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A Comprehensive Study on Morphometric Analysis for Prioritizing the Sub-Watershed and Conservation in Adyar Watershed Using Geospatial Techniques

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Abstract: **Integrated Watershed Management is indeed for these fast-growing cities and economic growth. Integrated water resource management helps to support the developing nation in better development. The surface water resources are easy to access and it is encroached by settlements causing flood. This study mainly studies the morphometric characterization of the adyar watershed using remote sensing satellite images. The unsuitable new land use and land cover pattern may lead to poor maintenance of water bodies. The spectral indices maps such as NDVI, and NDWI have been derived for land cover analysis. The land uses land cover pattern is analysed using GEE. Three parameters of topographic nature, climate, and anthropogenic activities are input to access the water body conservation. According to the landscape and climate, land use practices should be designed and planned to balance the region's ecology and environment. The stakeholders and land users insist on obtaining suggestions for efficiently utilizing, monitoring, and conserving the resources.**

The different periods of remote sensing satellite images are used to analyze the land cover change pattern and its impact on water bodies. The unplanned water supply and mismanagement of available resources are the major causes for this failure it may be sorted out using this analysis. In the future, this paper helps the engineers, NGOs, and government land policies to ensure the proper infrastructure and suitable activity over the region.

KEYWORDS: Morphometric Analysis, Watershed Management, Sustainable Development, Adyar Watershed.

I. Introduction

This analysis presents an insight into sustainable water resource management using GIS techniques and highlights the significant constraints that the city is facing. The Morphometric analysis for water resource management and other land use planning for the region is discussed and sub-watershed prioritization is derived. The techniques will be helpful for the planners to remove and clear the encroachments and obstructions in the waterways which may further leads to floods and other natural disaster due to climate extremes. The participants in this process must at least attempt to take into account the likely preferences of those not able to be present in this decision-making process, namely those who will be living in the future and who will be impacted by current resource management decisions. The morphometric analysis in the Ghaghara River basin is analyzed using SRTM data. The delineation of the basin and sub-watershed is delineated using a hydrology tool. The different aspects of morphometric parameters are calculated using the formulas commonly adopted for morphometric analysis. (Ajay Pratap Singh, et.al. 2020).

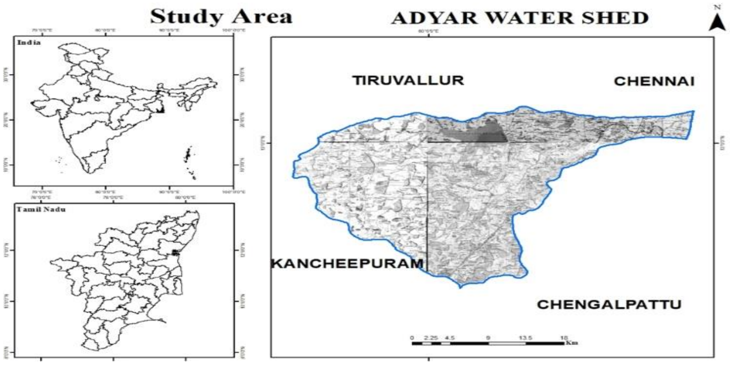
Using the SAR and RADARSAT data the watershed basin and sub-watershed were delineated using the hydrology tool. The delineated watershed is manipulated with morphometric analysis of different aspects such as basic, linear, shape, and relief were calculated using the formula for prioritizing the flash flood hotspot zones in the Wadi easel basin. (Mutawakil Obeidat, et.al. 2020). The morphometric characteristics assessment of the Chakar watershed is accessed and incorporated with different drainage patterns in the basin. The different drainage patterns indicate the region's geological control and structure. (Sandeep Soni, 2016). In this study, the water bodies show a parallel type and the remaining region indicates the dendritic type. Which is the most commonly found drainage pattern in the watershed. Using the derived values of morphometric analysis the sub-watershed prioritization is calculated using the compound ranking method. (Annaidasan Krishnan, et.al. 2022). With the help of the Geographic Information System (GIS), the work was made easier and derived appropriate results with the help of the morphometric formula adopted commonly by Strahler, Horton, and Schumn. The linear aspect is directly indicated by the soil erosion and infiltration capacity.

The drainage density, stream order, stream order length, etc. parameters are critically evaluated and analyzed for the region. (S. Sukristiyanti, et.al. 2018). A case study was conducted in the Charthana village of Maharashtra. The downloaded DEM data is delineated and subset for the drainage area in the study area. Each parameter is calculated and shown in the table. (M. L. Waikar, et.al. 2014). The elongation ratio, form factor, drainage density, and texture ratio of sub-watersheds were mapped using the chorochromatic method. Comparing each parameter of different aspects the prioritization of watershed is finalized using the composite parameter method. (Souleymane Bengaly, et.al. 2022).

GIS is proven that the most accurate values can be derived with the help of the most efficient tools in the GIS platforms. The derived values for correlated and morphometric analysis are scientifically proven using the adopted formula in the study region. (Sandeep Adhikar, 2020).

