GEO-EYE

RESEARCH ARTICLE

OPEN ACCESS

Received: 19.03.2018

Accepted: 22.05.2018

Published: 28.05.2018

Citation: Mayachar SK, Nandini N, Ramesh KS. (2018). Morphometric analysis for peak discharge estimation of sub and micro watersheds of Vedavathy river sub basin, Karnataka . Geo-Eye. 7(1): 43-52. https://doi.org/10.53989/bu.ge.v7i1.9

Funding: None

Competing Interests: None

Published By Bangalore University, Bengaluru, Karnataka

ISSN
Print: 2347-4246
Electronic: XXXX-XXXX

Morphometric analysis for peak discharge estimation of sub and micro watersheds of Vedavathy river sub basin, Karnataka

Shilpashree K Mayachar[1], N Nandini[2], K S Ramesh[3]

1 *Research Scholar, Department of Environmental Science, J B Campus, Bangalore University*
2 *Professor, Department of Environmental Science, J B Campus, Bangalore University*
3 *Scientist, RRSC-South, NRSC Bangalore*

Abstract

IRS and GIS technology are extensively used for basin analysis which helps in monitoring the development and management of watershed and its catchment areas. The present study was carried to estimate peak discharge of two mini and micro watershed of the Krishna river basin, the two watersheds selected for the above study are Chikkur sub-watershed and Lailapura micro watershed which forms a part of Vedavathy river sub-basin and falls under Krishna river basin lying in between Karagunda and Hiriyur village of Chikamagalur & Hassan districts in Karnataka. The satellite image used for the study are Ortho_rectified Cartosat -1(2.5m), digital elevation model (DEM) data & LISS-IV (5.86m) are used for extraction of basin Morphometric parameters, database generation using NRIS resource layers and Automatic delineation of the watershed under Arc GIS Environment. Morphometric Analysis of Chikkur subwatershed have shown less relief ratio, high ruggedness number, time of concentration, drainage density stream frequency, mean bifurcation ratio, and less form factor. Lailapura micro watershed has shown high relief ratio, form factor and time of concentration fewer ruggedness numbers, stream frequency. The peak discharge of Chikkur subwatershed is 46.56 cusecs and Lailapura micro watershed is 10.31 cusecs for 160mm of rain respectively.

Keywords: subwatershed; Krishna river basin; Vedavathy river subbasin; and Morphometric Analysis; peak discharge estimation

Introduction

India is a peninsular country and it's geographical and climate condition makes it highly susceptible to many natural disasters. Natural Disasters like flood and drought is very common, and always have an impact on developmental activities as well as on agriculture sector. Floods not only damage properties and endanger the lives of humans and animals, but also have negative effects on the environment and aquatic life. These include soil erosion, sediment deposition downstream and destruction of spawning grounds for fish and other wildlife habitats. The analysis of flood frequency of river catchment has, therefore, become imperative to curtail hazards of this nature. Flood frequency analysis involves using observed annual peak flow discharge data to compute statistical information (B K Sathna et al 2012) Use of remote sensing and Geographic I nformation Systems (GIS) has become a powerful tool in watershed management, flood estimation, Morphometric analysis and peak discharge analysis.

Ahmad et,al.,(2010) conducted the study on "Evaluation of Morphometric Parameters Derived from ASTER and SRTM DEM–A study on Bandihole Sub-watershed Basin in Karnataka". The study revelled drainage network from ASTER and SRTM DEM which are extracted, using hydrology toolset in Arc GIS9.2 adopting the standard procedures for Morphometric analysis. From there evaluation they found that considerable positive variation of the stream order, the total number of streams, stream length in II and V order, Stream length ratios are seen in satellite images when compared with top sheet. The variations in the Morphometric parameters from various sources can be attributed to the depth of data/information obtained from the terrain. Hence efficient results can be obtained by using high-resolution satellite data like ASTER (30m) which can be used for meso and micro level watershed characterization. "Estimation of surface runoff in malattar sub-watershed using SCS_CN method. In this study the watershed boundary, drainage and contour are delineated using toposheet then using satellite imageries land use and land cover, soil maps, hydrologic soil groups map was prepared for estimation of daily rainfall data of the year 1971 to 2007 for the calculation of runoff.

The objective of the study

The study aims to delineate the watershed boundary and extract drainage network from Cartosat DEM for a sub and micro-watershed of Vedavathy river sub-basin using GIS and Remote sensing technology. And to analyze Morphometric parameters to assess the flood derived from DEM is used to understand the hydrological behaviour of each watershed and to estimate the peak runoff.

Study area

The study area, Chikkur sub-watershed, and Lailapura micro watershed form a part of Vedavathy river sub basin which falls under Krishna river basin lying in between Karagunda and Hiriyur village of Chikamagalur & Hassan districts in Karnataka. The watersheds are bounded between longitude of 76°8 '30" E to 76°13' E and 13° 22 ' N to13°14' 45" N latitude in SOI topo sheets {No.57C/3 & No.57C/4} (Fig 1) The study area consist of one sub- watershed and one micro-watershed covering an area of 38.5sq km and 2.8 sq km respectively lying adjacent to each other annual.

