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ANALYSIS OF MORPHOMETRY AND WATERSHED PRIORITIZATION OF VANIYAR RIVER, DHARNAPURI DISTRICT, INDIA USING REMOTE SENSING AND GIS TECHNOLOGY

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Abstract
The application of remote sensing and geographical information system for the analysis of Morphometric parameters are found to be of immense utility in watershed prioritization for soil, water conservation and natural resources management at micro level. This study is an attempt to carry out detailed investigation of linear, shape and relief Morphometric parameters like stream length, stream order, drainage density, stream frequency, bifurcation ratio, Length of overland flow, basin perimeter, form factor, compactness coefficient, elongation ratio, basin relief, ruggedness ratio, shape factor and texture ratio in five micro-watersheds of Vaniyar watershed and their prioritization.

Key Words: Morphometric Analysis, Watershed Prioritization and Morphological Characters of the Watershed.

Introduction

The area is a mountain and plateau region. The area western side and south eastern side are mountain founded about 1000m above the mean sea level; north and north eastern side are 800 m above mean sea level. The area isn't uniform Morphometric character. It can be very low land in the eastern side high land region has been founded in western side of the Vaniyar watershed the river flowing of towards west to Northern wards.

Study Area

The Vaniyar Environment origin from northern portion of sharvory hill with flowing towards south-eastern side via Pappirappatti, Salem and Dharmapuri District. (Map No.1). The Watershed is one of the tributaries of the Ponniar basin. The study area extent 78^0 18' E to 78^0 28' E longitude and 12^0 35' N to 11^0 35' of latitudes. The major physiographic feature has controlled to the structural hill, denudantional and Pedi plain and fluvial process in the study area.

The major region is locked in the major relief feature are Samiyapuram, Pappirappatti, Venkadasamudharam, Adikarappatti, Pallipatti, Marakaranpatti. The highest spot height in 1000 in Southern portion of the kattur, 700 in the Pappirapatti. The study is located on the Pappirapatti and Harur Taluk of the Dharmapuri District. (fig2.5). The Vaniyar watershed originated in the northern portion of the sharvory hills and it is drain via Samiyapuram, Pappirappatti, Venkadasamudharam, Adikarappatti, Pallipatti, Marakaranpatti and their adjoing places. The river flowing on the west-east portion with length of 66.5908 km. In the study area is mainly hill and uplands in the youthful stage of the river.The Granite Gneiss rock placed in the portion of the southern side and the Uttatur, Trichinaopoly, Ariyalur are in the portion of the north-eastern side of the study area. The land utilization of the any land is based on the soil characteristic with their texture, productivity, and capability. From the study area major soil groups are Brown reddish, sandy, with hill soils. The feature controlled by the nature of the flowing of the Watershed.

The intensity of Eros ional unit is in the direction of the above said. From the study area the maximum contour interval is 1000 m, adjoining sharvoy hills and Manjavadi with Chittrai hill. The minimum contour intervals are in the part of the south-eastern basin, being 500 m in the part of the kuttar extension. The major land use Build up land the Samiyapuram Pappirappatti, Venkadasamudharam, Adikarappatti, Pallipatti, Marakaranpatti. Agriculture activities being in the entire study area. The wet crops are along the river course, the dry crops are in the portion of the North –west and South West and other adjoin place. The major RF is part of the southern side namely Bothakkadu, Kuttar Extension are placed. The fairly dense jungle situated in the adjoin of the Reserved forest. The other RF is part of the eastern portion of the study area like Chitteri hills with Pallippatti, also high dense forest covered in the basin. The Population of the study area is growth rate is based on their surrounding potential zone or available resources like water. The Total population of the study area is 32987, The Male Population is 16912 and Female Population is 16075 in the study area. The Major concentration of the population mainly Alapuram, Menasi, Molyanur and Venkatasamudram. The Literacy rate of the Vaniyar is concentrated mainly part of Alapuram, Menasi Pallipatti Molayanur Venkatesamudram. The Male Population11459 and Female Population are 7905.

Objectives

- To study the Morphological analysis of Vaniyar River and bring out the various classes through SOI and Satellite images.
- To interpreted and delineated the stream order with thematic layers, over 2005 and 2010 years and find the changing classes.
- To intergraded all parameters morphological characters of the Vaniyar watershed.