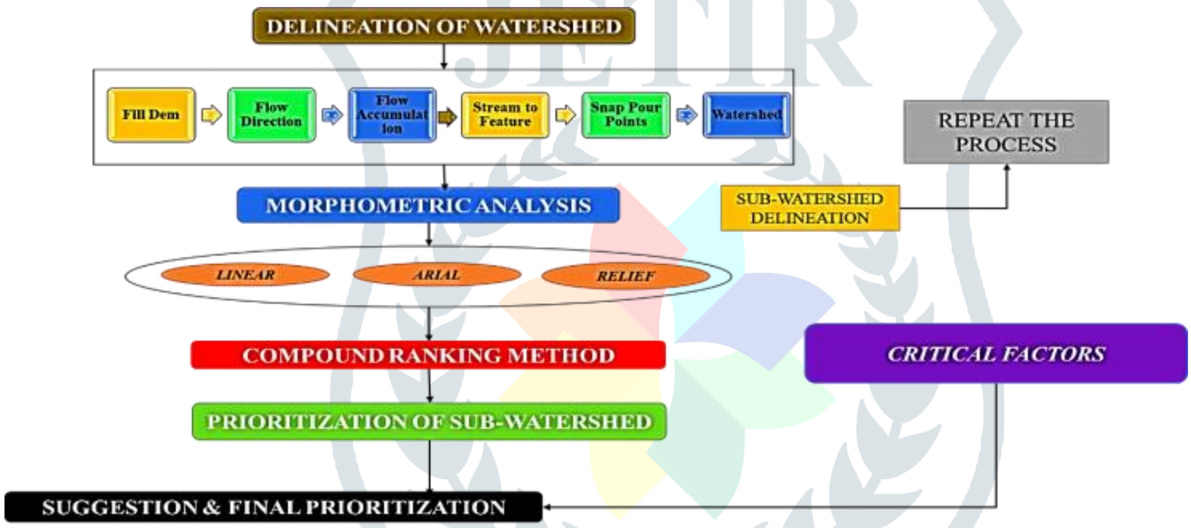
II. Study Area

The study area is delineated using geospatial techniques and hydrology tools from ARC GIS. The delineated watershed is repeated for delineating the sub-watershed in the basin. The major basin adyar is located on the southern banks of the Adyar River. The watershed covers the districts named Chennai, Kancheepuram, Chengalpattu, and Thiruvalur and this was the highest green cover recorded in the city. The total area of the Adyar watershed consists of 700 sq.km.



III. Dataset & Methodology

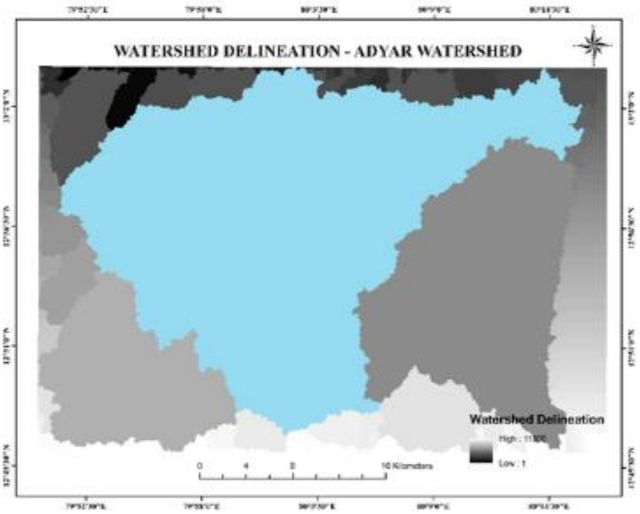
The SRTM Dem data of 30-meter resolution is downloaded using the Python code in Google Earth Engine. The downloaded DEM data is mosaicked and used for delineating the watershed.

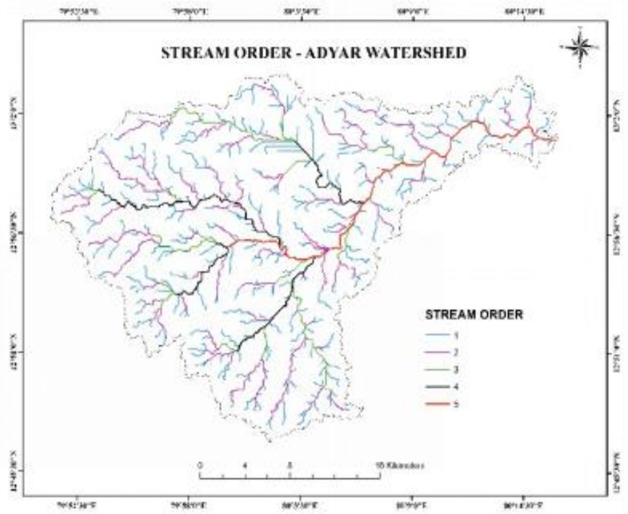


The spectral indices of the normalized difference vegetation index and normalized difference water index were analyzed using GEE. The land use land cover map was coded and derived from GEE using Landsat 9. The delineated watershed is repeated in its process for delineating the sub-watershed. The Adyar watershed is fixed as the region of interest. The morphometric analysis for prioritizing the watershed of parameters indicating high erosion and low permeability regions is identified. The indices and land use land cover maps were used to study the prioritized watershed status.

IV. Delineation of Watershed

Using the downloaded DEM the watershed delineation is include the following steps fill, flow direction, flow accumulation, stream to feature, snap pour points, and finally watershed is delineated. The stream order is the major feature to access the drainage pattern in the watershed. Using the hydrology tool in the geospatial platform. The stream features are derived in vector format. The derived stream features are dissolved for grouping the following orders as shown in fig. (4.1.b). There are five major orders are created where the 5th order is the major drainage path and the remaining orders are the distributaries of the drainage. (V. S. S. Kiran, et.al. 2014).





4.1.1. Sub Watershed Delineation:

From the delineated watershed adyar basin is fixed and further repeated the process for delineating the sub-watershed. There are 8 sub-watersheds delineated in the adyar basin. Each sub-watershed is vectorized thus, the area and perimeter are calculated in the attribute table.

