Research Paper
Impact Factor: 3.029
Peer Reviewed & Indexed Journal

IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

MORPPHOMETRIC ANALYSIS OF THE PUDUR SUB-WATERSHED OF VANIYAR RIVER, DHARMAPURI DISTRICT, USING REMOTE SENSING AND GIS

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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: Morphological Characters, Linear, Shape and Relief Aspects, Remote Sensing and GIS.

Introduction
Mohanty, R.R (1994). Analysis of urban land use change using sequential aerial photographs and Spot data. An example of north Bhubaneswar, Orissa. In India as well as in most developing countries, the excessive growth in population and the increased trend towards urbanization have led to many evils such as haphazard growth of industries, unplanned housing and utility networks, conversion of precious agricultural and forest land into urban land etc. Urban Land is one of the important resources provided to man by which necessary human activities are performed. Inaccurate and up to date information about the urban land is indispensable for scientific planning and management of urban resources of an area taking into consideration the potentials and the constraints to the environment. Alphan, H., 2003: “Land use change and urbanization in Adana, Turkey”, Land degradation and Development the rational planning and management of urban is possible through the regular survey of the land use helps in delineating land suitable for various activities. The IRS-LISS and PAN sensor provides high ground resolution and specified spectral resolution data for detailed studies of urban land use and for monitoring land use changes. Brahabhatt, V.S., Dalwadi, G. B., Chhabra, S. B., Ray, S. S., Dadhwal, V. K., 2000: “Landuse/land cover change mapping in Mahi canal command area, Gujarat, using multitemporal satellite data This study was undertaken for mapping the unplanned development in the Tiruchirapalli town region including its peripheral zones using IRS data and to provide up to-date information to the planners so as to fill up the gap between urban growth and information collection process.

In particular, it is doubtful whether a single kernel of any size can adequately characterize the complex spatial distribution of the cover types contained in all of the land use categories likely to be found within a typical urban scene (Barr 1992, Tonjes 1999). Besides using pixel-based approaches for image segmentation, we could use road and other linear features that can be derived from GIS data in image segmentation to support land use classification. The conventional pixel-based approaches for land use classification can be applied in a first step. The results will be used as indicators to determine the possibilities that an area, which is surrounding by linear feature from GIS data, can be classified as a certain class. Further measurements will be made based on types of land cover, derived by a pixel-based approach, as well as the proportions and compositions of each type. Since a number of those indicators are not fit the normal distribution, a fuzzy approach can be deployed to assess classification reliability (Molenaar 1996, Hootsmans 1996, Cheng 1999a).

Study Area
Pappiredipatti is one of the Taluk in the Dharmapuri district, is known as Vaniyar river flow via the town, utilize for agricultural activities in and around of the study area. The Pudur is one of the sub-watersheds in the study area. The study area ranging from $11^{o}51’ 30^{o}$ N and $11^{o}57’10^{o}$ of the Northern latitudes and $78^{o}12’40^{o}$ and $78^{o}21' 10^{o}$ Longitude. The sub-watershed covers 57.07 km2 area.

The major portion of the watershed is mountain portion. The area located in the central portion of the Vaniyar basin. The river passing towards west to eastern side. The area of the watershed in 57.07 and some of the adjoin portion covered. The contour interval minimum is 641 m and maximum is 1084m. The major area falling in the watershed is Pudur sub watershed. From the watershed have such tank irrigation, particularly in non-perennial in nature. Drainage of the sub-watershed, the pattern of the drainage is parallel and trills nature one with stream lines of the entire area. Only streams seen in the entire portion of the sub-watershed and one tank seen in the side of northern portion of the study area. Slope of the sub-watershed is straight line, dissected nature one. The lineament is N-S, W-W direction in the entire portion of the watershed. Geology of the study area is charnockites and Granite Gneiss in nature in portion of the sub-watershed. The nature of the study area is covered in the forest zone with high elevation. Landforms are mountain and undulating terrain of the watershed. Land use of the study area is mountainous with unfavorable Land utilization system. Only the forest land use with social forestry scheme by the government**.**

Objectives

- To study the Morphometric analysis of the Pudur sub-watershed of the Vaniyar River and bring out the various classes through SOI and Satellite images.
- To interpreted and delineated the stream order with linear, shape and relief parameters of the sub-watershed and analysis.
- To intergraded all parameters through GIS drainage analysis of the sub-watershed.