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Research Methodology

A methodology has been formulated to achieve the present task of Morphometry analysis of Vaniyar watershed. The following are the sequence of execution, through which the aims and objectives of the present study has been directed and achieved.

Data Sources: The different source for the present study, both primary and secondary data's was collected.

- The SOI source with scale of 1:50,000 for the study area
- Data's generated through the thorough analysis of the entire micro watershed. The addition to this data was collected from various private and public sector.
- To Study Morphological structure and characters of the Vaniyar Watershed in various parameters were studied. In addition to this also find the priority zone of the watershed.

Geology

The lithological discrimination of the drainage are placed in the rock types is charnockite, Granite Gneiss and Uttatur, Trichinaopoly, Ariyalur in the watershed(fig2.4) The drainage mainly controlled in the linear fracture of the rocks and their structural control. In the study area is mainly hill and uplands in the youthful stage of the river. The Granite Gneiss rock placed in the portion of the southern side and the Uttatur, Trichinaopoly, Ariyalur are in the portion of the north-eastern side of the study area.

Result and Discussion

Morphological Characters of the Vaniyar Watershed

Stream Number and Order (U)

For stream ordering Horton's Law was followed by designating an un-branched streams as first order stream, when two first order streams joint it was designated as second order, two second order join together to form third order and so on. This is the most important parameter for Vaniyar watershed analysis,(Map No.2) in the study area total number of streams found is 932 out of which 589 is of first order, 238 of second, 83 of third order, 19 of fourth, 3 of fifth . It reveals that maximum number of streams is found in Pudur VSW5 (290) and minimum number for Pallipatti SW4 (44), it is also noted that first order streams are highest in number in all micro watersheds while highest order has the lowest number. The Pudur SW5 is a 1st order stream covering an area about 188 km². The sub-watershed VSW1, VSW2, VSW3, VSW4, VSW6 are 1^{st} , 1^{st} , 1^{st} , 1^{st} 1^{st} streams covering an area of 52.56,29.89,63.70,19.40 and 85.61 km² respectively. The variation in order and size of the sub-watersheds is largely due to physiographic and structural conditions of the region. (VSW-Vaniyar Sub-Watershed).

Stream Length (Lu)

The stream length was computed on the basis of the law proposed by (Horton, 1945), for all the 6 sub-watersheds of Vaniyar river and is shown in the Table 1. It can be noted from the table that in each Sub-watershed stream length decreases as the stream order increases (Horton, 1945) except Irulapatti VSW4 and this change may be due to flowing of streams from high altitude, lithological variations and moderately steep slopes (Singh and Singh, 1997).

Stream Length Ratio (RI)

The stream length ratio is the ratio of mean of segments of order (Lu) to mean of segments of next lower order (Lu-1) (Horton, 1945). Change in stream length ratio shown in the table, between different sub-watersheds of Vaniyar river showed an increasing and decreasing trend in the length ratio from lower order to higher order and in all sub-watersheds, there was a change from one order to another order indicating the late youth stage of geomorphic development of streams in the inter basin area. The sub watershed showing decreasing trend in length ratio noted from lower order to higher order indicates their youth geomorphic stage and in these sub-watersheds no one is in mature geomorphic stage.

Liner Parameters

Linear parameters include stream frequency, drainage density, drainage texture, bifurcation ratio and length of overland flow.

Table No 1: Linear Parameters of the Vaniyar Sub-Watershed

SW	Stream Frequency	Drainage Density	Drainage Texture	Bifurcation Ratio	Length of over land flow
VSW1	5.08	28.8	2.23	8.07	0.165
VSW2	1.05	1.07	1.05	3.86	0.525
VSW3	4.42	2.8	3.7	2.78	1.4
VSW4	1.49	1.32	0.21	3.51	0.66
VSW5	5.08	2.51	4	3.57	1.255
VSW6	5.22	2.79	3.85	3.46	1.395

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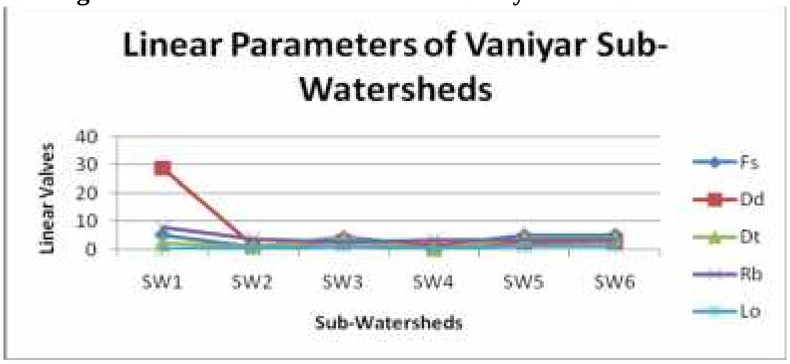
Fig No 1: Linear Parameters of the Vaniyar Sub-Watershed



