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Morphometric analysis in the Vaippar river basin Tamil Nadu, India

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ABSTRACT

In the present investigation an efforts have been made to find out the drainage characteristics of the eight sub basins of Vaippar river basin, Tamil Nadu, to the describe of their morphology and its related parameters. The following characteristics were carried out such as bifurcation ratio, stream length, form factor, circulatory ratio, elongation ratio, drainage density and stream frequency. The ratio between cumulative stream length and stream order is constant all the consequently order of the drainage basin. The less bifurcation ratio values and drainage density point out that drainage characteristics in the study area has lack structural control and also the surface area is mainly falls by resistant and permeable rocks with a intensive vegetative cover. The depth of groundwater levels in a few of the sub basins are compared to the less values of drainage density, stream frequency and infiltration number. The described morphometric analysis also solved to the conclusion as three sub basins with less infiltration numbers have great infiltration capacity and these more suitable for artificial recharge.

KEYWORDS

Drainage morphometric analysis;
Groundwater level;
Vaippar river basin;
Tamil Nadu.

INTRODUCTION

In the rapid growth of population and the essential need to food and state for future, which is proper as the water and land resources want to be utilized and managed in combined the ability to understand way which has been agreed that the soil and water preservation measures on a sub drainage basin accordingly could play a major role this strategy of important land and water management[2]. Since, a drainage basin which is region from which runoff produced from precipitation flows past a single point into extent stream, river, pond and ocean, is approach as a unit for the study of drainage characteristics.

The investigation of the characteristics of drainage network of a particular area is proposal in two methods like (i) descriptive approach and (2) genetic approach. The descriptive approach includes the study of the properties of the forms and patterns of the streams. At the same time the genetic approach includes the study of the evaluation of streams of an area in connection with tectonic activities lithology and structure[14]. Therefore, drainage system represent to the origin and evoluation of streams through beginning time while drainage pattern defined as mean spatial arrangement and form of drainage system.

The area, number and flow directions of various streams of a region related on the nature of slope, struc-

tural control, lithological types, tectonics factors, climatic conditions, vegetal characteristics etc. To this study of drainage characteristics by morphometric analysis of various sub basin in an area provides more knowledge pertaining to the denudational past events, subsurface material, geological structure, soil type and forest cover of the area. It is perform a critical note in mathematical relationship with a intention for watershed management which suggest the suitable use of land and water resources of a watershed for favourable production with less hazard to natural resources[2].

The morphometric analysis of different basins and sub-basins have been investigated using conventional methods earlier times[7,8,17]. The drainage pattern characteristics of different basins have also been workout through satellite imageries and aerial photographs [1,2,3,10,16]. In the present work, an effort have been put to study of the drainage /morphometric characteristics of Vaippar river basin of Tamil Nadu which includes sub basins.

Study area

The study area is geographically falls between latitudes 9°0' 05" and 9°44' 56" N and longitudes 77°23'25" and 78°17'02"E, the areal extent about 4410 square kilometers which is spread over Virudhunagar, Tirunelveli and Tuticorin Districts (Figure 1). Those district famous traditional by fire match works and cotton mills well transported facilities in the predominant plain areas. Physiographically the study area is characterized by highly elevated hills (1597- 180m AMSL), gently sloping plains (180-20m ASML) and coastal line (less than 20m AMSL). The varieties of soil occur in the region such as black cotton soils, red soils, red loamy, river alluvium and coastal sands. Geologically, the study region is comprised by Archaean age group of formations like charnockite, hornblende biotite-gneisses with minor isolated patches of pyroxene granultie, quartzites, granites, calc-granulites, ultramatic rocks and crystalline limestones. Alluvium of recent to sub recent age is trend all along the river courses and in the coastal alluvium exists in the study area coastal belts. The climate of the study area is arid-semi arid conditions and the north east and south west monsoons type with average annual rainfall is less than 900 mm. The area observed high annual range of temperature above 28.16^{0}C. The average daily temperature is more than 30.0^{0}C entire the year. The average relative humidity is 62%. The area is thus maximum hot with existing seasonal rain (NE monsoon high and SW monsoon low). An annual rainfall precipitation increase towards from eastern to western part of the study area. The depth of water TABLE ranges from 2.5 to 13.5 below ground level to 10.5 below ground level in pre and post monsoon periods in the study area. Groundwater conditions occur unconfined nature in the form of fissures, fractures, faults and lineaments in hard rock areas, whereas semi confined nature are found to be sedimentary formations.