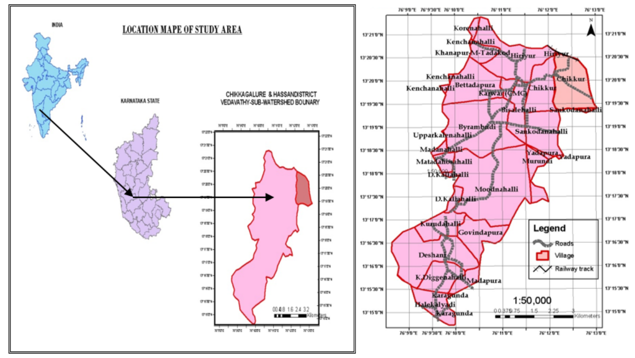

Fig. 1. Location map and Base map of the Chikkur sub –watershed and Lailapura micro watershed.

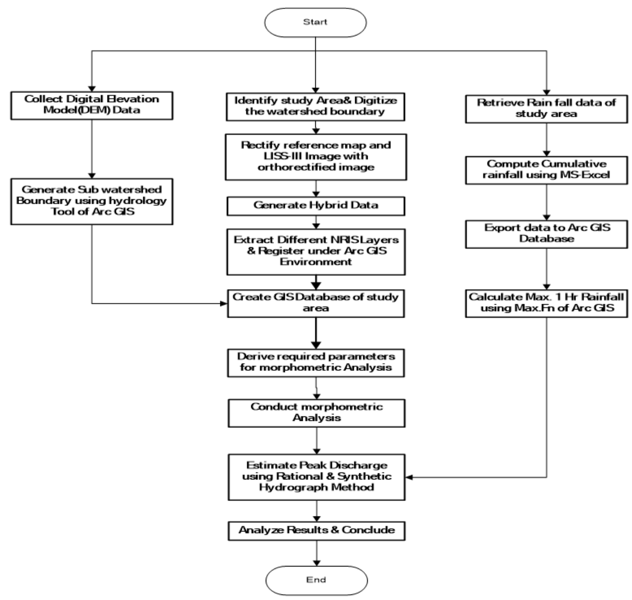

Fig. 2. Process flow chart of the methodology

Methodology

The Chikkur sub-watershed and Lailapura micro watershed were delineated using Survey of India (SOI) toposheets No.57C/3 & No.57C/4 and IRS-LISS-IV imagery of 2011 source RRSC-South. The Karnataka topo-grid and a layer shapefiles are added to Arc GIS and watershed boundaries are digitized. Reference map and LISS-IV data were rectified with Cartosat-1(Ortho_rectified) taking GCPs. The NRIS layers were spatially adjusted concerning Cartosat - 1. High-resolution Panchromatic Cartosat-1(2.5m) and LISS-IV (5.86m) were fused to get a hybrid data of 2.5m resolution for better visual interpretation. The Database for the study area is created by using Karnataka NRIS resources layers. Drainage analysis is carried out by the stream ordering method by applying. The excel sheet uses this data to calculate the linear aspects like stream order, a number of streams, total length of the streams of each order, bifurcation ratio, mean stream length, stream length ratio, areal, aspects like shape factor.

Compactness coefficient, circulation ratio, elongation ratio, stream frequency. Relief aspects like basin relief, relief ratio, relative relief, ruggedness number which aids in concluding Peak discharge estimation of the watershed and basic Morphometric parameters are derived from a digitized database.DEM was used to derive the slope map of the study are using ArcGIS 9.3 software

Table 1. List of formulae used for Morphometric analysis

Morphometric parameters	Formulas	Reference
Stream order	Hierarchical rank	Strahler's (1964)
Stream length (Lu)	Length of the stream	Horton (1945)
Mean stream length(Lsm)	Lsm=Lu/Nu	Strahler's (1964)
Stream length ratio RL	RL= Lu/Lu-1	Horton (1945)
Bifurcation ratio (Rb)	Rb=Nu/Nu+1	Schumn(1956)
Mean bifurcation ratio (Rbm)	Rbm is average of bifurcation ratio of all orders	Strahler's (1964)
Relief ratio (Rh)	Rh = H/Lb	Schumn(1956)
Drainage Density (D)	D=Lu/A	Horton (1945)
Stream frequency (Fs)	Fs=Nu/A	Horton (1945)
Drainage Texture (Rt)	Rt=Nu/P	Horton (1945)
Form factor (CRt)	Rg=A/Lb2	Horton (1932)
Circularity ratio (Rc)	Rc=4*Pi*A/p2	Miller(1953)
Elongation ratio (Re)	Re=2v(A/Pi/Lb)	Schumn(1956)