Stream frequency (Fs)
The Stream frequency is defined as the total number of stream segments of all orders per unit area (Horton, 1932). Generally high stream frequency is related to impermeable sub surface material, sparse vegetation, high relief and low infiltration capacity of the region. The stream frequency of all Vaniyar Sub-watersheds are mentioned in Table 1.The study revealed that the Irulapatti VSW3, Pallipatti VSW4 and Pudur VSW5 watersheds have high stream frequency because of the fact that it falls in the zone of fluvial channels and the presence of ridges on both sides of the valley which results in highest stream frequency while as watersheds SW3 has medium stream frequency and watershed Achalvadi VSW1 and Marakaranpatti VSW2 has low stream frequency because of low relief (Fig.1). Highest value of stream frequency noted for VSW4 (2.69 km/km2) and VSW5 (2.55 km/km2) produces more runoff in comparison to others. (Table and Fig No 1).

Drainage density (Dd)
The drainage density is the stream length per unit area in a region (Horton, 1945 and Strahler, 1952). It is an essential element of drainage morphometry to study the landscape dissection, runoff potential, infiltration capacity of the land, climatic condition and vegetation cover of the basin. Drainage density in all the watersheds is given in Table 1 which varies from 0.99 to 3.00. It has been observed that low drainage density is found to be associated with regions having highly permeable subsoil material under dense vegetative cover, and where relief is low while as high values of drainage density are noted for the regions of weak or impermeable subsurface materials, sparse vegetation and mountainous relief (Nag 1998). Hence in this study high drainage density was found in VSW3 and VSW4 because of impermeable sub surface material and mountainous relief (Fig.1). Low Dd value for VSW1 and VSW2 indicates that it has highly permeable sub surface material and low relief. (Table and Fig No 1).

Drainage texture (Dt)
Drainage texture is defined as the total number of stream segments of all orders per perimeter of the area (Horton, 1945). The drainage texture depends upon a number of natural factors such as climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of development (Smith, 1950) and classified drainage into five classes i.e., very coarse (<2), coarse (2-4), moderate (4-6), fine (6-8) and very fine (>8). The drainage texture (Table-1) found to be very coarse to coarse, value ranges from 3.46 for VSW6 to 3.7 for VSW3 for Vaniyar Sub-Watershed catchment(Table and Fig No1).

Bifurcation ratios (Rb)
Horton (1945) considered bifurcation ratio as an index of reliefs and dissections. Strahler (1957) demonstrated that bifurcation ratio shows only a small variation for different regions with different environments except where powerful geological control dominates. Lower bifurcation ratio values are the characteristics of structurally less disturbed watersheds without any distortion in drainage pattern (Nag, 1998). Bifurcation ratio is related to the branching pattern of a drainage network and is defined as the ratio between the total number of stream segments of one order to that of the next higher order in a drainage basin (Schumn, 1956). The values of mean bifurcation ratio of different watersheds of Vaniyar Sub-Watershed catchment shown in Table 1 varies from 2.78 to 8.07 indicating structural control in drainage development in some of the micro-watersheds. (Table and Fig No 1).

Length of Overland Flow (Lo)
It is one the most important independent variables affecting hydrological and physiographical development of a drainage basin. It is the length of water over the ground before it gets concentrated into definite stream channels and is equal to half of drainage density (Horton, 1945). Length of overland flow relates inversely to the average channel slope. Table-1 indicates the

