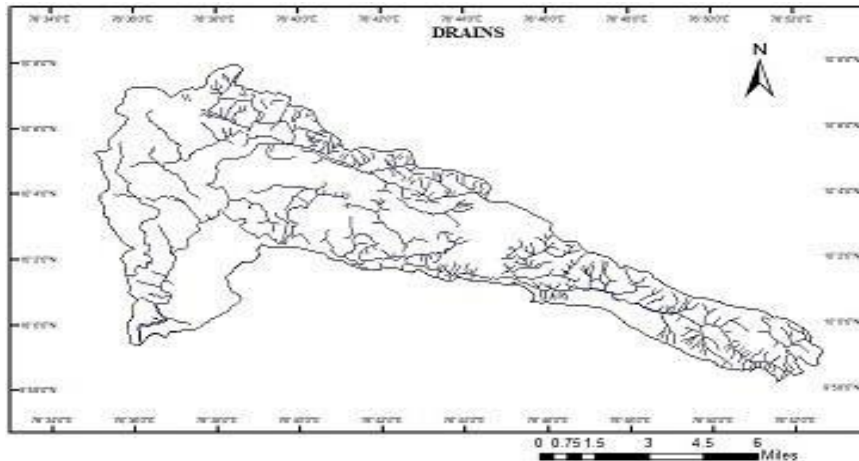


Fig 5: Drains for Morphometric study area

#### 2. MORPHOMETRIC PARAMETERS

Stream Order (U): It is the relationship between stream segments of different order. A third order stream is found by meeting two or more second order stream. Here the order of river is four.

Stream Number (Nu): Total number of streams present in the given segment. From the analysis the number of stream obtained is 551.

Stream Length (Lu): Total length of individual stream segments is known as the stream length of that particular order. The total length of the stream is 315.872 km

Mean Stream Length (Lsm): It is the ratio of total stream length of order "u" to the number of stream of segments in that order. It is directly proportional to the basin area and its topography.

Stream Length Ratio (Ri): It is the ratio of the mean of segments of order to mean length of segments of the next lower order. It has important relationship with surface flow and discharge and erosion stage of the basin.

Bifurcation Ratio (Rb): It is the ratio of the number of the stream segments of given order to the number of streams in the next higher order. The range of bifurcation ratio is between 2.08 to 2.5 which indicated a flat region. The bifurcation ratio is indicative parameter of shape of the basin also.

Basin Length: It is the longest dimension of basin parallel to the principal drainage line. The value is 35.56 km.

Drainage Density (Dd): It is the ratio of total stream length of all the streams in the watershed to the area of watershed. High drainage density is favoured in weak rocks. The subbasin has moderate drainage density as the value obtained lies between 1 and 2.

Stream/Drainage Frequency (Fs): It is the ratio of total number of all the streams in the watershed to the area of watershed. The value of stream frequency obtained lies in the moderate category.



Texture Ratio (T): It is the total number of stream sequence of all orders per perimeter of that area. Texture ratio of 3.14 indicates coarser nature.

Form Factor (Rf): Form factor is be defined as the ratio of basin area to square of the basin length. Smaller the value of form factor, more elongated will be the basin. The value obtained is 0.16 which indicates elongated basin.

Circulatory Ratio (Rc): Circularity ratio is the ratio of the basin area to the area of a same circumference perimeter as the basin. As the circulatory ratio is low, it indicates youth stages of tributary basins.

Elongation Ratio (Re): It is the ratio between the diameter of the circle of the drainage basin and the maximum length of the basin. A circular basin is more efficient in runoff discharge than elongated basin. The Elongation ratio of 0.45 indicates more elongated basin.

Constant Channel Maintenance (C): It is the inverse of drainage density or the constant of channel maintenance as a property of landforms. The constant channel maintenance of 0.64 indicates least erodible channel.

Length Of Overland Flow (Lg): It is the length of water over the ground surface before it is concentrated into definite stream channel. The value obtained is 0.32 indicates possibility of channel erosion than sheet erosion.

