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Vulnerable Area Assessind Due to Flood in Cuddalore District by Morphometric Analysis Method

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Abstract—**Flood is a natural disaster which causes serious damage on the earth surface; it is a relatively high flow of water that overtops the natural and artificial banks in any of the reaches of a stream. The severity of flood may vary from region to region and the destruction caused due to same varies accordingly. Cuddalore district being a coastal zone is mostly covered by plain terrain which often experience incessant rainfall. This brings the necessity to assess vulnerable regions in the study area by using remote sensing and ArcGIS. The present work is carried out by morphometric analysis of vulnerability assessment in river basins in Cuddalore district.It includes developed methodology process information of several parameters namely river waterbasin, stream order, stream length, stream frequency and drainage density. According to Hortan's that basin having high stream frequency and drainage density is most vulnerable to flooding. By using satellite images (LANDSAT & SRTMDEM) base map such as geology, geomorphology, slope, contour, stream, watershed, stream frequency, drainage density and circulatory ratio are prepared in ArcGIS software. This vulnerability assessment map will be useful for managing and mitigating the socio-economic losses from recurrent flood disaster in Cuddalore district.**

KEYWORDS: Vulnerable, Morphometric analysis, Stream frequency, Drainage density.

I. INTRODUCTION

Flood is the natural disaster that occurred by natural cause like heavy rainfall, rapid urban growth, climate change and deforestation. More than half of the world's population lives in Asia, which is approximately one-fifth of the earth's land area. As natural calamities increases it results in devasting effect around the world, the Asian region continues to suffer a disproportionate number of hazard events and related losses in lives in all the aspects. Flood hazard comprises many aspects which include structural and erosion damage, contamination of food and water, disruption on socio economic activity including transport and communication, as well as loss of life and property. Less developed places that are affected by climatic hazards face great challenges to future development. while improving development levels in the developing world has proved to be difficult in general.

FLOOD IN CUDDALORE DISTRICT

The Cuddalore district is categorically classified as Disaster Prone Area because of its geological position and low lying areas. The cuddalore district is frequently subjected to natural disaster such as Flood, Tsunami, Drought, Cyclone (ex: Thane, Nisha) etc., and the major reasons for flooding in cuddalore district are given below.All the rivers are draining into Bay of Bengal at closer intervals. Terrain is flat and just 1.50m above M.S.L,all the flood water got accumulated in this area could not be easily drained into the sea. The bed level of rivers are lyong minus 1m from the sea. Due to this, the back water in the rivers cause all the flood damage.

Cuddalore district of Tamil Nadu lies in the coastal line is one of the most backward districts frequently hit by natural disaster in every year after the Tsunami 2004. The district at the tail end and the draining points for more than 5 rivers and number of tributaries, water discharge and draining from Neyveli Lignite Corporation, deep depressions in Bay of Bengal and Indian ocean making cuddalore district as a regular Disaster-Prone zone of Tamil Nadu. Out of the 13 blocks in cuddalore district, 11 blocks have been affected by flood and 7 blocks have been put under the most affected list.The district witnessed the human loss of 54, thousands of cattle, 50000 damaged huts, over 24000 hectares had been completely damaged due to the cyclone, food and cash crops submerged, 53 villages had been affected by flood.. About 43,000 people in rural areas and 6700 in urban areas have been accommodate in relief centers. Government and non-government organization are also working for the welfare of flood area people.To overcome the national boarders, geographic location and socio-economic limitations the flood risk management are need to identify the impacts at regional scale require the identification of prone areas for provide early warning, facilitate quick response and decrease the impact of possible flood events.

Remote sensing and GIS-Arc SWAT tool technique are used to assessing various terrain, and its convenient method for morphometery analysis as the satellite images provides a view of large area and is very useful in the analysis of drainage basin morphometery.