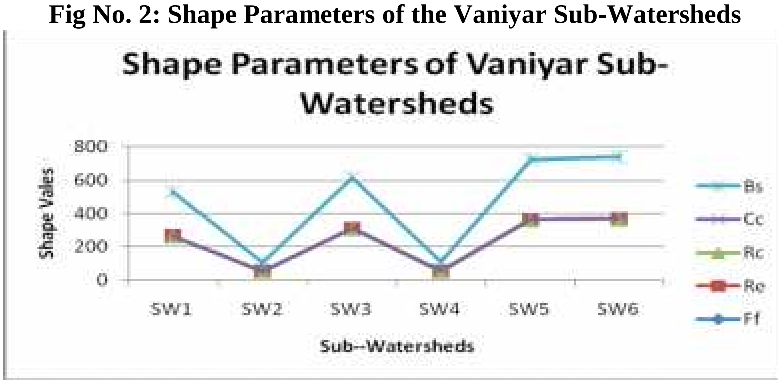
length of overland flow for various Sub-watersheds which ranges from 1.39 for VSW6 to 1.4 for VSW3. The shorter length of over land flow for VSW1 point out the quicker runoff process and higher length of over land flow for SW6 point out slower runoff process.

Shape Parameters of the Vaniyar Sub-Watersheds
Shape parameters include form factor, shape factor, elongation ratio, compactness ratio and circulatory ratio.

Table No.2: Shape Parameters of the Vaniyar Sub-Watersheds

SW	Ff	Re	Rc	Cc	Bs
VSW1	264.3	0.33	0.019	1.29	264.3
VSW2	49.75	0.94	0.029	0.87	49.75
VSW3	307.85	0.35	0.051	0.7	307.85
VSW4	51.76	0.75	0.001	4.67	51.76
VSW5	360.82	0.39	0.025	0.82	360.82
VSW6	368.44	0.36	0.028	0.86	368.44

Fig No. 2: Shape Parameters of the Vaniyar Sub-Watersheds



Form Factor (Ff)
Form factor is defined as the ratio of basin area to the square of the basin length (Horton, 1932). The values of form factor would always be less than 49.75 (perfectly for a circular basin). High value of form factor stating the circular shape of the basin and Smaller the value of form factor more elongated will be the basin. Form factor value (Table 2) for all watersheds varies from 49.75-368.44. The observation shows that the VSW6 and VSW5 watersheds are highly elongated while as the watersheds VSW1, VSW2 and VSW3, 4 are less elongated. The values of form factor for Vaniyar Sub-Watershed catchment indicates that the whole catchment is elongated. The elongated watershed with low value of form factor indicates that the basin will have a flatter peak flow for longer duration. Flood flows of such elongated basins are easier to manage than from the circular basin. (Table and Fig No 2).

Elongation Ratio (Re)
The elongation ratio is defined as the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin (Schumn, 1956). Analysis of elongation ratio indicates that the areas with higher elongation ratio values have high infiltration capacity and low runoff. A circular basin is more efficient in the discharge of runoff than an elongated basin (Singh et. al., 1997). The values of elongation ratio generally vary from 0.33 to 0.94 over a wide variety of climate and geologic types. Values close to 0.33 are typical of regions of very low relief, whereas values in the range 0.75 to 0.94 are usually associated with high relief and steep ground slope (Strahler, 1964). Values of the elongation ratio (Table 2) are in the range of 0.33 to 0.36 indicating high relief and ground slope for maximum portion of sub-watersheds (Fig.2) . Shape of the micro watersheds found to be elongated have low elongation ratio and less elongated have high elongation ratio. In the watershed, these values are less than 0.35 and hence all the mini-watersheds are generally elongated in shape(Table and Fig No 2).

Circularity Ratio (Rc)
Circularity ratio is defined as the ratio of the area of the basin to the area of a circle having the same circumference as the perimeter of the basin (Miller 1953). Circulatory ratio in the study area (Table 2) found in the range of 0.019 to 0.029 which

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shows that the sub-watersheds are almost elongated. High value of circulatory ratio indicates the maturity stage of topography. The value 0.051 for VSW3 indicates more circular in shape than the other sub-watersheds as can be observed from. (Table and Fig No 2).

Compactness Coefficient (Cc)
It is defined as the basin perimeter divided by the circumference of a circle to the same area of the basin. Compactness constant value for the whole study area is shown in Table 2 Highest value found for VSW4 (4.69) while lowest value for VSW3 (0.7). Compactness coefficient is directly proportional to the erosion risk assessment i.e. lower values signifies less vulnerability for risk factors, while higher values indicates great vulnerability and represents the need of implementation of conservation measures. So the study reveals that VSW4 and VSW1 are more prone to erosion risk in the whole catchment.