Automatic delineation of the Watershed

In ArcGIS Environment Automatic delineation of the Watershed was carried Using Arc Hydro Toolset. Creating a depression less DEM helps in identifying Sink is a cell. Sink cell is surrounded by higher elevation cells; the water is trapped in a sink cell and cannot flow. The sinks need to be filled in because; a drainage network is built that finds the flow path of every cell, eventually off the edge of the grid. If cells do not drain off the edge of the grid, they may attempt to drain into each other, which will lead to an endless processing loop. Fill is done either chopping off tall cells or filling in sinks. Sinks were removed to eliminate discontinuities in the drainage network, this process is important in any of the hydrologic modellings. Flow direction is important in hydrologic modelling to determine where a landscape drains, it is necessary to determine the direction of flow for each cell in the landscape. Flow direction was calculated for each pixel using the filled DEM, i.e. the direction in which water will flow out of the pixel to one of the eight surrounding pixels. Flow accumulation is the next step in Hydrologic modelling. Watersheds are defined spatially by the geomorphologic property of drainage. To generate a drainage network, it is necessary for the landscape grid. Flow accumulation was used to generate a drainage network, based on the direction of flow of each cell. The drainage network was extracted by considering the pixels greater than a threshold of 199 by trial and error approach. A feature class specified to define areas that should not be filled. A Threshold may also be specified in that case only sinks, whose depth is lower than the threshold, will be filled similarly watersheds can be delineated by giving an outlet or pour points where water flows out of an area, this is the lowest point source raster are used as pour points above which the contribution area is determined. Snap pour point tool is used to ensure the selection of point of high accumulation flow when delineating drainage basins using the watershed tool. Snap to pour point will search within a snap distance around the specified pour point for the centre of highest accumulation flow and move the pour point to that location. The value of each watershed will be taken from the value of the source in the input raster or feature pour point data when the pourpoint is a raster dataset. The cell values will be used when the pourpoint is a point feature dataset the value will come from the specified field the value of each watershed will be taken from the value of the sources cell in the source dataset.

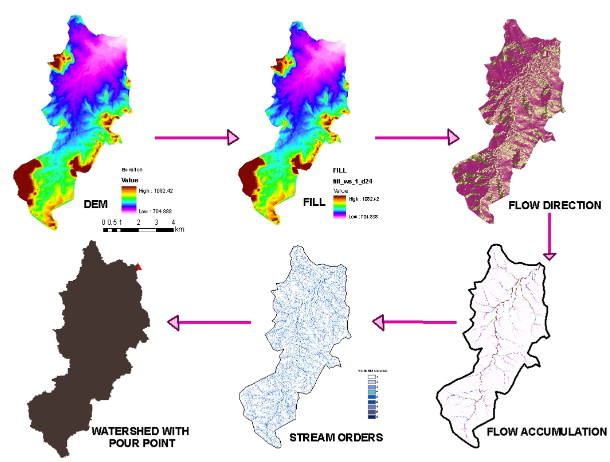

Fig. 3. Automatic delineation of Watershed using DEM data

Peck discharge estimation

The Rational method and Synthetic unit hydrograph method are used for peak discharge estimation The rational method has a set of formulas which estimates peck discharge. The entire method, tabulated into a Microsoft Excel sheet which calculates the peak discharge by using input data provided in a table -3 this also calculates parameters like Runoff coefficient rainfall intensity, Time of concentration. The rainfall data

Table 2. List of formulae for peak discharge estimation.

Sr. no	Parameters	Formulas
1	Time of concentration in hr	$tc=[L3/H]^{0.345}$
2	calculation of rain fall intensity in mm/hr	$I=R_{50(tc)}/tc$
A	Time concentration and elevation ratio	tch ratio
B	One hour Rain fall of 50 years in mm	$R_{50(1)}=R_{50(24)}x1h$ 24h rainfall
C	Time concentration of 50 years in mm	$R_{50(tc)}=KXR_{50(1)}$
3	Runoff coefficient	$C=0.537XR50(tc)^{0.179}tc^{-0.1}$
4	The peak discharge of 50 year return period in m3/s	$Q_{50}=0.278xCxIxA$

Computation using synthetic unit hydrograph method

The procedure followed is a short cut method of unit hydrograph approach for design flood peak estimation and involves estimation of unit hydrograph peak value by using a synthetic equation and multiplying the same direction with R50 (tc). Synthetic unit hydrograph method has a set of formulas which estimates peck discharge. In (Table-4) formulas are depicted which are used to calculate parameters.