4.2. Morphometric Analysis:

The Morphometric analysis is the scientific calculation of forms or structures which is the quantitative determination of landform. The most dominant geomorphic systems of the earth's surface are rivers and fluvial process which leads to changes in drainage basin or watershed. Analyzing the different aspects of land and water. They are linear, Arial, and relief aspects in the delineated watershed

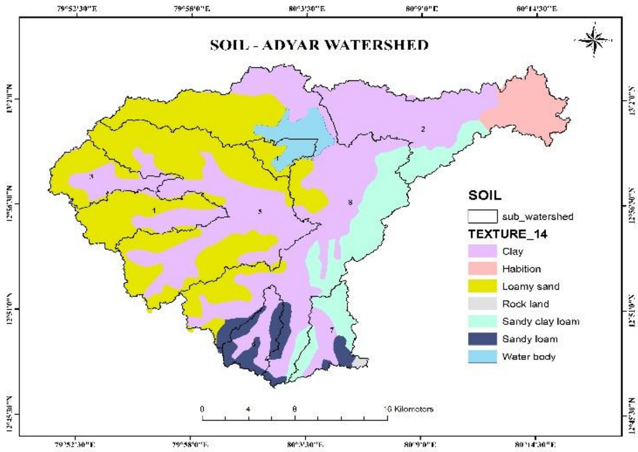
SI. NO.	ASPECT	MORPHOMETRIC PARAMETERS	FORMULA	REFERENCE
1	*LINEAR*	Stream Order(u)	Hierarchical Rank	Strahler (1964)
2		Stream Length	(L) of the stream	Horton (1945)
3		Mean Stream Length	Lsm = Lu/Nu	Horton (1945)
4		Stream Length Ratio	RL = Lu/Lu-1	Horton (1945)
5		Bifurcation Ratio	Rb = Nu/Nu+1	Horton (1945)
6		Mean Bifurcation Ratio	Rbm	Schumm (1956)
7		Sinuosity Index	SI = AL/EL	Schumm (1956)
1	*ARIAL*	Basin Area	A	Horton (1945)
2		Basin Perimeter	P	Horton (1945)
3		Length of the Basin	Lb	Horton (1945)
4		Drinage Density	Dd = L/A	Horton (1945)
5		Stream Frequency	Fs = N/A	Horton (1945)
6		Length of the Overland Flow	Lg = 1/2Dd	Horton (1945)
7		Basin Shape	Bs = (Lb)square/A	Horton (1945)
8		Form Factor	Rf = A/(Lb)square	Horton (1945)
9		Elongation Ratio	Re = (square root of (A/phi)/Lb)	Schumm (1956)
10		Circularity Ratio	Rc = 4∏(A/Psquare)	Miller (1953)
11		Compactness constant	Cc = 0.2821*P/A*0.05	Strahler (1964)
12		Texture Ratio	T = N1/P	Smith (1950)
13		Drinage Intensity	Di = Fs/Dd	Horton (1945)
14		Infiltration Number	If = Fs*Dd	Horton (1945)
15		Drinage Texture	Dt = Nu/P	Horton (1945)
16		Constant of Channel Maintanence	C = 1/Dd	Horton (1945)
1	RELIEF	Basin Relief (Bh)	Bh = H-h	Schumm (1956)
2		Relief Ratio (Rh)	Rh = Bh/Lb	Schumm (1956)
3		Ruggedness no. (Rn)	Rn = Bh*Dd	Schumm (1956)

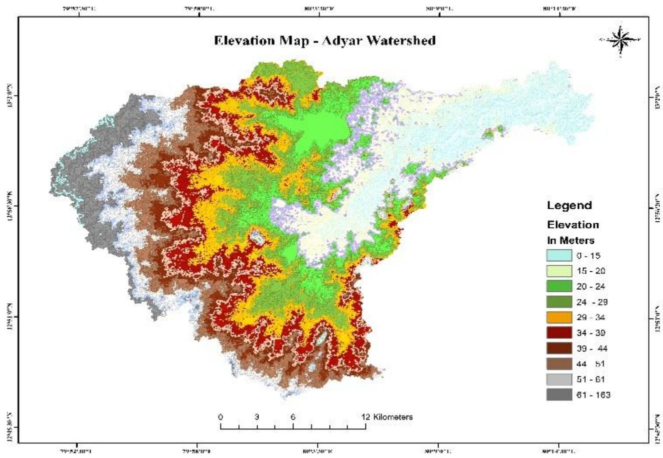
The different parameters of each morphometric analysis are analyzed and the values were ranked for prioritization. The linear and arial aspect of morphometric analysis is directly proportional and the shape and relief aspects are indirectly proportional. Considering the characteristics of different parameters the values were calculated using the formula mentioned in the table.

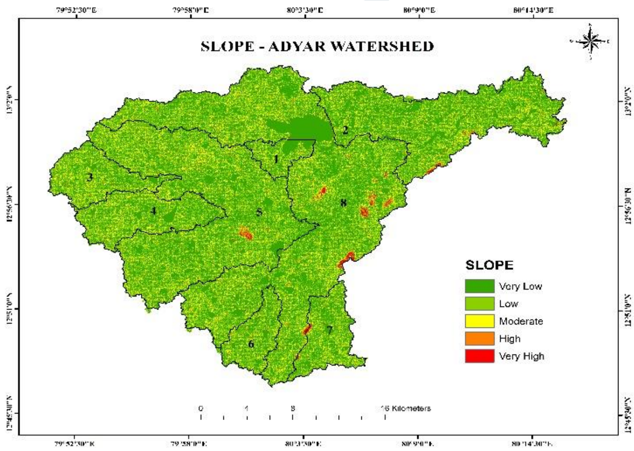
V. Result and Discussion:

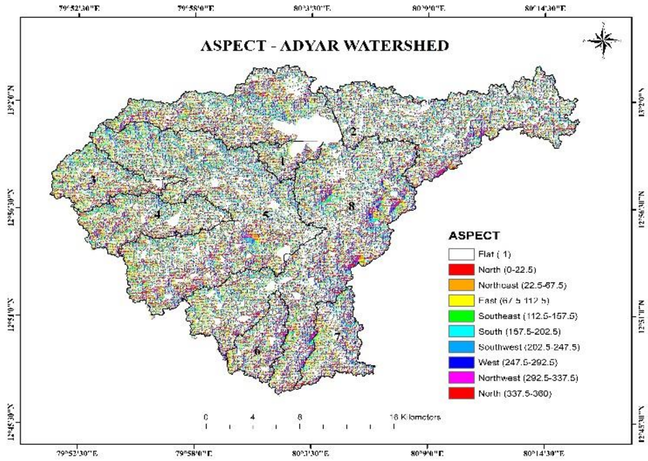
5.1. Topographic Characteristics of the Watershed:

The gradient of the surface and the geomorphological structure play a major role in hydrologic control. The terrain and relief characteristics have a major impact on the morphometric dynamic in the basin. The varying relief nature and continuous and discontinuous geologic structure create an impact on hydrological patterns.