Relief Ratio (Rh): The relief ratio is the ratio of maximum relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line is termed as relief ratio. Relief ratio of 833m indicates high relief.

Ruggedness Number (Rn): Ruggedness number is the product of the basin relief and the drainage density and usefully combines slope steepness with its length. The obtained value is greater than 0.79 which indicates the area is more prone to soil erosion.

**IV. RESULTS OF ANALYSIS**

Area of the watershed, A = 202.3 km<sup>2</sup>,  
 Total length of the streams , L = 315.872 km  
 Total number of first order streams, N1 = 312

Perimeter of the watershed, P = 99.333 km<sup>2</sup> ,  
 Total number of the streams, N = 551  
 Length of longest flow path= 35.56 km

	Morphometric Parameter	Method	Result
<b>LINEAR</b>	Stream Order (U)	Hierarchical order	Refer Table 4
	Stream Length (Lu)	Length of the stream of order ‘U’	
	Mean Stream Length (Lsm)	$Lsm = Lu / Nu$ Nu=Number of streams of order ‘U’	
	Stream Length ratio (RI)	$RI = Lu / (Lu-1)$ Lu-1 = Stream length of stream of order ‘u-1’	
	Bifurcation Ratio (Rb)	$Rb = Nu / (Nu+1)$ Nu+1 = Number of streams of order ‘u+1’	
<b>RELIEF</b>	Basin Relief (Bh)	Vertical distance between the lowest and highest points of the study area	0.833
	Relief Ratio (Rh)	$Rh = Bh / Lb$ Lb = BasinLength	0.023
	Ruggedness Number (Rn)	$Rn = Bh \times Dd$ Dd = Drainage Density	1.3



ARIAL	Drainage Density (Dd)	$Dd = L / A$ L = Total Length of the streams A = Total area of the study area	1.561
	Stream Frequency (Fs)	$Fs = N / A$ N = Total number of streams	2.724
	Texture Ratio (T)	$T = N1 / P$ N1 = Total number of first order streams P = Perimeter of the study area	3.141
	Form Factor (Rf)	$Rf = A / (Lb^2)$	0.16
	Circulatory Ratio (Rc)	$Rc = 4\pi A / P^2$	0.258
	Elongation Ratio (Re)	$Re = \frac{2\sqrt{A/\pi}}{Lb}$	0.45
	Length of Overland Flow (Lof)	$Lof = 1 / (2 \times Dd)$	0.32
	Constant Channel Maintenance (C)	$C = 1 / Dd$	0.64

Table 3 Morphometric Parameter’s Equations and Results

Stream Order(U)	Stream Length (Lu) in km	No. Of Streams of OrderU(Nu)	Mean Stream Length( Lsm) in km	StreamLength Ratio (RI)	Bifurcation Ratio (Rb)
1	176.717	312	0.576	-	2.08
2	93.236	150	0.621	1.079	2.5
3	32.0997	60	0.535	0.861	2.069
4	10.819	29	0.373	0.697	-

Table 4: Linear Parameters

V. CONCLUSION

The analysis of ground water potential zone of kothamangalam watershed was done with the help of GIS ,RS and MIF techniques. This analysis is one of the best way to minimise the time, labour and money and thereby enables quick decision making for sustainable water resource management. MIF technique was used for assigning weightage for thematic layers. Kothamangalam sub basin is divided into four different zones namely, high ,medium, low and very low. The result of this study can be used as a reference for the future recharge projects. In the morphometric analysis, based on the order of drainage the sub basin was calssified as fourth order. The study reveals that the drainage basins are in the youth stage. Low form factor indicates low peak flow and longer duration indicates that the basin is not good for absorbing water into the soil and the groundwater recharging is more and also there is risk of flooding. If such floods



would be emerged, those could be managed easily from this type of elongated basins than from circular basins by adopting suitable precautionary measures.

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