Results and Discussion

Extraction of different NRIS Karnataka layers applying watershed boundary and registered in Arc map environment. Watershed map of Chikkur subwatershed

Table 3. List of Formulae for synthetic hydro graph method

Sr. no	Parameters	Formulas
1	Time of peck discharge in hrs	$tp=0.553[LxLc/Se]^{0.405}$
2	Peak discharge per unit area of the catchments	$q_p=2.043/(tp)^{0.872}$
3	Base width of the unit hydrograph	$TB=5.083x(tp)^{0.733}$
	The width of unit hydrograph measured at 50%max discharge ordinate Qp in hours	$W_{50}=2.197/(q_p)^{1.067}$
4	The width of unit hydrograph measured at 75%max discharge ordinate Qp in hours	$W_{75}=1.325/(q_p)^{1.088}$
5	The width of rising side unit hydrograph measured at 50%max discharge ordinate Qp in hours	$W_{R50}=0.799/(q_p)^{1.138}$
6	The width of rising side unit hydrograph measured at 75%max discharge ordinate Qp in hours	$W_{R75}=0.536/(q_p)^{1.109}$
7	The peak discharge of unit hydrograph in cumecs or cubic meter	$Qp=q_p$xcatchment area
8	Time for the center start rise to the peak of the unit hydrograph	$Tm=tp+tr/2$

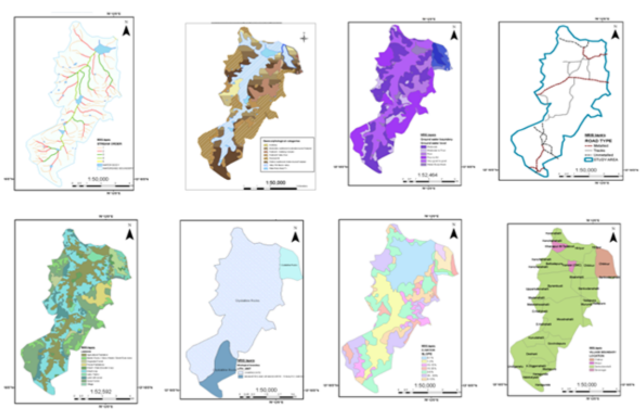

Fig. 4. GIS database creation using NRIS layers

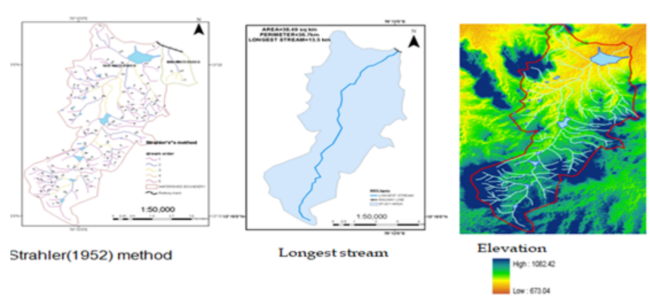

Fig. 5. Stream ordering, relief map, ordered drainage map and longest stream length of Chikkur sub-watershed and Lailapuramicro watershed

Morphometric analysis

Table 4. Measurements of areal parameters

Sl No	Parameters	Chikkur sub-watershed	Lailapura micro water-shed
1	Area	38.40sqkm	2.76sqkm
2	Perimeter	36.70km	7.03km
3	Width	4.91km	1.32km
4	Length	12.32km	2.52km
5	Highest elevation point	469m	342m
6	Lowest elevation point	45m	50m
7	Mainstream length	13.22km	2.45km

Table 5. Morphometric parameters of Chikkur sub-watershed and (b) Lailapuramicro-watershed

Stream order	No of segments	Total length	Bifurcation ratio	Mean length	Cumulative length	Length ratio	Drainage density
1	114	58.64	-	0.51	58.64	-	
2	52	21.74	2.19	0.42	80.38	2.6973	
3	20	7.71	2.60	0.39	88.09	2.8197	2.58
4	15	10.8	1.33	0.72	98.89	0.7139	
5	1	0.0086	15	0.01	98.90	1255.8	

Table 6. Morphometric parameters of Lailapura micro-watershed

Stream order	No of segments	Total length	Bifurcation ratio	Mean length	Cumulative length	Length ratio	Drainage density
1	3	1.9394	-	0.65	1.94	-	
2	1	2.319	3	2.32	4.26	0.8368	1.54

Discussion

Basic parameters

The main task for the geomorphologists is the use of an ideal unit for the Earth's surface study. The results are tabulated in Table 5.

Area (A)

The area of the drainage basin is also important, as the length is responsible for the stream draining. Hence the area of

Table 7. List of results of Derived parameters of Chikkur sub-watershed and Lailapura micro-watershed

Parameters	Chikkur sub-watershed	Lailapura micro-watershed
Watershed shape factor	3.95	2.30
Compactness coef-ficient	1.67	1.19
Circularity ratio	0.4	0.7
Form factor	0.40	0.52
Elongation ratio	0.6	0.74
Stream frequency	5.26	1.45
Basin relief	424	292
Relief ratio	34.42	115.87
Relative relief	11.55	41.54
Channel gradient	460.596	321.59
Dissection index	0.0733	0.3388
Constant channel maintenance	0.388	0.648
Ruggedness num-ber	1.09	0.45

the watershed is 38.5s q.km which comes under the sub-watershed hierarchical system and another watershed has an area of 2.76 sq.km which is micro-watershed.