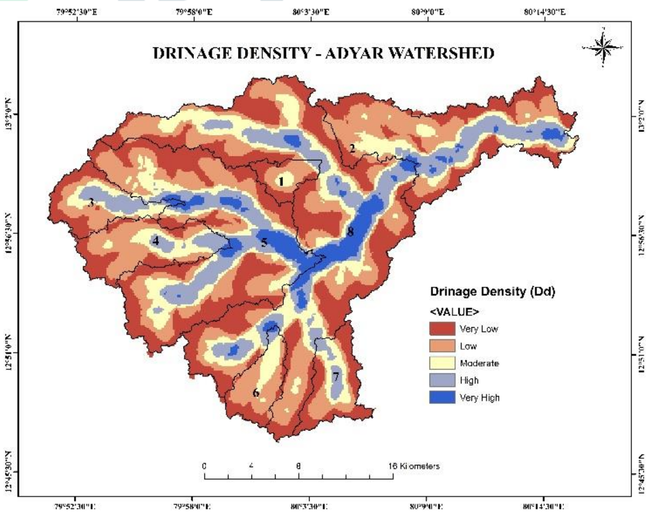






5.1.1 Soil:

The soil texture is shown in fig. (5.1.1) the adyar basin is highly dominated by clay and loamy sand soil which indicates poor infiltration and fewer absorption characteristics in the study region. Most of the portion resembles the porosity is higher.



5.1.2 Elevation:

The elevation map shows showing the relief is a flat and plain region. In the western part, only a few parts are showing max relief in the basin. The elevation of the basin ranges from 0 to 163 m above mean sea level.

5.1.3Slope:

The slope is derived using the fill DEM data as an input and it shows the very high to very low slope portion in the basin. It is playing a major role in accessing the morpho-climatic process in the varying gradient of the basin. (Avijit Majala, 2019).

5.1.4. Aspect:

The aspect shows the direction of low-lying and high-relief portions in the basin. The water bodies are indicated as white patches and the velocity of the flow direction is manipulated using the raw DEM data of the study area. (Ritambhara K Upadhyay, et al. 2021).

5.1.5. Drainage Density:

Drainage density (Dd) is the total length of streams of all orders (Km) per drainage area (Km2). The values are classified into <2 is very coarse, 2-4 is coarse, 4-6 is moderate, 6-8 is fine and >8 is very fine. In fig (5.1.5) the five classifications show the hydrological response of the drainage pattern. (S. Sukrishtiyanti, et.al. 2018).

5.2. Morphometric Analysis of Adyar Watershed

Each aspect of morphometric analysis is calculated for individual sub-watersheds. The linear aspect is calculated for each stream order mentioned in the given table (4.2.) Each parameter indicates the nature of the drainage pattern, obstruction in the terrain at the flow path, and the flow speed which is manipulated using scientific methods. (M. L. Walikar & et.al. 2014), (S. Sukristiyanti, et.al. 2018).

5.2.1. Linear Aspect:

The linear aspects access stream order, stream order length, mean stream length, stream length ratio, bifurcation ratio, stream frequency, drainage density, length of the overland flow, RHO co-efficient, drainage intensity, infiltration number, and constant of channel maintenance. Which all access direct relationship with soil erosion and infiltration capacity. The stream order (U) is the measure of no. of drainage patterns using strahler law in morphometry. The stream order length (Lu) is related to the terrain and SW6 and 7 possess very min values of stream length which may be caused to less permeability in the region. In SW2 and SW5 the bifurcation ratio is indicating >5 which means it is controlled by geologic structure. (Sandeep Adhikari, 2020). The drainage texture ratio is similar to Dd which compares the different sub-watershed hydrological responses. 4th order of SW3 is showing the value 11.0 which indicates a higher possibility of soil erosion in the region. (Alireza Arabameri, et.al. 2020). The length of the overland flow (Lg/AOLF) shows the length of water over the ground before it gets concentrated into a certain stream channel. (A.K. Bharadwaj, et.al. 2014). In this basin, there are no values identified below 0.3 which indicates that the basin has not come under a highly vulnerable status like a flash flood, with very little infiltration.

Lg = 1/ (Dd*2), where Dd is drainage density in Km or Km2

5.2.2. Arial Aspect:

The aerial aspect is indirectly related to the erosion nature of the soil. If the arial aspect is showing a higher value the basin does not have the characteristic of erosion and simultaneously the lower value indicates higher erosion in the basin area. (Padala Raja Shekar, et.al. 2022). The form factor (Rf) is the ratio of the watershed area to the square of the length of the watershed. The SW1, SW6, and SW7 is showing lower value and indicates a higher impact of soil erosion in the basin. (Shruti Verma, et.al. 2020). The elongation ratio (re) is the ratio of the diameter of a circle of the same area as the basin to the maximum basin length. There is no absolute value only with the relative measurement the (re) is interpreted. SW2 and SW6 are showing higher values it indicating the shape is not that much elongated when comparing other sub-watersheds. The circularity ratio (Rc) is the ratio between the areas of watersheds to the area of the same circumference as the perimeter of the watershed. In the sub-watershed, 6 shows a higher value indicating the higher existence of strong structural control of the watershed. (Mangesh Deepak Kulkarni, 2013).