Research Methodology

A methodology has been formulated to achieve the present task of Morphological analysis. 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 Pudur sub- watershed. The addition to this data was collected from various private and public sector
- To Study Morphological structure of the Vaniyar Watershed in various parameters were studied. In addition to this also find the potential zone of the watershed.

Result and Discussion

Morphological Study of the Watershed

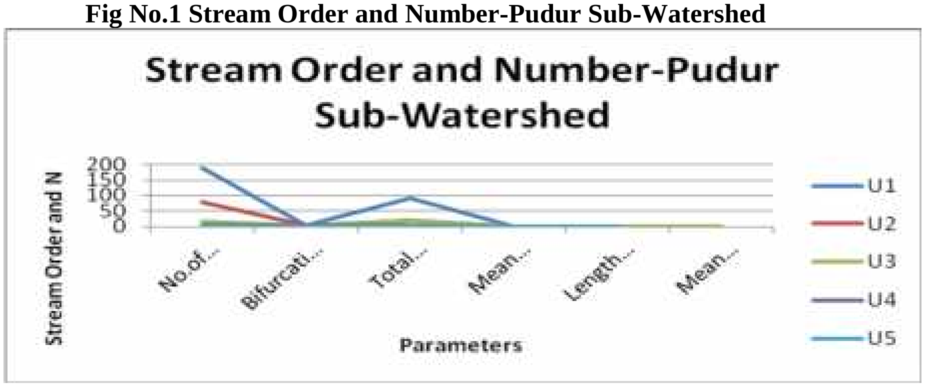
Stream Number and Order (U)

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 drainage basin analysis, in the study area Pudur sub-Watershed total number of streams found is - out of which 188 is of first order, 79 of second, 18 of third order, 5 of fourth, 0 of fifth. The watershed wise number, order and length are given in Table 1. It reveals that maximum number of streams is found in First order (188) and minimum number found in fourth order (5), 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 sub-Watershed covering an area 57.07.

Table No.1 Stream Order and Number-Pudur Sub-Watershed

Order	No. of Streams	Bifurcation Ratio	Total Length (km)	Mean Length (km)	Length Ratio	Mean Ratio
1	188	2.38	90.84	0.48	0.42	
2	79	4.38	20.35	0.36	0.22	
3	18	3.6	20.91	1.16	0.27	0.3
4	5	5	3.4	0.68	0	
5	0	0	0	0	0	

Fig No.1 Stream Order and Number-Pudur Sub-Watershed



IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

Stream Length (Lu)

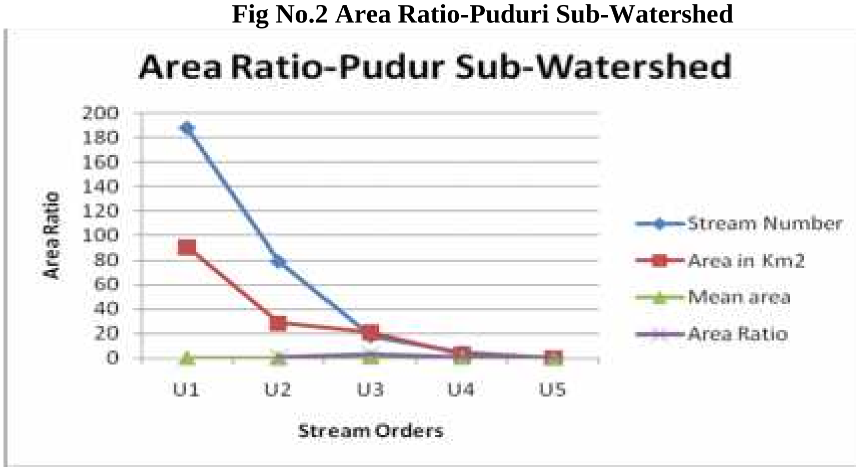
Average length ratio is 0.3 and comparing with first, second, and third order it is observed to be indicating that water flow in the source region is limited which is due to semi- arid environment. Length ratio of 2nd order is high which indicates higher surface flow. It can be seen from the table.5 that as the order increases mean length also increases and so ratio increases. Length ratio of the 1st to 3rd order stream shows that length of 1st order stream is highest among all.