Perimeter (P)

The perimeter (P) is the total length of the drainage basin boundary the perimeter of the Chikkur sub-watershed is 36.5 km and micro-watershed is 7.03km respectively for toposheet, whereas the watershed derived from the satellite data have36.8 km and 7.2km for DEM respectively. So it is noticed that the accurate delineation is possible with the use of a higher resolution image. But the area remains approximately the same for all the data sets i.e. Toposheet, Cartosat-1, LISS-IV & DEM data.

Stream order (Nu)

A stream net is the interrelated drainage pattern formed by a set of streams in a certain area. A junction is a point where two channels meet. A link is an unbroken stretch of the river between two junctions this is then known as the interior link if it is between the source and first junction it is a called the exterior link. The classification of stream orders is the first step in drainage basin analysis and is based on a hierarchic ranking of streams .stream orders or classification of streams is a useful indicator of stream size, discharge and drainage area. The number of streams (N) of each order (u) is presented in table 6. The highest stream order in Chikkur subwatershed is 5 and the highest stream order in Lailapura micro watershed is 2.

Derived parameter

Stream length ratio (RL)

It is the ratio between the mean lengths of streams of any two consecutive orders. Horton (1945) termed the length ratio as the ratio of the mean length of streams of one order to that of the next order stream segments. Horton's law of stream length states that mean stream length segment of each of the successive order of a basin tends to form a distinct geometric series, with stream length increasing towards the higher order of the streams. In the present study, the stream length ratio shown is in Table 6. Which refers that stream length ratio increases towards higher stream order.

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 surface. The mean stream length has been calculated by dividing the total stream length of the order by the number of stream length of by number or streams Table 6, indicates that Lsm in the sub-watershed ranges from 0.51 to 0.72 and 0.65 to 2.35 for micro-watershed**.**

Bifurcation ratio

Streams vary depending upon bedrock control of uniform materials underlie the drainage basin, the streams usually branch randomly were folds or faults control weakness and stream development. The development of branches can be restricted to zones of faults or fracture or weak sedimentary strata. Demonstrated that Rb shows only a small variation for different regions on different environment except where powerful geological control dominates lower Rb values are the characteristics of structurally less disturbed watershed without any distortion in drainage pattern (nag,1998) higher Rb values indicate corresponding higher overland flow and discharge due to hilly metamorphic formation associated with high slope configuration Table 6 shows that mean bifurcation ratio of the Chikkur sub-watershed is 2.4 and 3 for micro watershed indication the basin in subwatershed is young and micro watershed is mature and moderate structural control in the drainage development reveals that they do subscribe to Strahler's law of stream number and these irregularities are caused during the development of drainage basin (Strahler's).

Drainage density (D)

Drainage density expressed the closeness of spacing of channel. It is the measure of the total length of the stream segment of all orders per unit area. It is affected by factors which control the characteristic length of the stream like resistance to weathering permeability of rock formation, climate, vegetation etc. Langbein (1947) recognized the significance of D as a factor determining the time of travel by water within the basin and suggested that it varies between 0.55 and 2.09 km/km 2 in a humid region. Strahler (1964) considered the drainage density to be variable dependent on runoff rate per unit area. In general, a low value of D is observed in regions underlain by a highly resistant permeable material with vegetative cover and low relief. High drainage density is observed in the regions of weak and impermeable subsurface material and sparse vegetation and mountainous relief. The drainage density of Chikkur watershed is 2.58 km per km2 and Lailapura micro watershed drainage density is 1.54 km per km2. It reveals that they have low drainage density with highly resistant permeable material indicate that area is humid in nature resulting in low runoff rate per unit area.

Stream frequency (Fs)

Channel frequency is the total number of stream segment of all orders per unit area (Horton 1932) stream frequency higher in one area than the other means the growth of new channels or lengthening of existing streams as evidenced by sub-catchment development over the gneissic formation shows a close correlation with the drainage density. The values of Chikkur sub-watershed and Lailapura micro watershed are moderate. From the worldwide data analysis (Peltier 1962) found that for areas of the comparable average slope, stream frequency is greater in semi-arid regions; it is least in the arid regions and intermediate in humid regions.

Drainage pattern:

The drainage pattern is the general arrangement of channels in a drainage basin. Drainage pattern reflects the influence of such factors as initial slope, inequalities in rock hardness, structural control, recent diastrophism and recent geomorphic and geologic history of the drainage basin. The drainage pattern identified as Dendritic.for the study area

Drainage Texture (Rt)

An important geomorphic concept about the drainage pattern is the drainage texture. It is a relative spacing of drainage lines. Drainage texture is commonly expressed as fine, medium or coarse. Climate affects the drainage texture both directly and indirectly the amount and type of precipitation influence directly the quantity and character of runoff. It is the total number of stream segment of all orders per perimeter of that area(Horton, 1945). Horton recognized infiltration capacity is the single important factor which influences drainage texture and considered the drainage texture to include drainage density and stream frequency has classified drainage density in 5 different texture .i.e. very coarse (<2) coarse (2-4) moderate (4-6) fine (6-8) and very fine (>8) In the present Chikkur subwatershed and Lailapura micro watershed the drainage density is 2.58 and 1.75 respectively so it indicates subwatershed is coarse and micro-watershed is very coarse in texture.