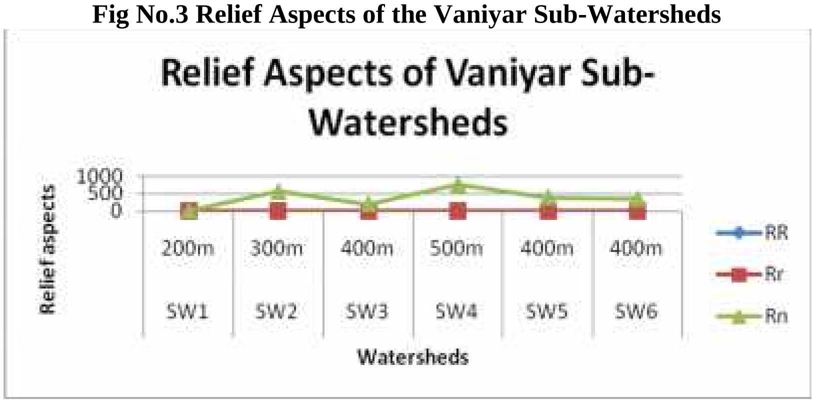
Shape Factors (Bs)
It is the ratio of the square of the basin length (Lb) to area (A) of the basin (Horton, 1945) and is in inverse proportion with form factor (Rf). Shape factor is highest for VSW6 (368.44) and Lowest for VSW2 (49.75).

Relief Aspects of the Vaniyar Sub-Watersheds
The relief aspects of sub-watershed are also important in water resources studies, direction of stream flow analysis and denudation conditions of the watershed. Relief aspects like basin relief (H), relative relief (Rp), relief ratio (Rh) and ground slope or ruggedness number (Rn) were measured and are given in Table 3.

Table No.3 Relief Aspects of the Vaniyar Sub-Watersheds

SW	Basin Relief	Relief Ratio	Relative Relief	Ruggedness Number
VSW1	200m	2.24	1.5	20.83
VSW2	300m	6.38	2	560.74
VSW3	400m	3.64	1.66	214.28
VSW4	500m	12.79	2	757.57
VSW5	400m	2.78	1.66	398.4
VSW6	400m	3.03	1.66	358.42

Fig No.3 Relief Aspects of the Vaniyar Sub-Watersheds



Basin Relief (H)
Basin relief is described as the elevation difference between the reference points i.e. maximum vertical distance between highest (divide) and the lowest (outlet) located in the drainage basin (Fig. 3). Schumm (1956) measured it along the longest dimension of the basin parallel to the principle drainage line. The relief for sub-watersheds varies from 200 to 1000 meters (Fig. 10). The watersheds have been divided into high, medium and low relief regions in which sub-water VSW3,4 and VSW5,6 are having highest basin relief. The high relief of these sub-watersheds indicates low gravity of water flow as well as infiltration and high runoff conditions as well as sediment down the slope.

Relief Ratio
Relief Ratio is the ratio of basin relief to the horizontal distance on which relief was measured (Schumm, 1956). According to Schumm (1956), there is a direct relationship between the relief and gradient of the channel. It measures overall steepness of

the watershed and is also considered as an indicator for the intensity of erosion process occurring in the watershed. High value of relief ratio is the characteristics of the hilly region. The relief ratio for watersheds varies from 2.24 to 12.79 (Fig. 2). It was noticed that the higher values of relief ratio for VSW3,4 and VSW5,6 indicated steep slope and high relief, while the lower values for VSW1 and VSW4 indicated the presence of lower degree of slope shown .

Relative Relief (Rr)
Relative Relief (Rr) is the ratio of relief (H) to the perimeter of basin. It is an important morphometric variable used for the general estimation of morphological characteristics of terrain. The relative relief for watersheds varies from 2 to 1.66. The watersheds having higher relative relief have higher runoff potential than others. Therefore, the watershed VSW1 and VSW3 are having the lowest and highest runoff potential respectively.

Ruggedness Number (Rn)
Ruggedness number (Rn) is the product of drainage density (Dd) and basin relief (H) (Strahler, 1957; Melton, 1958) in the same unit. In the present study ruggedness value ranges from 20.83 to 757.57. The highest value of ruggedness was observed in VSW4 (757.57), VSW2 (560.74) and VSW3 (358.42) in which both total basin relief and drainage density values are high, i.e., in these sub-watersheds slope is very steep linked with its slope length. The sub-watersheds having low relief but high drainage density are ruggedly textured as areas of higher relief having less dissection. The higher ground slopes in case of above sub-watersheds lying in upper reach of the basin specify lower time of concentration of overland flow and the possibilities of soil erosion will be higher in these sub-watersheds. In relief aspect calculation, some of the linear (length, perimeter, etc.) and shape (drainage density) parameters are applied. Thus, the morphometric description has shown substantial role in differentiating the hydro-topographical behavior of the watershed through the analysis of linear, areal and relief aspects of the sub-watersheds.