Figure 1 : Location map of vaippar river basin

Data used methodology

In the present study, the drainage and thematic maps were maps prepared from Survey of India (SOI) Topo sheets Nos. 58G/6, 58G/8, 58G/10, 58G/11, 58G/12, 58G/14,58G/15, 58G/16, 58K/3, 58K/4, 58K/8 in the scale of 1:50,000 scale. A numerous parameters such as the number and length of streams of different order, drainage area (Ab), basin perimeter (P) and maximum basin length (Lb) of various sub basins were established. The above parameters were calculated using GIS. According to these parameters, sub basin-wise drainage characteristics like the bifurcation ratio (Rb), drainage density (Dd), Stream frequency (Fs), infiltration number (IF), and shape parameters namely form factor (Rf), circulatory ratio (Rc), elongation ratio (Re) etc. were established[17]. Morphometric analysis is best achieved through measurement and mathematical calculation at configuration of the earth'ssurface, shape and dimensions it land forms[4]. The depth of groundwater TABLE

data for the year from 2000 to 2002 for different sub basins were collected from Public Works Department (PWD), Ground Water Division (GWD), Government of Tamil Nadu and seasons wise water TABLE depth for various sub basin map of the investigated area and corrected with the surface drainage to every sub basin.

Drainage

The drainage system of region shows a dendritic and sub dendritic pattern by irregularly at angled bends at any direction the pattern produced by streams tree like structures. Vaippar river is beginning from Western Ghats, which flows towards from north western to south eastern part (Bay of Bengal) along with a number of streams, valleys which have major tributaries such as Nichabanadhi, Deviar, Arjunanadhi, Uppar, Sinkottaiar and Kayal Kudiyar. In this river patterns are moderate and owing to medium rainfall, they river systems are

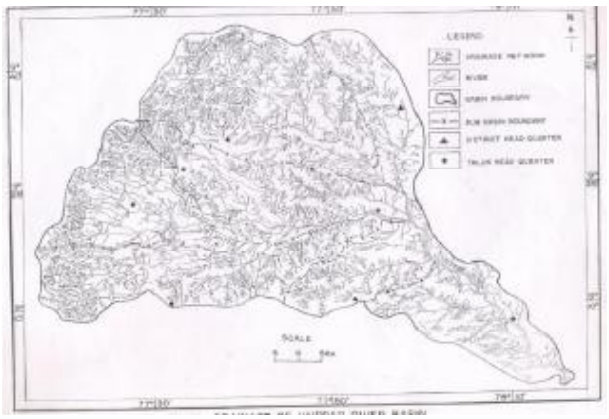

Figure 2 : Drainage of Vaippar river basin

lateral erosion is greater than the vertical erosion capability, which causes river takes meandering path[11]. This vaippar river basin is (spread over) classified 8 sub basin such as SBI, SBII, SBIII, SBIV, SBV, SBVI, SBVII and SBVIII falls partial in three district. (Figure 2).

TABLE 1: Order, number and length of streams the Vaippar river in sub basins

Sub basin no.	Stream caracteristies	Stream order					
		1st	2nd	3rd	4th	5th	6th
SBI	Total stream length (Km)	261	87	40.5	27.5	-	-
	Cum. stream length (Km)	261	348	388.5	416	-	-
	Total no. of stream	245	54	12	2	-	-
	Mean Stream length (Km)	1.06	1.61	3.37	13.75	-	-
SBII	Total stream length (Km)	225	108.5	41	18	-	-
	Cum. stream length (Km)	225	333.5	374.5	392.5	-	-
	Total no. of stream	249	60	9	1	-	-
	Mean Stream length (Km)	0.90	1.81	4.55	18	-	-
SBIII	Total stream length (Km)	183.5	63	44	13	-	-
	Cum. stream length (Km)	183.5	246.5	290.5	303.5	-	-
	Total no. of stream	252	64	10	1	-	-
	Mean Stream length (Km)	0.73	0.98	4.4	13	-	-
SBIV	Total stream length (Km)	463	127	87	45	5.5	-
	Cum. stream length (Km)	463	590	677	722	727.5	-
	Total no. of stream	779	172	33	4	1	-
	Mean Stream length (Km)	0.59	0.74	2.64	11.25	5.5	-
SBV	Total stream length (Km)	536	176.5	115	101.5	23	-
	Cum. stream length (Km)	536	712.5	827.5	929	952	-
	Total no. of stream	865	176	37	6	1	-
	Mean Stream length (Km)	0.62	1.0	3.11	16.92	23	-
SBVI	Total stream length (Km)	524	183.5	69	53	31.5	-
	Cum. stream length (Km)	524	707.5	776.5	829.5	861	-
	Total no. of stream	662	122	21	3	1	-
	Mean Stream length (Km)	0.79	1.50	3.28	17.66	31.5	-
SBVII	Total stream length (Km)	958.5	362	154.5	77.5	23.5	-
	Cum. stream length (Km)	958.5	1320.5	1475	1552.5	1576	-
	Total no. of stream	1390	329	53	9	2	-
	Mean Stream length (Km)	0.69	1.10	2.91	8.61	11.75	-
SBVIII	Total stream length (Km)	233	92	33.5	14.5	21.5	60
	Cum. stream length (Km)	233	325	358.5	373	394.5	454.5
	Total no. of stream	307	72	12	2	2	1
	Mean Stream length (Km)	0.76	1.28	2.79	7.25	10.75	60