Relief Ratio (Rh)

The elevation is the difference between the highest elevation point to the lowest point on the valley floor of a subwatershed. Its total relief is the ratio of maximum relief to a horizontal distance along the longest dimension of the basin parallel to the principal drainage line (Schumn 1956). It measures the overall steepness of a drainage basin and is an indicator of the intensity of erosion process operating on the slopes of the basin. The Rh normally increases with decreasing drainage area and size of a given drainage basin of Chikkur subwatershed is 34.42 m/km and Lailapura micro watershed 115.87 m/km having an area of 38.75 sq km and 2.75 sq km respectively. Hence the relief ratio of a micro-watershed is more than the subwatershed.

Shape parameter

Circulatory ratio (Rc)

It is the ratio of the area of the basin to the area of the circle having the same circumference as the perimeters of the basin (Miller 1953).it is influenced by length, stream frequency, geological structure, land use/land cover, climate, relief, and slope of the basin. A circulatory ratio is helpful for assessment of flood hazard. Higher the Rc value higher is the flood hazard at a peak time at the outlet point while the sub-catchment associated with low values of Rc are porn to low flood. In the above study area. i.e. Chikkur sub-watershed Circulatory ratio is 0.4 and Lailapura micro watershed has 0.7 respectively. Which indicate that the area is characterized by high relief and drainage system is structurally controlled with homogeneous basins of 1st and 2nd order.

Elongation ratio (Re)

Elongation ratio is the ratio of the diameter of the circle with the same area as basin and the length of the basin a circler basin is more efficient in runoff discharge than an elongated basin (Singh 1997) the value of elongation ratio generally varies from 0.6 to 1.0 lower value for areas with strong relief and steep slope the values can be grouped into these categories namely circular (> 0.9), oval (0.9-0.8) and less elongated (0.7-0.8) elongated (0.5-0.7) more elongated (< 0.5). The elongation ratio of Chikkur subwatershed is 0.6 and Lailapura micro watershed has 0.74 the ratio revels that subwatershed is elongated and micro watershed is less elongated.

Form factor (CRt)

The form factor suggested by Strahler (1968) is the ratio of the basin area to the squared value of the basin length (L). The form factor value varies from 0 in highly elongated shape to the unity .i.e. 0.7854 in a perfect circular shape. Hence, higher the value of form factor more circular the shape of the basin and vice- versa. The basin with a high form factor has high peak flows of shorter duration. Whereas elongated subwatershed with low form factor has the peak flow of longer duration? Form factor obtained in Chikkur subwatershed and Lailapura micro watershed is 0.40 and 0.52 respectively it suggest that subwatershed is more elongated with low peak flow for longer duration and micro-watershed is less elongated with peak flows with shorter duration**.**

Constant of channel maintenance (CCM)

CCM is the area of basin surface need to sustain a unit length of stream channel and is expressed by the inverse of drainage density (Schumm1956). The constant of channel Maintenance depends on rock type, permeability climatic region, vegetation cover as well as the duration of erosion. The constant is extremely low in the area of close dissection. The CCM for Chikkur subwatershed is 0.38 km2/km and for Lailapura micro watershed CCM is 0.64 km2/km respectively.

Compactness coefficient

Compactness coefficient is used to express the relationship of the hydrologic basin with that of a circular basin having the same area of the hydrologic basin. A circular basin is the most hazardous form drainage standpoint because its wick yields the shortest time of concentration before peak flow occurs in the basin (Akram et al 2009). Hence micro watershed is less elongated which is more prone to floods than Chikkur sub-watershed which is more elongated**.**

Ruggedness number

Ruggedness number is the product of basin relief (H) and drainage density (Dd), where both terms must be in the same units. It is a dimensionless quantity used to combine the qualities of slope, steepness, and length. Generally, the ruggedness values range from 0.06 in subdued low relief (Plain areas) to over 1.0 in a mountain range or badlands or on weak clays. The ruggedness number calculated for Chikkur sub watershed and Lailapura micro watershed are 1.0 and 0.45 respectively. The result reveals that subwatershed has mountain ranges and micro watershed has a plain area. Rainfall is taken as 160mm for peak discharge analysis

Table 8. Peak discharge computation for Chikkur sub – watershed and Lailapura micro-WS

Sr.No	Parameters	Chikkur sub-watershed	Lailapura micro-watershed
	Catchment area	38.495sqkm	2.76sqkm
	Length of the longest stream course from Source to the pore point	13.2km	2.452km
	Length of the main stream from a point opposite to centroid of the catchment area to the bridge site along the main stream	8.05km	1.177km
	Equivalent stream slope	32.12m/km	119m/km
	The height of the farthest point above the point of interest along the river	469m	349m

Table 9. Results of peak discharge estimation using rational formulas of Chikkur sub-watershed andLailapura microwatershed