5.2.3. Relief Aspect:

The relief ratio is the difference between the lowest and highest relief points in a watershed. The ruggedness number indicates the potential of flooding the basin. SW2 possesses the maximum chance of potential flooding is higher than the other SW in the basin. Relative relief is showing higher value in SW2 and SW7 which indicates high and sudden peak discharge may be adequately happening in that region. (Sahil Sanjeev Salvi, et.al. 2017). The basin relief indicates the infiltration capacity of the region. SW2, 5, and 7 show higher values which indicates low infiltration and high surface runoff and inundation causes in the region.

Sub-Watershed	LINEAR ASPECT													
	Stream Order	Stream Number(Nu)	Stream Length	Mean Stream Length	Bifurcation Ratio(Rb)	Stream Length Ratio(Rl)	Stream Frequency (Fs)	Drinage Density (Dd)	Drinage Texture (Dt)	Length of the Overland Flow(Lo)	RHO co-efficient (p)	Drinage Intensity (Di)	Infiltration Number (If)	Constant of Channel maintanence (Ccm)
SW - 1	1st order	9.0	4.6	0.5	0.0	0.0	0.6	0.3	0.4	0.2	0.0	2.0	0.2	3.1
	2nd order	6.0	4.2	0.7	1.5	0.9	0.4	0.3	0.3	0.1	0.6	1.4	0.1	3.4
	3rd order	2.0	3.0	1.5	3.0	0.7	0.1	0.2	0.1	0.1	0.2	0.7	0.0	4.6
	4th order	2.0	1.2	0.6		0.4	0.1	0.1	0.1	0.0	0.4	1.6	0.0	11.4
	5th order	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		19.0	13.0	3.3	5.5	2.0	1.4	0.9	0.8	0.5	1.3	5.7	0.4	22.4
SW - 2	1st order	77.0	63.0	0.8	0.0	0.0	0.7	0.6	0.8	0.3	0.0	1.2	0.4	1.8
	2nd order	46.0	37.0	0.8	1.7	0.6	0.4	0.3	0.5	0.2	0.4	1.2	0.1	3.0
	3rd order	8.0	6.0	0.8	5.8	0.2	0.1	0.1	0.1	0.0	0.0	1.3	0.0	18.7
	4th order	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5th order	24.0	18.0	0.8	0.0	0.0	0.2	0.2	0.2	0.1	0.0	1.3	0.0	6.2
Total		155.0	124.0	3.1	7.4	0.7	1.4	1.1	1.6	0.6	0.4	5.1	0.6	29.7
SW - 3	1st order	17.0	16.0	0.9	0.0	0.0	0.5	0.5	0.4	0.2	0.0	1.1	0.2	2.1
	2nd order	6.0	9.0	1.5	2.8	0.6	0.2	0.3	0.2	0.1	0.2	0.7	0.0	3.8
	3rd order	3.0	3.0	1.0	2.0	0.3	0.1	0.1	0.1	0.0	0.2	1.0	0.0	11.3
	4th order	9.0	11.0	1.2	0.3	3.7	0.3	0.3	0.3	0.2	11.0	0.8	0.1	3.1
	5th order	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		35.0	39.0	4.7	5.2	4.6	1.0	1.1	1.0	0.6	11.4	3.5	1.2	20.3
SW - 4	1st order	28.0	24.0	0.9	0.0	0.0	0.6	0.5	0.6	0.3	0.0	1.2	0.3	1.9
	2nd order	20.0	15.0	0.8	1.4	0.6	0.4	0.3	0.4	0.2	0.4	1.3	0.1	3.0
	3rd order	7.0	10.0	1.4	2.9	0.7	0.2	0.2	0.1	0.1	0.2	0.7	0.0	4.5
	4th order	3.0	2.0	0.7	2.3	0.2	0.1	0.0	0.1	0.0	0.1	1.5	0.0	22.5
	5th order	1.0	1.0	1.0	3.0	0.5	0.0	0.0	0.0	0.0	0.2	1.0	0.0	45.0
Total		59.0	52.0	4.7	9.6	2.0	1.3	1.2	1.2	0.6	0.9	5.7	2.1	76.9
SW - 5	1st order	142.0	97.0	0.7	0.0	0.0	0.8	0.6	0.8	0.3	0.0	1.5	0.5	1.8
	2nd order	73.0	58.0	0.8	1.7	0.6	0.4	0.3	0.5	0.2	0.4	1.3	0.1	3.0
	3rd order	10.0	10.0	1.0	5.8	0.2	0.1	0.1	0.1	0.0	0.0	1.0	0.0	17.3
	4th order	28.0	23.0	0.8	0.4	2.3	0.2	0.1	0.2	0.1	5.3	1.2	0.0	7.5
	5th order	13.0	11.0	0.8	2.1	0.5	0.1	0.1	0.1	0.0	0.2	1.2	0.0	15.7
Total		266.0	199.0	4.1	10.0	3.5	1.5	1.2	1.7	0.6	5.9	6.1	0.6	45.3
SW - 6	1st order	18.0	13.0	0.7	0.0	0.0	0.8	0.5	0.4	0.3	0.0	1.4	0.4	1.8
	2nd order	12.0	11.0	0.9	1.2	0.8	0.5	0.5	0.4	0.2	0.7	1.1	0.2	2.2
	3rd order	5.0	3.0	0.6	3.7	0.3	0.2	0.1	0.1	0.1	0.1	1.7	0.0	8.0
	4th order	4.0	2.0	0.5	1.5	0.7	0.2	0.1	0.1	0.0	0.4	2.0	0.0	12.0
	5th order	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		39.0	29.0	2.7	6.3	1.8	1.6	1.2	0.9	0.6	1.2	6.1	0.7	24.0
SW - 7	1st order	31.0	19.0	0.6	0.0	0.0	1.0	0.6	0.5	0.3	0.0	1.6	0.6	1.6
	2nd order	10.0	7.0	0.7	2.7	0.4	0.3	0.2	0.2	0.1	0.1	1.4	0.1	4.4
	3rd order	34.0	8.0	0.2	0.9	1.1	1.1	0.3	0.2	0.1	1.3	4.3	0.3	3.9
	4th order	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5th order	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		75.0	34.0	1.5	3.6	1.5	2.4	1.1	0.9	0.5	1.4	7.3	1.0	9.9
SW - 8	1st order	154.0	153.0	1.0	0.0	0.0	0.6	0.6	0.8	0.3	0.0	1.0	0.3	1.7
	2nd order	118.0	72.0	0.6	2.1	0.5	0.5	0.3	0.4	0.1	0.2	1.6	0.1	3.6
	3rd order	32.0	32.0	1.0	2.3	0.4	0.1	0.1	0.2	0.1	0.2	1.0	0.0	8.2
	4th order	28.0	24.0	0.9	1.3	0.8	0.1	0.1	0.1	0.0	0.6	1.2	0.0	10.9
	5th order	39.0	15.0	0.4	1.6	0.6	0.1	0.1	0.1	0.0	0.4	2.6	0.0	17.5
Total		371.0	296.0	3.8	7.3	2.3	1.4	1.1	1.5	0.6	1.4	7.4	0.5	41.9