Stream Length Ratio (RI)

Table No.2 Area Ratio-Puduri Sub-Watershed

Stream Order	Stream Number	Area in Km2	Mean Area	Area Ratio
1	188	90.84	0.48	
2	79	28.35	0.35	0.72
3	18	20.91	1.16	3.31
4	5	3.4	0.68	0.58
5	0	0	0	0
	290	143.5		

Fig No.2 Area Ratio-Puduri Sub-Watershed



Linear Aspects

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

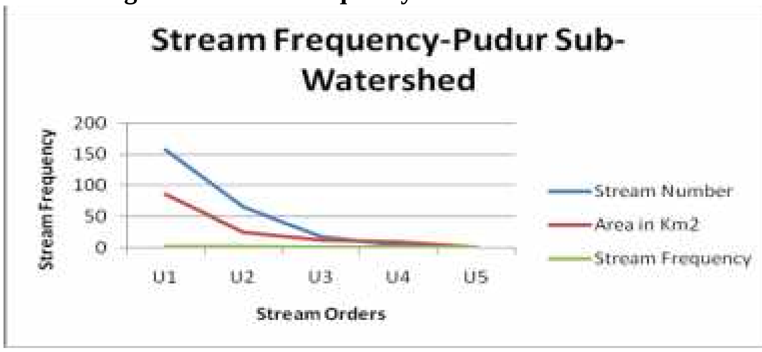
Stream Frequency (Fs)

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 stream order is mentioned in Table 3. The study revealed that the Stream orders 1st 2nd 3rd Sub -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 Stream order 3 and 4 has low stream frequency because of low relief (Fig.3). Highest value of stream frequency noted for Stream order 1 (85.61 km/km2) and Stream order 2 (24.8 km/km2) produces more runoff in comparison to others.

Table No.3 Stream Frequency-Pudur Sub-Watershed

Stream Order	Stream Number	Area in Km2	Stream Frequency
1	158	85.61	1.84
2	66	24.8	2.66
3	18	11.77	1.52
4	4	9.24	0.43
5	1	0.58	0.72
	247	132	1.87

Fig No.3 Stream Frequency-Pudur Sub-Watershed



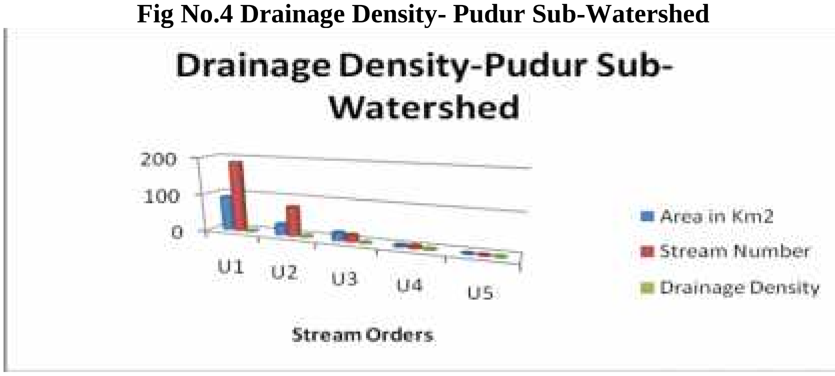
Drainage Density (Dd)

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 4 which varies from 0.86 to 2.78. 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 Stream order 1 and Stream order 2 because of impermeable sub surface material and mountainous relief (Fig.4). Low Dd value for Stream order 4 and 3 indicates that it has highly permeable sub surface material and low relief.

Table No.4 Drainage Density- Pudur Sub-Watershed

Stream Order	Area in Km2	Stream Number	Drainage Density
1	90.84	188	2.06
2	28.35	79	2.78
3	20.91	18	0.86
4	3.4	5	1.47
5	0	0	0

Fig No.4 Drainage Density- Pudur Sub-Watershed



Drainage Texture (Dt)

The 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 found to be Moderate, value 4 Pudur Sub-Watershed for Vaniyar catchment.

Bifurcation Ratio (Rb)

Bifurcation ratio related to the branching pattern of the drainage network is defined as a ratio of the number of streams of a given order to the number of streams of the next higher order.

IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

Bifurcation ratio is supposed to be controlled by drainage density, stream entrance angles, lithological characteristics, basin shape; basin area etc. (Singh 1998) Bifurcation values are ranging from 2 to 5. The higher values of 4 and 2 order streams indicate well developed stream network. The bifurcation values in the 1st and 5th order are low compared to the overall bifurcation ratio of the basin. Bifurcation values ranging from 2 to 5 suggest that it is a natural river system where uniformity is seen with respect to climate, rock type and stage of development. The purpose of stream ordering is not only to index size and scale but also to afford an approximate index of the amount of stream flow which can be produced by particular network.