2. STUDY AREA

Cuddalore District is situated in the south Indian state of Tamilnadu between 11˚ 45' and 12˚ 27' of northern latitude and 78˚ 48' and 80˚ 12' of East longitude and covering an area of 3,698.68 Sq. K.M. The cuddalore district is encircled by Pondicherry and Villupuram District on the north, Nagapattinam and Ariyalur District on the south, Bay of Bengal on the east and Perambalur district on the west. the eastern side of the district has a coastline of 52 Kms covered by the Bay of Bengal.The cuddalore district being a coastal zone is mostly covered by plain terrain with out any high relief zone except some sedimentary high ground in vriddhachalam, cuddalore and panruti taluks. The Gadilam and pennaiyar rivers flow in the northern side of cuddalore district and velar and coleroon river flows in south.The cuddalore district experiences a tropical wet and dry climate and witness heavy rainfall during north east monsoon season. The period from November to February, the climate in cuddalore district is full of warm days and cool night. The onset of summer is from march and reaches its peak by the month of may and June. The average temperature ranges from 22.5℃ (72.5℉) in January to 37℃ (99℉) in may and June. Summer rain are spare and south west monsoon sets in June and continues till September. North east monsoon starts in October and continues till December.

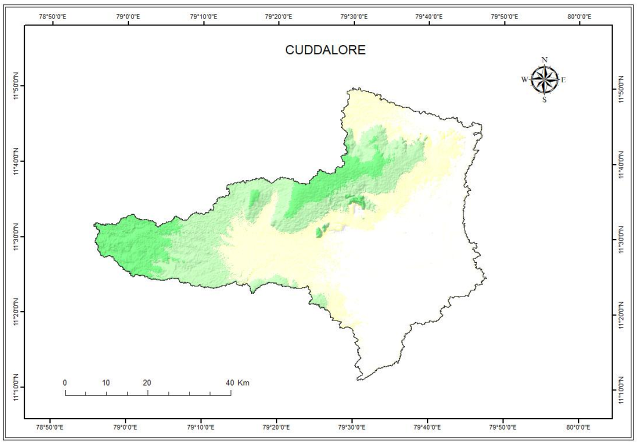

Fig 1: Boundary map of Cuddalore

3. MATERIALS AND METHODS

In this project work for identification of stream channels to delineate the watershed in cuddalore district by satellite images (DEM) is collected from United States Geological Survey (USGS). By applying Strahler,stream ordering method in GIS environment the river basins are exploited by using spatial analyst tools (Hydrological model) and prepare a comprehensive flood zone map to predict and determining the potential flood vulnerability and list of vulnerable sectors, elements and resources for the community of cuddalore river basin Satellite Image (Landsat TM) is also collected from United States Geological Survey (USGS) for Land Use and Land Cover classification of RS tools and techniques for vulnerability mapping for cuddalore district.

STREAM CHANNEL EXTRACTION

The stream network of the study area is extracted from a series of geo processing tools . According to Strahler the output of this technique creates a stream network grid with stream classification. Strahler's system of classification designated a segment with no tributaries as a first order stream. Second order stream are formed by joining the two first order stream segments. The highest stream order in the study area was determined as third. Manual corrections are made by merging the streams of same order with seperated nodes.

Table 1: Formula for computation of morphometric parameters:

	Morphometry Parameters	Methods	References
LINEAR	Stream order (U)	Hierarchical order	Strahler, 1964
	Stream length (Lu)	Length of the stream	Horton, 1945
	Mean stream length (Lsm)	Lsm = Lu/Nu where, Lu=Stream length of order 'U' Nu=Total number of stream segments of order 'U'	Horton, 1945
	Stream length ratio (Rl)	Rl=Lu/Lu-1; where Lu=Total stream length of order 'U', Lu- 1=Stream length of next lower order.	Horton, 1945
	Bifurcation ratio (Rb)	Rb = Nu/ Nu+1; where, Nu=Total number of stream segment of order'u'; Nu+1=Number of segment of next higher order	Schumn,1956
RELIEF	Basin relief (Bh)	Vertical distance between the lowest and highest points of watershed.	Schumn, 1956
	Relief ratio (Rh)	Rh=Bh/Lb; Where, Bh=Basin relief;Lb=Basin length	Schumn, 1956
	Ruggedness number (Rn)	Rn = Bh × Dd Where, Bh =Basin relief; Dd=Drainage density	Schumn, 1956
ARIAL	Drainage density (Dd)	Dd = L/A where, L=Total length of streams;A=Area of watershed	Horton, 1945
	Stream frequency (Fs)	Fs = N/A where, N=Total number of streams; A=Area of watershed	Horton, 1945
	Texture ratio (T)	T = N1/P where,N1=Total number of first order streams; P=Perimeter of watershed	Horton, 1945
	Form factor (Rf)	$Rf=A/(Lb)^2$;where, A=Area of watershed, Lb=Basin length	Horton, 1932
	Circulatory ratio (Rc)	$Rc=4\pi A/P^2$;where, A=Area of watershed, π=3.14, P=Perimeter of watershed	Miller, 1953
	Elongation ratio (Re)	$Re=2\sqrt{(A/\pi)}/Lb$;where, A=Area of watershed, π=3.14, Lb=Basin length	Schumn,1956

STREAM ORDER

For analyzing the drainage basin, it is needed to determine stream orders. In this study, the channel segment of the drainage basin has been ranked with lens of strahler's stream ordering system. According to strahler's the smallest fingertip tributaries are designed as order 1. Where two first order channels join, a channel segment of order 2 is formed; where two of order 3 is formed.

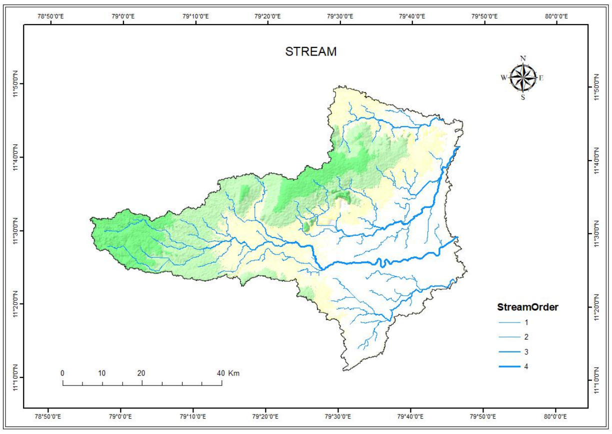

Fig 2: Stream order map of Cuddalore

STREAM LENGTH(Lu)

In this work, Horton law has been applied to measure stream length (Lu) of river basin and sub-basin. Stream length reflects surface runoff of a river basin which is one of the essential hydro-morphometric features for assessing flood hazard vulnerability. According to Horton, Stream length of a river basin is a first order and gradually decreases in next orders. ArcGIS is considered as the tool for spatial analysis in hydrological environment along with the number of stream in a stream order and their stream length.

MEAN STREAM LENGTH(Lsm)

The mean stream length of a channel is a dimensional property and reveals the characteristic size of drainage network components and its contributing basin surfaces (Strahler, 1964). The mean stream length (Lsm) has been calculated by dividing the total stream length of order by the number of streams. Table indicates that Lsm in the sub watersheds ranges between km found at watersheds and watersheds respectively. Lsm of any given order is greater than the lower order and less than the next higher order in the river basin. This might be due to variations in relief, slope and lithology of the area.

STREAM LENGTH RATIO(Rl)

It is the ratio between the mean lengths of streams of any two consecutive orders. Horton's law (1945) of stream length states that the mean stream length of the segments of each of the successive orders of a basin tends to approximate a direct geometric series with stream lengths results in increasing towards higher stream order. Stream length ratio (Rl) in these sub-watersheds varies between km at paces mentioned here respectively as like Lsm. This variation is majorly caused due to changes in slope and topography. All sub watersheds in the present study area have changes from one order to next order representing their stage of demographic development. It is the ratio of number of streams of a given order to the number of streams of the next higher order (Schumm, 1956).