Ranking and Prioritization of Sub-Watersheds Based on Morphomatric Analysis
The morphometric parameters i.e., drainage density, stream frequency, mean bifurcation ratio, drainage texture, length of overland flow, form factor, circularity ratio, elongation ratio, basin shape and compactness coefficient, are also termed as erosion risk assessment parameters and have been used for prioritization watersheds (Biswas et. al., 1999). The linear parameters such as drainage density, stream frequency, mean bifurcation ratio, drainage texture, length of overland flow have a direct relationship with erodibility while as shape parameters such as elongation ratio, circularity ratio, form factor, basin shape and compactness coefficient have an inverse relationship with erodibility (Nooka et. al., 2005). Hence, priority of the watersheds has been carried out for giving highest priority/rank based on highest value in case of linear parameters and lowest value in case of shape parameters. The highest value of the linear parameter was ranked 1, the second highest value ranked 2, and so on. On the contrary, the shape parameters have converse relation with linear parameters, which means lower their value, more is the erodability. Thus the lowest value of the shape parameter was rated as rank 1 and the second lowest as rank 2, and so on. From the present study of Vaniyar watershed, among the sub-watershed Rank 1 (Achalvadi), Rank 2 (Pallipatti), Rank 3(Marakaranpatti and Irulapatti), Rank 4 (Pudur), and Rank 5 (Samiyapuram), prioritization of the sub-watershed in the study area.

Conclusion
The present study demonstrates the utility of remote sensing and GIS techniques in prioritizing subwatersheds based on morphometric analysis. All the sub- watersheds show dendritic to sub dendritic drainage pattern with course drainage texture. Low bifurcation ratios indicate normal basin category. The low drainage density indicates the basin is highly permeable subsoil, thick vegetation cover, low relief and course drainage texture. Circulatory and elongation ratios show that most of the sub-watersheds are more or less circular or oval. Further, the remote sensing techniques have been found to be suitable for the preparation of updated drainage map in a timely and cost-effective manner and should be preferred in soil erosion studies for deriving input data.

From the chosen the paper as morphometric analysis of the Vanniyar River with sub-watershed carried linear and areal aspect of the watershed .The linear aspects of the watershed is stream order, length, shape of the basin and Bifurcation ratio. The Areal aspect of the watershed is Drainage density, stream frequency, Texture ratio, Elongated ratio, form factors, length of overland, and Laws of stream length was studied.

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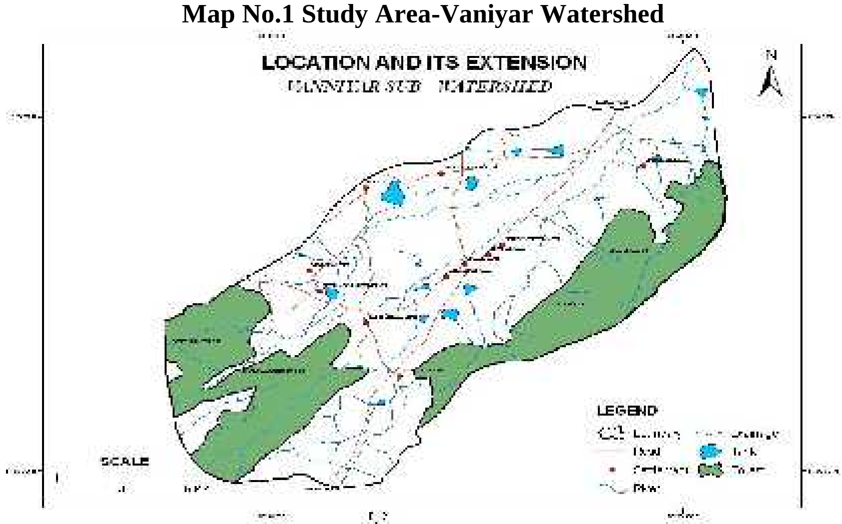
Map No.1 Study Area-Vaniyar Watershed



Map No.2 Sub-Watershed-Stream Order of Vaniyar