Sub-Watershed	ARIAL ASPECT										RELIEF ASPECT		
	Basin Area	Basin Perimeter	Length of the Basin	Basin Shape	Form Factor	Shape Index	Elongation Ratio	Circularity Ratio	Compactness constant	Texture Ratio	Longest Path	Basin Relief (Bh)	Relief Ratio (Rh)	Ruggedness no. (Rn)
SW - 1	14	24	2.15156	0.331	6.507	0.154	1.92421	0.30528	0.9672	0.375	6.507	26	12.08	314.19
SW - 2	112	97	3.7331	0.124	30	0.033	2.87438	0.14951	0.48864	0.794	30	153	40.98	6270.7
SW - 3	34	41	2.27194	0.152	14.97	0.067	2.6824	0.25404	0.68036	0.415	14.97	63	27.73	1747
SW - 4	45	48	2.79287	0.173	16.11	0.062	2.48429	0.24531	0.60181	0.583	16.11	66	23.63	1559.7
SW - 5	173	118	5.95267	0.205	29.06	0.034	2.22955	0.15605	0.38483	1.203	29.06	124	20.83	2583
SW - 6	24	31	2.07489	0.179	11.57	0.086	2.51078	0.31367	0.72876	0.581	11.57	41	19.76	810.16
SW - 7	31	38	2.87825	0.267	10.77	0.093	2.03003	0.26964	0.6916	0.816	10.77	102	35.44	3614.7
SW - 8	262	192	8.20518	0.257	31.93	0.031	1.98449	0.08927	0.41346	0.802	31.93	153	18.65	2853

5.3. PRIORITIZATION OF SUB WATERSHED:

THE SUB-WATERSHED IS PRIORITIZED USING THE COMPOUND RANKING METHOD. EACH ASPECT AND ITS PARAMETERS ARE RANKED ACCORDING TO THE VALUES THAT INFLUENCED MORPHOMETRIC ANALYSIS AND A SUM OF A RANKING COMPOUND PARAMETER IS CALCULATED FOR MANIPULATING THE RANKS FOR EACH PARAMETER IN THE SUB-WATERSHED. (MUTAWAKIL OBEIDAT, ET.AL. 2021)

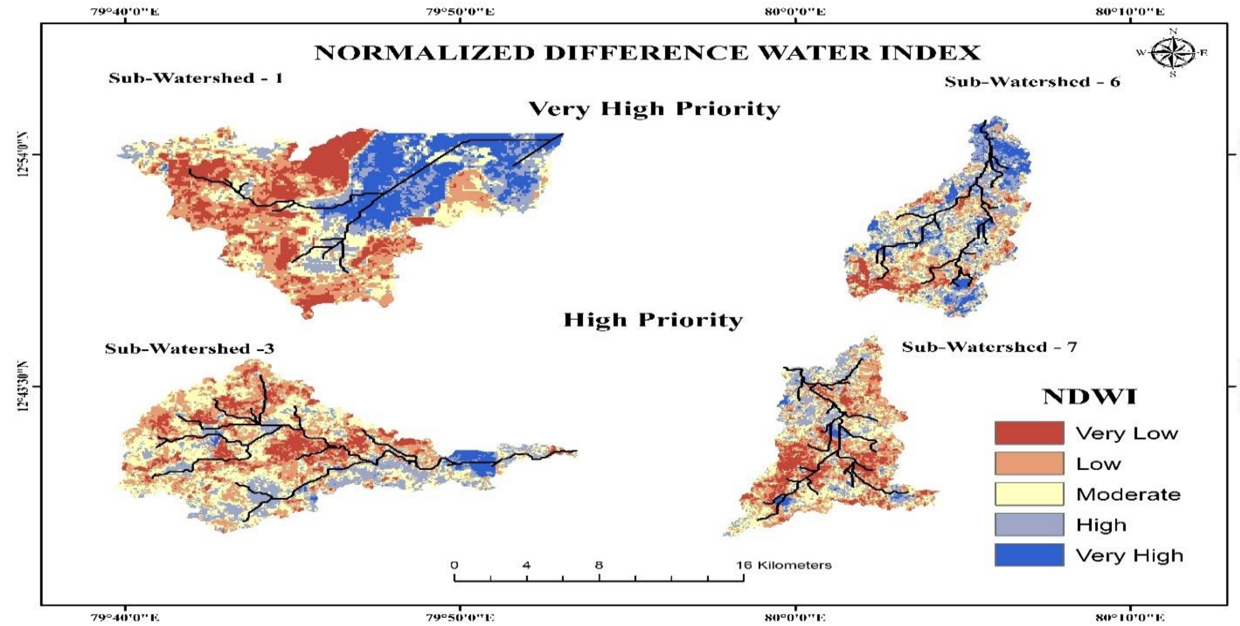
ASPECTS	Category	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8
LINEAR ASPECT	Stream Order	7	7	7	8	8	7	6	8
	Stream Number	1	6	2	4	7	3	5	8
	Mean Stream Length Ratio	5	4	8	8	7	3	2	6
	Bifurcation Ratio	3	6	2	7	8	4	1	5
	Mean Bifurcation Ratio	5	7	4	8	8	6	3	7
	Stream Frequency	5	5	3	4	6	7	8	5
	Drinage Density	6	7	7	8	8	8	7	7
	Drinage Texture	2	7	4	5	8	3	3	6
	Length Overland Flow	8	7	7	7	7	7	8	7
	RHO Coefficient	5	2	8	3	7	4	6	6
	Drinage Intensity	6	7	8	6	5	5	4	3
	Infiltration Number	2	4	7	8	4	5	6	3
	Constant of Channel Maintanance	3	5	2	8	7	4	1	6
ARIAL ASPECT	Basin Area	1	6	4	5	7	2	3	8
	Basin Length	7	3	6	5	2	8	4	1
	Longest Path	1	7	4	5	6	3	2	8
	Form Factor	8	2	5	4	3	6	7	1
	Shape Index	6	8	7	7	8	7	7	8
	Elongation Ratio	8	1	2	4	5	3	6	7
	Circularity Ratio	3	7	5	5	6	3	4	8
RELIEF ASPECT	Relief	2	8	4	5	7	3	6	8
	Relief Ratio	1	8	6	5	4	3	7	2
	Ruggedness Number	1	8	4	3	5	2	7	6
RANKING	Sum of Ranking	83	115	99	112	121	93	100	112
	Total No. of Parameters	23	23	23	23	23	23	23	23
	Compund Parameter	3.6	5.0	4.3	4.9	5.3	4.0	4.3	4.9
	Ranking	1	5	4	5	7	2	3	6
	Final Priority	Very High	Moderate	High	Moderate	Low	Very High	High	Low