RESULTS AND DISCUSSION

The stream order, number and length of segment in various subdivisions are given in the TABLE 1. Cumulative length of streams for individual order was calculated and the average length of that order stream acquired by dividing cumulative stream length by number of segments of that order. In this work, which was noticed that logarithm of the cumulative stream length vis a vis stream order for all the sub basin provide nearly a straight like suitable type (Figure 3). Which is point out that relation between cumulative stream lengths and stream order is constant entire the following one another order of a sub basin and consider that geometrical similar is existed state in basins of increasing order. The bifurcation ratio (Rb) is helped to convey the ratio of the number of streams of any provided order to the number of streams in the next order[13]. The stream order is measure should be a stream in the hierarchy of the tributaries. The first order streams occur without tributaries where two first order channel joined a form channel stream order second, while two second order join a stream order third is formed, and so fourth[7]. Birfurcation ratio values less than 5 are believe to be characteristics of the sub basin with less structural disturbance[17]. Nag[9] has also suggested drainage pattern have not been distorted due to the structural disturbances. In the present investigation the Rb values of sub basin varies between 3.85 (SB VIII) and 6.78 (SB III) with a mean value of 5.46 (TABLE 2). This is carryout that the drainage pattern in nearly all the sub basin has affected by structural disturbances except sub basin VIII. The drainage basin shape effects stream flow hydrographs and intensity flows, the following shape parameters like form factor (Rf), circulatory ratio (Rc) and elongation ratio (Re) calculated for all the eight sub basin of the study region are shown in TABLE 3.

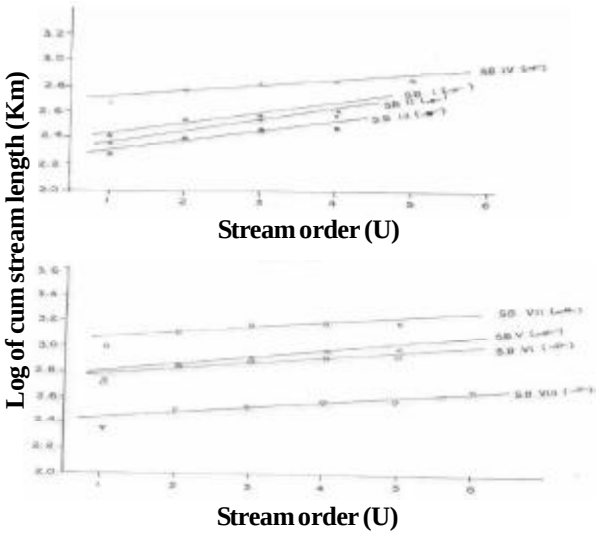

Figure 3 : Regression of logarithm of cumulative stream length and stream order

TABLE 2 : Bifurcation ratio the Vaippar river in sub basins

Sub basin no.	Rb (1^{st} / 2^{nd} order)	Rb (2^{nd} /3^{rd} order)	Rb (3^{rd} / 4^{th} order)	Rb (4^{th}/5^{th} order)	Rb (5^{th} / 6^{th} order)	Rb (6^{th} / 7^{th} order)
SBI	4.54	4.5	6.	-	-	5.01
SBII	4.15	6.67	9	-	-	6.61
SBIII	3.94	6.4	10	-	-	6.78
SBIV	4.53	5.21	8.25	4	-	5.49
SBV	4.91	4.76	6.16	6	-	5.46
SBVI	5.43	5.81	7	3	-	5.31
SBVII	4.22	6.21	5.89	4.5	-	5.21
SBVIII	4.26	6	6	1	2	3.85