BIFURCATION RATIO(Rb)

Bifurcation ratio is defined as the ratio of total number of stream segments of order to number of streams in the next higher order. According to Strahler (1957), Rb shows only a small variation from region to region or different environments except where powerful geological control dominates. It observed from table that the Rb value is not uniformly decreasing from one order to its next order in most of the sub-watersheds, which denotes the geological control and lithological development on all sub – watersheds of the study area.

RHO COEFFICIENT

Rho coefficient is the ratio between the stream length ratio (RL) and bifurcation ratio (Rb). The computed value of Rho coefficient for the study area is value substitute here. It is an important parameter to determines the relationship between the drainage density and the physiographical characteristic of the basin, and allows the evaluation of the storage capacity of the drainage network. It is influenced by climate, geologic, biologic, geomorphologic and anthropogenic factors.

STREAM FREQUENCY (Fs)

Stream frequency(Fs) is defined as number of stream segments of all orders per unit drainage area. A higher Fs shows that the greater surface runoff and a steeper ground surface. According to Kale flooding is more likely in basins with a high drainage and stream frequency. Reddy stated that low values of stream frequency Fs indicate presence of a permeable subsurface material and low relief. The factors which influence F are rainfall amount, erodibility, permeability, structure of rock, basin shape, tectonic influences etc. the stream frequency of the basin is value substitute here. This low value indicates the basin possess low relief and the almost flat topography.

DRAINAGE DENSITY

Drainage density (Dd) express total stream length per unit drainage area. It depend on the climatic factor, geology, vegetation cover, and helps in determing the erosivity, infiltration capacity and permeability of underlying rock and soil, relief and slope aspect of the basin. Dd increase rapidly; while towards old stage its decreases. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture. In the study area, Dd is 0.23 km in RW1, 0.30 km in RW2, 0.31 km in RW3, 0.26 km in RW4 among these the RW2 is more vulnerable to flooding in the study area.

DRAINAGE TEXTURE

Drainage texture is the total number of stream segments of all order in a river basin to the perimeter of the basin. Unit of drainage texture is km^{-1}. The classification of drainage texture is the same with the classification of drainage density. Classification of drainage texture mostly do not use a classification by applying certain values ranges for each class, but the classification tends to be more relative among studied watersheds by comparing one to another. A watershed which has very fine texture or the highest value of drainage texture (>8) implies that it has more risk of soil erosion.

LENGTH OF THE BASIN

According to Horton defined basin length as the straight-line distance from a basin mouth to the point on the water divide intersected by the projection of the direction of the line through the source of the main stream, parallel to the principal drainage line. The length of ponnaiyar river basin is 37.84 km, and sub basin of paravanar (uppanar) is 63.88 km, vellar is 71.10 km and coleroon is 46.67 km has arrived.

BASIN SHAPE

Basin shape is defined as the ratio of the square of basin length (Lb) to the area of basin (A). It indicates that the basin is neither too elongated nor too circular. Cauvery, vellar, and south pennaiyar area here has a shape factor of 0.26, 0.23, 0.22, 0.25.

CIRCULATORY RATIO

Miller (1953) define circulatory ratio as the ratio of the basin area to the area of circle having the same circumference parameter as the basin. It is a dimensionless index to the form outline of drainage basins. The ratio is influenced by the length and frequency of stream, geological structure, vegetation cover, climate, relief and slope of the basin. In the present study the Rc values for all sub watersheds vary from

0.05 to 0.18 which shows that the watersheds are almost elongated. This irregular is due to diversity of slope, relief and structural conditions prevailing in these watersheds.