Length of Overflow Land (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. The shorter length of over land flow for Pudur Sub-Watershed point out the quicker runoff process, value is 1.255.

Shape Parameters

Shape parameters include form factor, shape factor, elongation ratio, compactness ratio and circulatory ratio.

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 0.7854 (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 for all watersheds varies from --- .The values of form factor for Romushi - Sasar 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.

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 0.6 to 1.0 over a wide variety of climate and geologic types. Values close to 1.0 are typical of regions of very low relief, whereas values in the range 0.6 to 0.8 are usually associated with high relief and steep ground slope (Strahler, 1964). Shape of the Pudur Sub- watersheds found to be elongated have low elongation ratio and less elongated have high elongation ratio. In the watershed, these values are less than 0.39 and hence all the Sub-watersheds are generally elongated in shape.

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). .High value of circulatory ratio indicates the maturity stage of topography. The value 0.025 for Pudur Sub-Watershed indicates very less circular in shape than the other sub-watersheds.

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 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 Pudur Sub-Watershed (0.82) is very less 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---.

Relief Aspects of the Watershed

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.

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. 9). Schumm (1956) measured it along the longest

IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

dimension of the basin parallel to the principle drainage line. The relief for sub-watersheds varies from 200 to 1000 meters. The watersheds have been divided into high, medium and low relief regions in which Pudur sub-watershed are having highest basin relief (400). 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. It was noticed that the lower values of relief ratio for Pudur Sub-Watershed indicated steep slope and high relief (2.28).

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 1.5 to 2.0. The Pudur Sub- watershed having lower relative relief have lower runoff potential than others.

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 0.698 to 7.065. The highest value of ruggedness was observed in RSMW4 (7.065), RSMW5 (6.049) and RSMW3 (3.599) 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.

Conclusion

The present study of Pudur sub-watershed demonstrates the utility of remote sensing and GIS techniques in prioritizing sub watersheds 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 Pudur sub-watershed 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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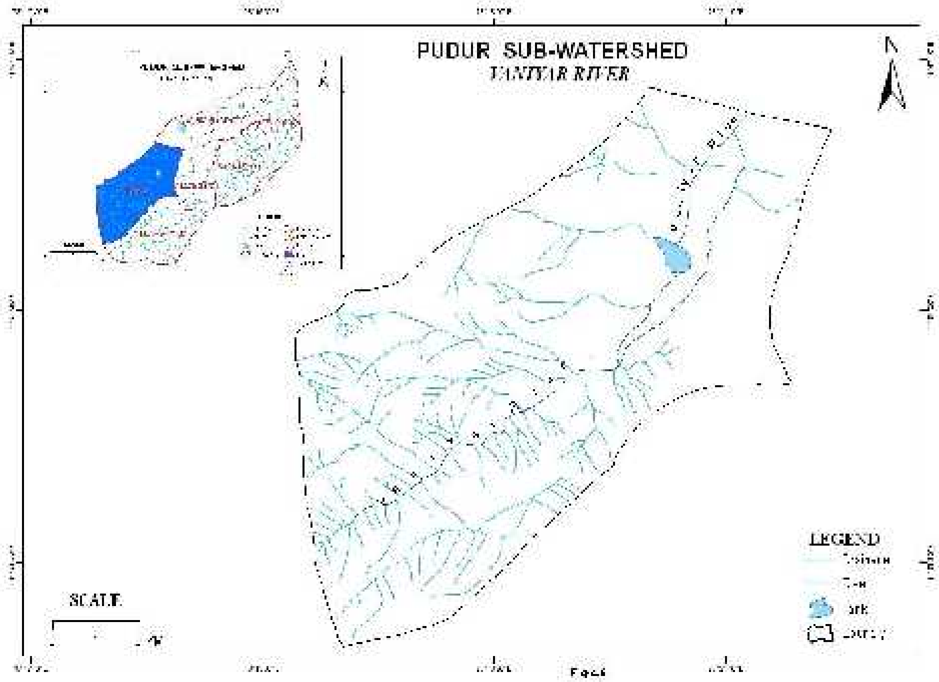
IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

Map No.1 Sub-Watershed of Pudur, Vaniyar River



Map No.2 Sub-Watershed of Pudur-Stream Order, Vaniyar River