TABLE 3 : Shape parameters of Vaippar river in sub basins

Sub basin no.	Basin in area (Km^2) A_b	Basin perimeter (Km) P	Max length of the basin (Km)	Form factor Rf= A_b/L_b	Ci rculatory ratio R_c= $4\pi Ab/P^2$	Elongation ratio $R_c = \frac{2x\sqrt{Ab/\pi}}{L_b}$
SBI	386.2	105.75	45	0.191	0.434	0.492
SBII	355.4	78	31	0.369	0.733	0.686
SBIII	214.4	79	37.5	0.152	0.431	0.441
SBIV	610.8	144	60.5	0.197	0.369	0.461
SBV	628	122	43.9	0.326	0.529	0.644
SBVI	587.6	155	60.25	0.162	0.307	0.454
SBVII	1064	152.5	57	0.327	0.575	0.646
SBVIII	559.6	215	95	0.062	0.152	0.281
Mean	550.75	131.41	53.77	0.219	0.441	0.513

Form factor

Based to the[6], form factor may be expressed as,

Form factor (Rf) = Area of Basin / (Length of Basin)2

From the TABLE 3 which is noticed that the Rf ranges from 0.062 (Sub Basin VIII) to 0.369 (Sub Basin II). The value of form factor could always be less than 0.7854 (for a perfectly circular basin), smaller the values of form factor indicates that elongated the basin. Whereas the study area carryout all the sub basins are elongated with less value to form factor and have level peak flow for great length of period at the same time high form factors are circular and have highest point flows for small length of period.

Circularity ratio

Miller[8] has introduced the circularity ratio, which

TABLE 4 : Morphometric analysisof Vaippar river in sub basins

Sub basin no.	Basin area (Km^2)	Total no. of streams (Sn)	Total length of streams (SI)	Stream frequency Fs=Sn/Ab	Drainage density Dd= SI/Ab	Bifurcation ratio (Rb)	Infiltration no. If = dd×Fs
SBI	386.2	313	416	0.810	1.077	5.01	0.872
SBII	355.4	319	392.5	0.897	1.104	6.61	0.990
SBIII	214.4	327	303.5	1.525	1.415	6.78	2.158
SBIV	610.8	989	727.5	1.619	1.191	5.49	1.928
SBV	628	1085	952	1.727	1.515	5.46	2.616
SBVI	587.6	809	861	1.376	1.465	5.31	2.015
SBVII	1064	1783	1576	1.676	1.481	5.21	2.482
SBVIII	559.6	396	454.5	0.707	0.812	3.85	0.574
Mean	550.75	752.63	710.38	1.292	1.257	5.47	1.704

TABLE 5 : Ground water level dynamics during 2000-2002 the Vaippar river in sub basins

Sub basin	2000		2001		2002		Avg.(2000-2002)	
no.	Pre-mon	Post-mon	Pre-mon	Post-mon	Pre-mon	Post-mon	Pre-mon	Post-mon
I	4.51	4.06	4.55	2.35	3.05	1.87	4.04	2.76
II	3.61	3.72	4	2.99	2.37	1.88	3.33	2.86
III	6.32	7.4	7.63	6.02	6.29	5.69	6.75	6.37
IV	5.3	6.10	10.44	9.91	13.23	10.29	9.66	8.77
V	4.72	7.55	6.6	6.92	9.57	8.38	6.96	7.62
VI	8.06	7.74	11.72	10.43	12.68	9.62	10.82	9.26
VII	3.77	4.62	4.21	3.64	4.27	4.51	4.08	4.26
VIII	4.67	5.58	7.87	7.04	7.66	7.25	6.73	6.62

may be defined as

Circularity Ratio (Rc) = Area of Basin / Area of circle

(* Circle having the same perimeter as that of the Basin)

The circularity ratio (Rc) is efficient by the length and frequently of streams, geological structures, land use/land cover, climate, relief and slope of the basin. The values of the circularity ratio is varies from 0.152 to 0.733 with an average value of 0.441 in the study area (TABLE 3). More Rc values 0.733 (Sub Basin II), 0.529 (Sub Basin V) and 0.575 (Sub Basin VII) point out that they are more or less circular. The values of Rc and Re proposed 1 as the shape of the basin almost begin to be circular. The remaining sub basins have lower than 0.50 showing that they are elongated.

Elongation ratio

According to Schumm (1956), elongation ratio (Re) defined as the formula,

Elongation ratio (Re) = Diameter of circle/ Basin of Length Maximum

The circular basin is high effort in the discharge of run-off than elongated basin[14]. The values of Re is normally range from 0.6 to 1.0 due to various climatic conditions weathering of surface rock structures. Values nearly to 1.0 are characteristics of area of very low relief, comparatively the range between 0.6 to 0.8 are generally related with high relief and steep ground slope[17]. These values classified into three types namely (a) circular (<0.9), (b) oval (0.9 to 0.8), (c) less elongated (< 0.7). In the present study area, the values of Re ranges from 0.281 to 0.686 with a mean value 0.513 (TABLE 3). Which point out that the all the sub basin area is characterized by almost elongated, high to moderate relief and the drainage system is structurally controlled. If flood flows of elongated basins are simple to manage than those of the circular basins.