FORM FACTOR(Rf)

Form factor is defined as the ratio of basin area and square of the basin length. The values of form factor would always be > 0.7854 which determines it perfectly for circular basin. Smaller value of form factor (<0.78) the basin will be more elongated. The form factor of all watersheds varies from 0.2 to 0.3, but the whole river basins and sub basins in the cuddalore have 0.26, 0.23, 0.22, and 0.25. The values of form factor indicates that the whole watersheds are elongated. Elongated watershed means has low peak flows for longer duration. While a circular watershed means it has high peak flows for a shorter duration.

ELONGATION RATIO(Re)

Schumm's (1956) defined elongation ratio (Re) is the ratio of the diameter of a circle of the same area as the basin to the maximum basin length. The values of elongation ratio generally vary from 0.6 to 1.0 over a wide variety of climate and geological type. Values close to 1.0 which are typical to regions of very low relief, whereas the values lies in the range of 0.6 to 0.8 are typical to regions of high relief and steep ground slope.

TOTAL BASIN RELIEF

Basin relief is defined by the difference in elevation between the highest and the lowest point of the basin. The sub basin relief range from 78 to 192m.

RELIEF RATIO(Rh)

Rh is defined as the ratio between the basin relief (R) and the basin length (L). It it's also an indicator of intensity of erosion process and sediment delivery rate of the basin. The gravity of water flow, low infiltration and high runoff conditions are the indicators of the highest relief. The areas with high relief and steep slope are considered by the high value of relief ratios. The (Rh) is normally increases with decreasing the drainage area and size of sub basin of a given area.

RELATIVE RELIEF(Rhp)

The maximum basin relief was obtained from the highest point the watershed perimeter to the mouth of the stream. By using basin relief values104, 197, 147,78m, a relief ratio was computed as suggested by Schumm by dividing it with computed length of basin, which is 0.58, 0.77, 0.31, and 0.35. Melton's relative relief was also calculated using the formula:

Rhp = (H*100)/P value about mentioned, where P is perimeter in meters.

RUGGEDNESS NUMBER(Rn)

Ruggedness number is used to measure the surface roughness or unevenness. The value of N is measured as N=Dd*(Rhp /1000). The basin shows N value mentioned here. Low value of N reveals less fragmentation of relief which implies highly eroded surface and gentle slope.