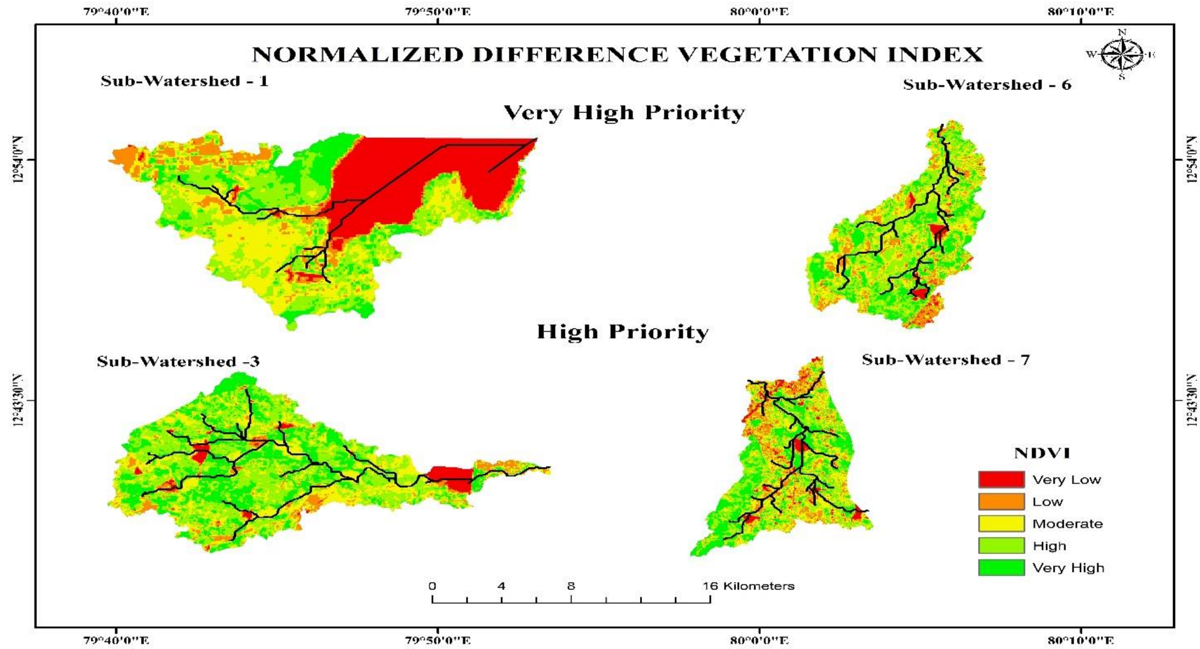
5.4.1. Normalized Difference Water Index

The Normalized Difference Water Index (NDWI) was first suggested to detect surface waters in wetland environments and measure surface water dimensions. The NDWI separates water and non-water objects well, with water areas generally having values greater than zero and vegetation areas having strong negative values. As a result, water features have positive values and are enhanced. Vegetation and soil features usually have zero or negative values and are suppressed. Monitor drought using NDWI in West Java during El Niño 2015 and its impact on rainfall variability. The max NDWI values are 0.2, 0.1, 0.1, and 0.1 for SW1, SW6, SW3 and SW7 respectively.

5.4.2. Normalized Difference Vegetation Index:

The NDVI is derived using the codes imported with GEE. The derived map helped to analyze the vegetation cover status. The values were assigned from min -1 to max 1. The max NDVI values are 0.6, 0.7, 0.6, and 0.7 for SW1, SW6, SW3 and SW7 respectively. The NDVI is shown in the figure where the red color patches indicate the water body and non-vegetation class in the region.