Parameter	S-WS Results	micro-WS Results
Time of concentration	1.730	0.335
t_ch ratio	0.596	0.115
$R_{50(1)} = R_{50(24)}$ x 1h to 24h rainfall ratio in mm	67.2	67.2
$R_{50(tc)} = K \text{ X } R_{50(1)}$ in mm	95.49	18.51
$I = R_{50(tc)}$ / tc in mm/hr	55.172	55.1752
K	1.420	0.275
Runoff coefficient $C = 0.537 \text{ X } R_{50(tc)}{}^{0.179}$ X tc-0.1	1.149	1.004
The peak discharge of 50 year return period in m^3/s	678.85	45.75

Discussion

Basic parameters

Catchment area (A)

The catchment area is derived from the NRIS layers for Chikkur subwatershed and Lailapura micro watershed and found that they have an area of 38.495 sq km and 2.45 sq km respectively. Catchment area, Length of the longest stream course from Source to the bridge site, Length of the mainstream from a point opposite to centroid of the catchment area to the bridge site along the mainstream, Equivalent stream slope, Height of the farthest point above the point of interest along the river, input parameters are derived from morphometric analysis and NRIS layers. The centroid of the drainage is located using ArcGIS tool and rest of the computation is carried out and they are tabulated

Derived parameters

Time of concentration (tc)

Time of concentration is the time taken by the water flow to move from the most remote point on a watershed to the outlet of the watershed. This longest flow path is called the Hydraulic length. t_c is very important to define the design rainfall intensity. The value of t_c for small catchment may vary from a few minutes to about three hours. Thus t_c for subwatershed is 1.3 hr and 0.33 hr for micro-watershed.

Rainfall Intensity

It is the amount of rainfall per unit time. However, for the current runoff estimation, 160 mm is considered based on the database of similar work carried out earlier in the nearby area. The value obtained for rainfall intensity is 55.17 mm/hr

Runoff coefficient(C)

It is the coefficient of runoff of a resulting flood to the specified storm. Strictly speaking, the value of C has to change according to the storm resulting flood and different antecedent moisture conditions of the catchment. The value of C depends upon the soil, soil cover and slope. Some of the predetermined values of C depending on the description of the catchment are available, however, if the description of the catchment is not available the approximate value of C can be computed using the regression equation given below C=0.537R50 (tc) 0.179X tc-0.1. The coefficient obtained for Chikkur subwatershed and Lailapura micro watershed is 1.149 and1.009 respectively.

50-year design flood discharge (Q50)

Design flood peak of 50 year return period is 679 cusecs and 450 cusecs for Chikkur subwatershed and Lailapura micro-watershed.

Table 10. Results of peak discharge estimation using rational SUH method of Chikkur sub watershed and Lailapura micro-watershed

Parameters	Results of s-ws	Results of micro-ws
Time in an hour from the center of unit rain-fall duration to the peak of unit hydrograph in hr	1.855 hour	0.5 hour
The peak discharge of unit hydrograph per unit area of catchment in cubic meter or cusecs	1.11 cusecs	3.73 cusecs
Base width of unit hydrograph in hr	8.45 hour	3.05 hour
The width of unit hydrograph measured at 50%max discharge ordinate Qp in hours	1.95 hour	0.537 hour
The width of unit hydrograph measured at 75%max discharge ordinate Qp in hours	1.17 hour	0.315 hour
The width of rising side unit hydrograph measured at 50%max discharge ordinate Qp in hours	0.705 hour	0.178 hour
The width of the rising side of unit hydrograph measured at 75%max discharge ordinate Qp in hours	0.474 hour	0.124 hour
Time for the center start rise to the peak of the unit hydrograph	2.5 hour	1 hour
Peak discharge of unit hydrograph in cusecs or cubic meter	42.94 cusecs	10.31 cusecs

S-WS= subwatershed

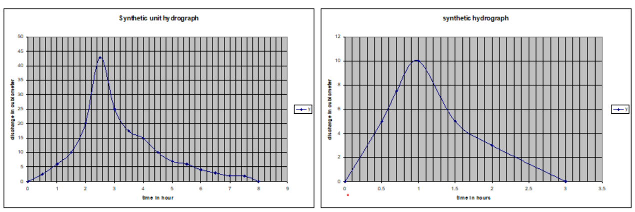

Fig. 6. Synthetic unit hydrograph ofChikkur sub-watershed and Lailapura micro-watershed

Conclusions

Creation of image database and GIS database fulfils primary requirements for Morphometric analysis and peak discharge estimation. This database can also be used for visual interpretation. Morphometric analysis is one of the important inputs to understand the working and behaviour of the catchment area from which we can precisely predict the effect of development on the watershed and behavioural changes. Hence delineation of drainage network by using topographic maps and with advanced methods of using Remote sensing data DEM is the present requirement to fulfil the demands of this era which is more economical and accurate in nature within the short period.