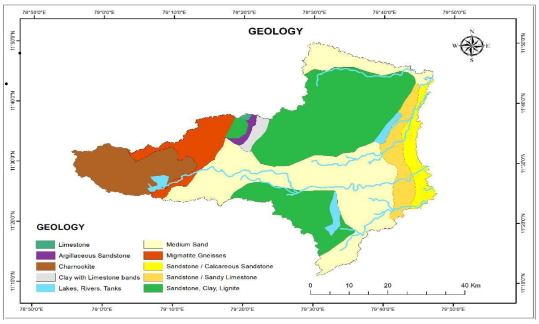

Fig3: Geology map of Cuddalore

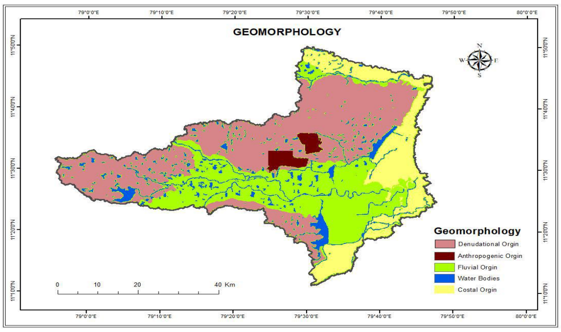

Fig 4: Geomorphology map of Cuddalore

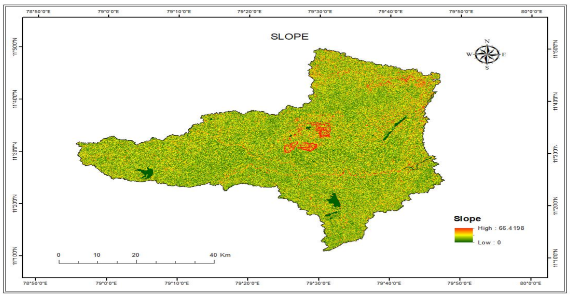

Fig 5: Slope map of Cuddalore

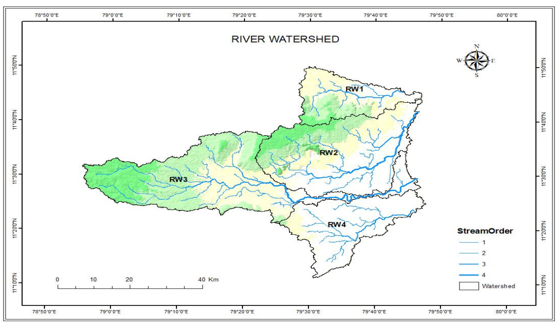

Fig 6: River watershed map of Cuddalore

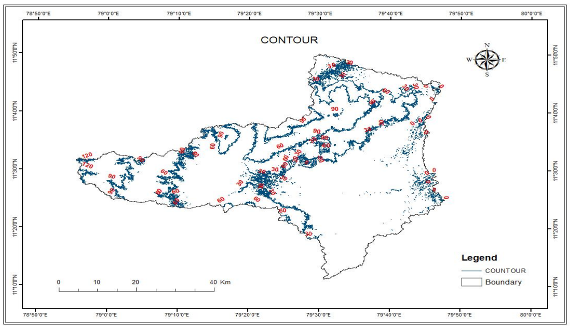

Fig 7: Contour map of Cuddalore

4. RESULT

The morphometric parameters, river subwatershed RW2 and RW3 contains high stream frequency and drainage density also having low bifurcation ratio , which means this basin is most vulnerable to flooding.

Table 2: Morphometric properties matrix of river watershed 1:

Parameters	Total	1st Order	2nd Order	3rd Order	4th Order
Number of Streams	13	10	2	1	
Stream Length	84	47	11	26	
Bifurcation Ratio(Rb)	4.70	4.27	0.42		
Stream Length Ratio (Rl)		0.23	2.36	0.00	
Mean Stream Length(Lsm)		4.70	5.50	26.00	
Rho Coefficent		0.05	5.59		
Perimeter(P) Km	180				
Area(A) Sq Km	372				
Stream Frequency(Fs)	0.03				
Drainage density (Dd)	0.23				
Drainage Texture (Dt)	0.07				
Length of Basin (Km)	37.84				
Basin Shape	0.26				
Circularaty Ratio	0.14				
Form Factor	0.26				
Elongation Ratio	3.13	59.24			
Minimum Elevation	-1				
Maxmium Elevation	103				
Total Basin Relief	104				
Relief Ratio	2.75				
Relative Relief	0.58				
Ruggedness Number	23.48	0.02348			

Table 3: Morphometric properties matrix of river watershed 2:

Parameters	Total	1st Order	2nd Order	3rd Order	4th Order
Number of Streams	43	30	9	3	1
Stream Length	277	159	54	28	36
Bifurcation Ratio(Rb)	4.87	2.94	1.93		
Stream Length Ratio (Rl)		0.34	0.52	1.29	
Mean Stream Length(Lsm)		5.30	6.00	9.33	
Rho Coefficent		0.12	0.27		
Perimeter(P) Km	255				
Area(A) Sq Km	935				
Stream Frequency(Fs)	0.05				
Drainage density (Dd)	0.30				
Drainage Texture (Dt)	0.17				
Length of Basin (Km)	63.88				
Basin Shape	0.23				
Circularaty Ratio	0.18				
Form Factor	0.23				
Elongation Ratio	4.66	148.89			
Minimum Elevation	-74				
Maxmium Elevation	123				
Total Basin Relief	197				
Relief Ratio	3.08				
Relative Relief	0.77				
Ruggedness Number	58.36	0.05836			