Drainage density

It is measure of the lengths of the stream order per unit area[6]. The factors determining drainage density are resistance to measuring and permeability of rock formations away from the climatic and other factors such as vegetation[12]. In usually, areas having highly resistant or permeable soil material under dense vegetation spread and less relief are typical by less drainage density and areas of lack and impermeable subsurface material, thinly vegetation and mountainous terrain indicate more drainage density. In the present work the drainage density value of the sub basins varies from 0.812 (SB VIII) to 1.515 (SB V) with are average value of 1.257 which they are indicate that low drainage density (TABLE 4). In this present case, the low

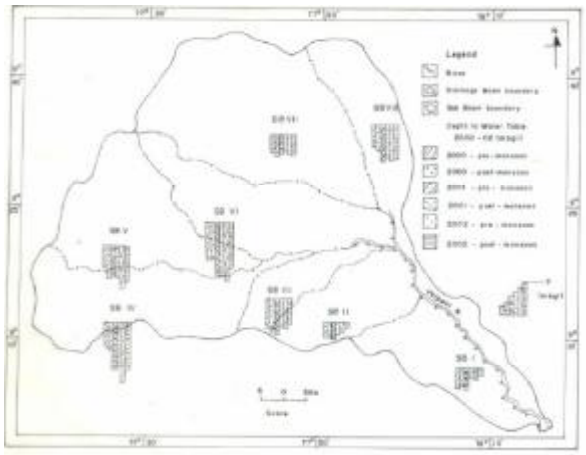

Figure 4 : Depth to water table during 2000-02(pre- and post-monsoon)

values of Dd point out the regions are highly underlain by permeable sub soil and dense vegetative cover. Based on the Nag[9], low drainage density results to coarse drainage texture, at the same time high drainage results to fine drainage texture.

Stream frequency

According to Horton[6], stream of frequency (Fs) explained, it is the total number of stream segments of all orders per area of the basin. Sub basins in the investigated area ranges from 0.574 (SB VIII) to 2.616 (SB V) with a mean value 1.704. The less than 1 infiltration values for the sub basins SBI, SBII and SBIII point out that may be high infiltration and descending less, run off in these sub basins. It is considered as the surface drainage typical area explained the sub-surface groundwater relation to water TABLE in this area, to a important manner. Given the TABLE 5 shows that sub basin wise ground water level constantly changing for the years 2000, 2001 and 2002. The depths to water TABLE for these years (Pre and Post monsoon seasons) have been thematically shown in the figure 4. Based on the Dd, Fs and IF are lowb values for the sub basins SB, SB VII and SB VIII indicate that may be more infiltration and less runoff, as a results in theses sub basins are more joined and highly weathered for relations of its indicate a good relation of depth to the water TABLE in those sub basins, and also these sub basins have groundwater level is higher which is helped by the report that the basaltic rocks in the coastal region of the study area are highly weathered and fractured[5] Subsequently, The remaining sub basin indicates higher values at Dd, Fs and 1F, slowing less infiltration and more run off from the figure 4, which could be justified that the ground water level occur in these sub basin are low. This considered the presence of less weathered charnockite and hornblende biotite-gneiss or highly impermeable materials in
these sub basins.

SUMMARY AND CONCLUSION

In the present study, which could be decision that the relation between cumulative stream length order is constitutive the successive orders of the sub basin, it consider that geometrical similarity is existing state in basins of ascending order. Less values of bifurcation ratio and less values of drainage densities nearly all the sub basins shows that the drainage in the investigation area has not been behaviour by structural disturbances and in addition to that most of the area falls under the resistant and permeable formations with dense vegetative spread shown in the sub basins SB I, SB II, and SB VIII with low infiltration values and those are more infiltration ability have good possibility for artificial recharge. Those are also added to be the potential zones for deep aquifer exploration. The sub basins SB I, SB II, SB IV, SB VI, and SB VIII having minimum form factors have high intensity flows for short duration. Since those sub basin are highly suffer to mechanical erosion by water. The ground water level in the sub basins SB III, SB IV, SB V, SB VI, and SBVII, are lower because the higher values of drainage density, stream frequency and infiltration value. The study reveals that remote sensing and Geographical information system (GIS) are power full tools in the study of drainage and their behaviour variation intensity of rainfall in this study area.

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