Acknowledgements and Legal Responsibility

The authors are thankful to the Department of Environmental Science, Bangalore University JB camps, Bangaluru-560056 and RRSC-South ISRO allowing to carry out student project. The entire work has been carried out in the RS and GIS labs of RRSC-South. Wholeheartedly thank research supervisor Dr N Nandini, Department of Environmental Science, Bangalore University JB camps, Bangaluru-560056 and Dr K S. Ramesh, Scientist RRSC-South for constant encouragement and motivation.

References

1) Strahler AN. Quantitative analysis of watershed geomorphology. *Transactions, American Geophysical Union*. 1957;38(6):913–920. Available from: https://dx.doi.org/10.1029/tr038i006p00913.
2) Schumm SA. Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. *Geological Society of America Bulletin*. 1956;67(5):597–597. Available from: https://dx.doi.org/10.1130/0016-7606(1956)67[597:eodsas]2.0.co;2.
3) Singh SR. A drainage morphological approach for water resources development of the sur catchment, Vidarbha region. *Journal of the Indian Society of Remote Sensing*. 2006;34(1):79–88.
4) Bhatt S, Ahmed SA. Morphometric analysis to determine floods in the Upper Krishna basin using Cartosat DEM. *Geocarto International*. 2014;29(8):878–894. Available from: https://dx.doi.org/10.1080/10106049.2013.868042.
5) Chopra R, Dhiman RD, Sharma PK. Morphometric analysis of sub-watersheds in Gurdaspur district, Punjab using remote sensing and GIS techniques. *Journal of the Indian Society of Remote Sensing*. 2005;33(4):531–539. Available from: https://dx.doi.org/10.1007/bf02990738.
6) Javed A, Khanday MY, Ahmed R. Prioritization of sub-watersheds based on morphometric and land use analysis using remote sensing and GIS techniques. *Journal of the Indian Society of Remote Sensing*. 2009;37(2):261–274. Available from: https://dx.doi.org/10.1007/s12524-009-0016-8. doi:10.1007/s12524-009-0016-8.
7) Pankaj A, Kumar P. GIS-based morphometric analysis of five major sub-watersheds of Song River, Dehradun District, Uttarakhand with special reference to landslide incidences. *Journal of the Indian Society of Remote Sensing*. 2009;37(1):157–166. Available from: https://dx.doi.org/10.1007/s12524-009-0007-9.
8) Strahle AN. Hypsometric (area-altitude) analysis of erosional topography. *Geological Society of America Bulletin*. 1952;63(11):1117–1142. Available from: https://dx.doi.org/10.1130/0016-7606(1952)63[1117:haaoet]2.0.co;2.
9) Rao KHVD, Singh AK, Roy PS. Study of morphology and suspended sediment of Bhopal Upper Lake using spatial simulation technique and remote sensing data. *Journal of the Indian Society of Remote Sensing*. 2009;37(3):433–441. Available from: https://dx.doi.org/10.1007/s12524-009-0034-6.
10) Smith KG. Standards for grading texture of erosional topography. *American Journal of Science*. 1950;248(9):655–668.
11) Amutha R, Porchelvan P. Estimation of surface runoff in Malattar sub-watershed using SCS-CN method. *Journal of the Indian Society of Remote Sensing*. 2009;37(2):291–304. Available from: https://dx.doi.org/10.1007/s12524-009-0017-7. doi:10.1007/s12524-009-0017-7.
12) Ahmed SA, Chandrashekarappa KN, Raj SK, Nischitha V, Kavitha G. Evaluation of morphometric parameters derived from ASTER and SRTM DEM — A study on Bandihole sub-watershed basin in Karnataka. *Journal of the Indian Society of Remote Sensing*. 2010;38(2):227–238. Available from: https://dx.doi.org/10.1007/s12524-010-0029-3.
13) Thakkar AK, Dhiman SD. Morphometric analysis and prioritization of miniwatersheds in Mohr watershed, Gujarat using remote sensing and GIS techniques. *Journal of the Indian Society of Remote Sensing*. 2007;35(4):313–321. Available from: https://dx.doi.org/10.1007/bf02990787.
14) Rudraiah M, Govindaiah S, Vittala SS. Morphometry using remote sensing and GIS techniques in the sub-basins of Kagna river basin, Gulburga district, Karnataka, India. *Journal of the Indian Society of Remote Sensing*. 2008;36(4):351–360. Available from: https://dx.doi.org/10.1007/s12524-008-0035-x.
15) Singh SR. A drainage morphological approach for water resources development of the sur catchment, Vidarbha region. *Journal of the Indian Society of Remote Sensing*. 2006;34(1):79–88.
16) Fairfield J, Leymarie P. Drainage networks from grid digital elevation models. *Water Resources Research*. 1991;27(5):709–717. Available from: https://dx.doi.org/10.1029/90wr02658.
17) Strahle AN. Part II. Quantitative geomorphology of drainage basins and channel networks. In: Handbook of Applied Hydrology. 1964;p. 4–39.