Table 4: Morphometric properties matrix of river watershed 3:

Parameters	Total	1st Order	2nd Order	3rd Order	4th Order
Number of Streams	43	30	9	3	1
Stream Length	348	163	84	41	60
Bifurcation Ratio(Rb)	3.99	1.94	2.05		
Stream Length Ratio (Rl)		0.52	0.49	1.46	
Mean Stream Length(Lsm)		5.43	9.33	13.67	
Rho Coefficent		0.27	0.24		
Perimeter(P) Km	471				
Area(A) Sq Km	1129				
Stream Frequency(Fs)	0.04				
Drainage density (Dd)	0.31				
Drainage Texture (Dt)	0.09				
Length of Basin (Km)	71.10				
Basin Shape	0.22				
Circularaty Ratio	0.06				
Form Factor	0.22				
Elongation Ratio	5.06	179.78			
Minimum Elevation	-14				
Maxmium Elevation	133				
Total Basin Relief	147				
Relief Ratio	2.07				
Relative Relief	0.31				
Ruggedness Number	45.31	0.04531			

Table 5: Morphometric properties matrix of river watershed 4:

Parameters	Total	1st Order	2nd Order	3rd Order	4th Order
Number of Streams	23	17	5	1	
Stream Length	142	77	35	30	
Bifurcation Ratio(Rb)	3.37	2.20	1.17		
Stream Length Ratio (Rl)		0.45	0.86	0.00	
Mean Stream Length(Lsm)		4.53	7.00	30.00	
Rho Coefficent		0.21	0.73		
Perimeter(P) Km	224				
Area(A) Sq Km	538				
Stream Frequency(Fs)	0.04				
Drainage density (Dd)	0.26				
Drainage Texture (Dt)	0.10				
Length of Basin (Km)	46.67				
Basin Shape	0.25				
Circularaty Ratio	0.13				
Form Factor	0.25				
Elongation Ratio	3.67	85.67			
Minimum Elevation	-8				
Maxmium Elevation	70				
Total Basin Relief	78				
Relief Ratio	1.67				
Relative Relief	0.35				
Ruggedness Number	20.59	0.02059			

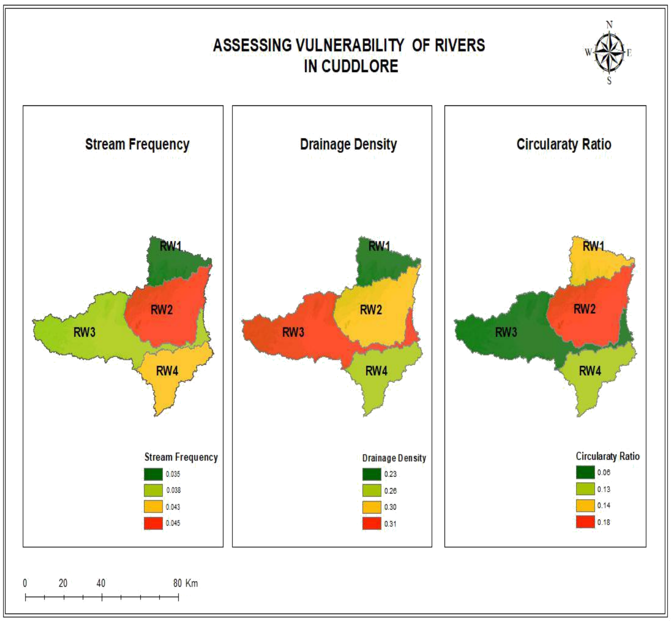

Fig 8:vulnerability map of Cuddalore

5. CONCLUSION

For prediction of flood hazard and vulnerable assessment of SOI Toposheets ,Landsat images are collected and DEM are created. Remote sensing and GIS play a vital role for the preparation of vulnerability map and morphometry analysis.The morphometry analysis , draianage system and its characteristic has been examined each river sub-watersheds in the study area it has found that RW2 and RW3 are falls in moderate and high vulnerable zones, hence this watersheds may taken for conservation measurement by decision makers for planning and development.