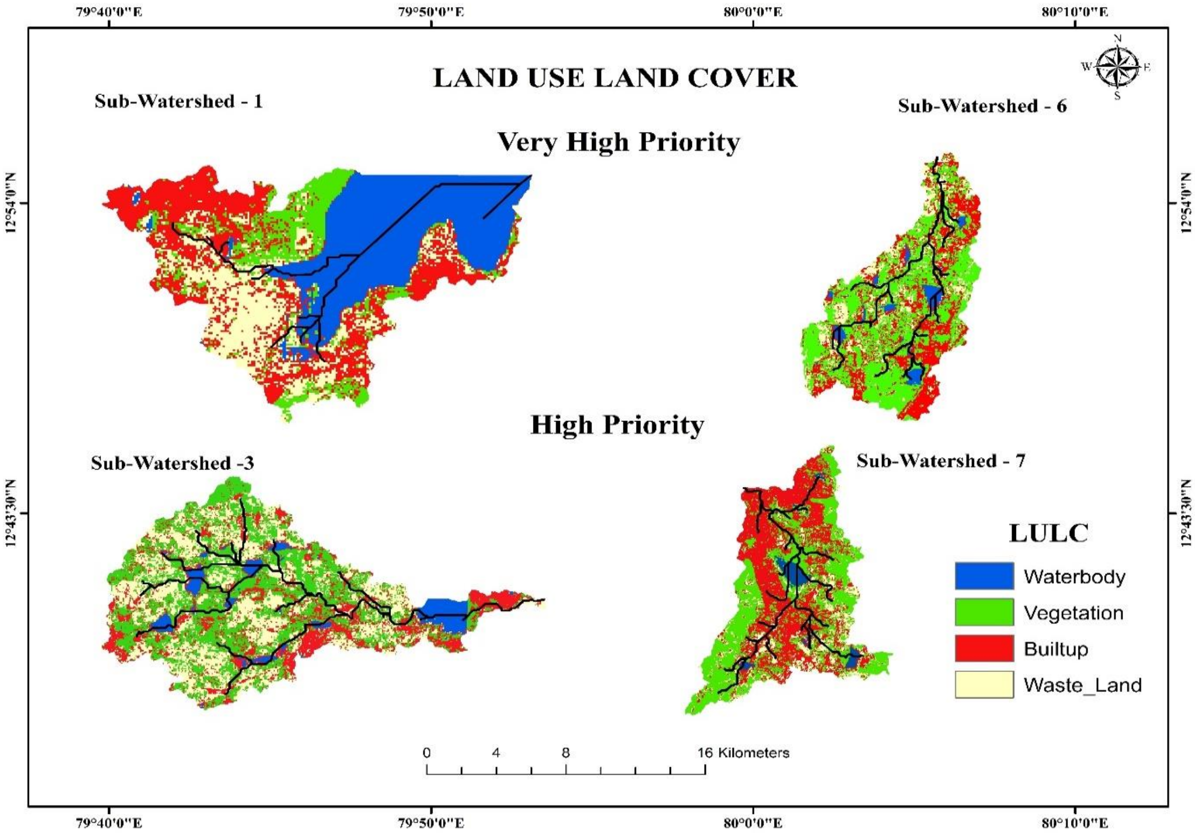


5.5. Land Use Land Cover Analysis:

The land uses land cover of first level classification is derived from LANDSAT – 9. The different classes of water bodies, vegetation, settlement, and wasteland include scrub and fallow. The 100 sample points for each class are inputted for analyzing the land use land cover. (Sandheep Adhikari, 2020). The result is showing almost the land is dominated by the settlements. Many water bodies shrink and modified their path due to encroachments. The very high and highly prioritized sub-watersheds 1, 6, and 3, 7 respectively.

Stakeholder participation is more prominent and sustainable adoption to the region. The SW1 shows the major lake and the source region. Which very highly prioritized morphometric parameter and it has a dendritic drainage pattern while another sub-watershed has a sub-dendritic pattern. The source region of sub-watershed 1 is dominated by encroachments the usual pattern of the flow path is modified and disturbed. It should be sorted out by the edges of a water body.

The SW6 shows high vegetation cover but very less water resources for 1% of the land. The built-up is encroaching and lavishing the water resources. The SW3 shows the dominant feature of vegetation and is followed by water resources. The anthropogenic activity is moderately created impacts on this region. In the future, it should be maintained and an increase in vegetation will be possible to change this sub-watershed to low priority from problems.



The SW7 is showing the very high settlements it changing and not adapting to the ecology. This leads to a change in this sub-watershed condition from high to very high. Stake holder's participation is highly recommendable.

VI. Suggestion:

The fast-growing city is facing water stress and inundation in seasonal time according to the seriousness of the disaster the rehabilitation and reconstruction of the affected areas in the region. This paper is suggesting that to manipulate the efficient usage of surface water bodies to conserve and protect all different aspects of the region. The different aspect of morphometric parameters such as linear, Arial, and relief which is categorized using the compound parameter method of ranking. The prioritized sub-watersheds SW1, SW3, SW6 & SW7 are analyzed for the current status of water and vegetation cover as well the new land use land cover pattern impacts.

The result shows that SW6 is very highly deviating from its ecological environment. The local community and the government, local NGOs should create awareness and develop a sustainable approach in the region.

VII. Conclusion:

Sustainable water resources management is a concept that emphasizes the need to consider the long-term future as well as the present. Water resource systems that are managed to satisfy the changing demands placed on them, now and on into the future, without system degradation, can be called sustainable. Because sustainability is a function of various economic, environmental, ecological, social, and physical goals and objectives, water resources management must inevitably involve multi-objective trade-offs in a multidisciplinary and multi-participatory decision-making process. I believe no single discipline, and certainly, no single profession or interest group, has the wisdom to make these trade-offs themselves. They can only be determined through a political process involving all interested and impacted stakeholders.

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