REFERENCES

[1] Abdul Rahaman S, Abdul Ajeez S, Aruchamy S, Jegankumar R (2015) "Prioritization of sub watershed based on morphometric characteristics using fuzzy analytical hierarchy process and geographical information system -A Study of Kallar Watershed, Tamil Nadu", International Conference On Water Resources, coastal and ocean engineering (ICWRCODE 2015) 1322-1330.

[2] Sukristiyani S, Maria R and Lestiana H (2018) "Watershed-based Morphometric Analysis: A Review", IOP Conf. Ser.: Earth Environ. Sci. 118 012028.

[3] Oyatayo Kehinde Taofik, Bello Innocent, Ndabula Christopher, Godwill Geofrey Jidauna, Ademola Sunday James (2017) "A Comparative Analysis of Drainage Morphometry on Hydrologic Characteristics of Kereke and Ukoghor Basins on Flood vulnerability in Makurdi town, Nigeria" *Hydrology.*Vol.5, No. 3, 2017, pp. 32-40. doi: 10.11648/j.hyd.20170503.11.

[4] Priyardharshini S, Dr. R Jegankumar, Dr. S Aruchamy (2017) "Morphometric Study of Sweta Nadi Basin, Salem District, Tamil Nadu, India: GIS approach", International Journal of Academic Research and Development ISSN: 2455-4197 Volume 2; Issue 6; November 2017; page No. 978-985.

[5] Jothibasu A and Anbazhagan S, (2016) "Flood susceptibility Appraisal in Ponnaiya River Basin, India using Frequency Ratio (FR) and Shannon's Entropy (SE) Models",International Journal of Advanced Remote Sensing and GIS 2016, Volume 5, Issue 10,pp. 1946-1962.

[6] Jesuraj.C, Murugan G, Anandhkumar M (2016) "Tamil Nadu (Chennai & cuddalore) had seen its worst floods", International Journal of Novel Research in physics chemistry & Mathematics Vol. 3, Issue 1, pp: (16-24).

[7] Bharadwaj A.K, Pradeep C, Thirumalaivasan D, Shankar C.P, Madhavan N (2014) "Morphometric Analysis Of Adayar Watershed", IOSR Journal of Mechanical and Civil Engineering e-ISSN: 2278-1684, P-ISSN : 2320-334X PP 71-77.

[8] Adger,W.N. (2006). Vulnerability, Global EnvironmentalChange-Vol.16 (3), pp.268-281.

[9] Thakkar, A.K., and S.D. Dhiman . 2007. Morphometry analysis and prioritization of mini- watershed s in a mohr watershed, Gujarat using remote snsing and GIS technique , jounal of the indian society of remote sensing, 35(4) :313-321.

[10] Aher, P. D., J. Adinarayana, and S.D. Gorantiwar. 2013. prioritization of watersheds using multicriteria evaluation through uzzy analystical hierachy process. Agric Eng Int: CICR journal, 15(1): 11-18.

[11] Sani yahaya 2008/ Multicriteria analysis for flood vulnerable areas in hadeja-jama are river basin,nigeria, APRS 2008 Annual conference portland, oregon, April 28-May 2, 2008.

[12] Yahya, F., Omar, A. and Ali, s. (2016). Morphometric analysis and flash floods assessment for draiage basins of the Ras En Naqb Area, South Journal of Geoscience and Environment protection, 14, 9-33.

[13] Strahler AN (1964) Quantitative geomorphology of drainage basin and channel networks. Handbook of applied hydrology.