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WATERSHED MANAGEMENT PRIORITIZATION IN TEA LAND USES: A CASE STUDY IN BADULU OYA SUB-WATERSHED OF MAHAWELI BASIN

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ABSTRACT: A watershed is an ideal hydrological unit for its management. Prioritization of watersheds using morphometric analysis is a popular way for proper planning and management of soil and water resources. Remote Sensing and GIS techniques have become very comprehensive tools in prioritizing watersheds. In this study, prioritization of micro-watersheds was carried out for the Badulu Oya sub-watershed in which tea is a main land use. Stream network and micro-watersheds were extracted from DEM derived from 20 m contour interval using Hydrology toolset in ArcMap 10.4.1 software. 30 micro-watersheds named BD1 to BD30 were delineated. The spatial data derived from GIS tools were used to determine linear and areal aspects of morphometric parameters for each micro-watershed. Watershed prioritization was done adopting the methods proposed in scientific literature. The micro-watersheds with the highest values for linear parameters and lowest values for areal parameters were ranked as the first priority. Accordingly, all the 30 micro-watersheds were ranked from 1 to 30 for all the linear and areal parameters used in this study. Finally compound values were obtained for prioritizing and they were categorized into three priority levels as high, medium and low priority. The results of the morphometric analysis revealed that Badulu Oya has an 8th order stream network with a dendritic drainage pattern which also complies with the Hortonian Laws of stream networks. The prioritization results showed that micro-watersheds BD20, BD22 and BD19 can be identified as medium priority and hence they are under severe soil erosion susceptibility. Finally, it can be suggested that, identified three micro-watersheds with medium sensitivity for topsoil loss and erosion, need immediate attention to take up mechanical soil conservation measures for sustainable tea cultivation in Badulu Oya sub-watershed in Mahaweli River Basin of Sri Lanka.

INTRODUCTION

The watershed is a basic unit of water resource management. A watershed is defined as a land area that provides rainfall through a common point in the drainage system (Biswas, *et al*., 1999) and it can be classified into sub-watersheds, mini-watersheds, or micro-watersheds depending on the purpose of the study. Watershed management is the process of identifying pollution sources in a watershed and recommending ways to reduce or eliminate those pollutants. It is a technology that manages water resources to maximize benefits without affecting ecological sustainability (Wang, *et al*., 2016). Watershed management is very important to conserve the soil, plant and water resources of a watershed (Garde, 2006; Mohd, *et al*., 2013).

Watershed prioritization is the ranking of different sub-watersheds according to an order in which they have to be taken up for treatment by soil and water conservation measures and they are prioritized on a scale of high, medium, and low priority (Biswas, *et al*., 1999). Further, morphometric analysis of watershed parameters is a common and comprehensive approach of prioritizing watersheds for planning and implementing watershed management ((Uniyal and Gupta, 2013).

Morphometric analysis of watershed provides a quantitative description of the drainage system, which is an important aspect of the characterization of watersheds and three aspects of morphometric parameters *viz*, linear, shape and relief are basically considered (Strahler, 1964; Horton, 1932; Mohd, *et al*., 2013). Linear morphometric parameters are stream order, stream number, bifurcation ratio, stream length ratio, drainage density, drainage intensity, drainage texture, length of overland flow and stream frequency and they are directly related to erodibility. If linear parameters have a higher value, the more is the erodibility. The areal morphometric parameters are watershed area, perimeter, length of the watershed, circularity ratio, elongation ratio and form factor. They have an inverse relationship with erodibility; if areal parameters have a low value, the more is the erodibility (Uniyal and Gupta, 2013).

Geographic information systems (GIS) and remote sensing (RS) are the most important tools for watershed development, management, and studies on sub-watershed prioritization (Javed, *et al*., 2011). GIS techniques are widely used at present for assessing various terrain and morphological parameters of the drainage basins and watersheds, as they provide a flexible environment and powerful tools for the manipulation and analysis of spatial information (Mohd, *et al*., 2013).

There are 103 major rivers in Sri Lanka, and the central highlands contain the major upper catchment areas of those rivers and tributaries (National Atlas of Sri Lanka, 2007). Badulu Oya is a main tributary of the longest Mahaweli River and hence Badulu Oya sub-watershed is an important hydrological unit in the biggest Mahaweli River Basin. A considerable land area of the upper catchment areas of the Badulu Oya sub-watershed is covered by tea plantations, where frequent land use changes are occurring for different cultural practices of tea. However, these changes in land use/land cover badly affect the sustainability of water resources within the watershed. Therefore, there is a need to identify such effects and protect the sensitive areas within the Badulu Oya sub-watershed. In this context, watershed prioritization would be a good tool, which can be done effectively in a GIS environment and morphometric analysis of the watershed area and its river network. Therefore, the present study was an attempt to prioritize watershed management in Badulu Oya sub-watershed of Mahaweli River Basin of Sri Lanka using spatial data derived from GIS and morphometric analysis tools available in the scientific literature.

METHODOLOGY

Study Area

Badulu Oya is one of the main tributaries of the longest Mahaweli River of Sri Lanka (Figure 1). This area receives 2000 mm annual average rainfall during the wet season (October to March) of the country (Gunawardhana, *et al*, 2018) and a particular dry weather exists from April to September. The main soil type in the area is red yellow podzolic (De Alwis and Panabokke, 1972).

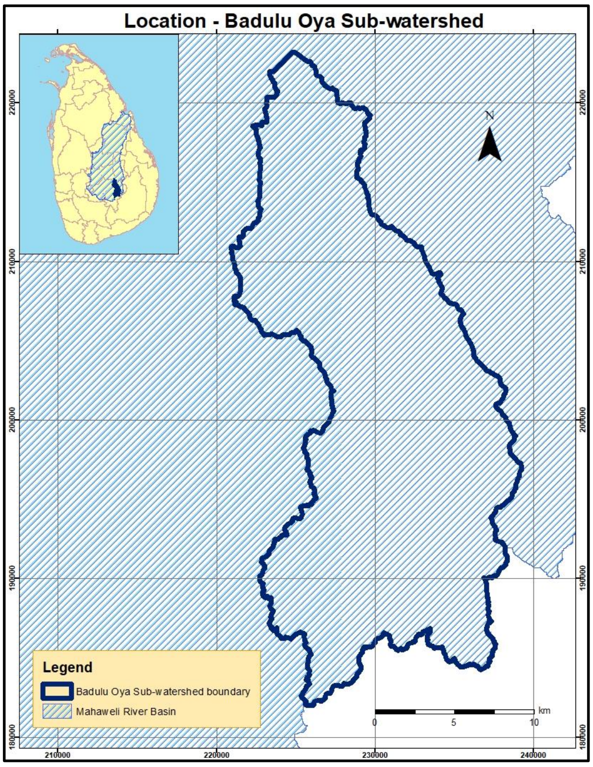

Figure 1: Location of Badulu Oya Sub-watershed

Materials

A contour layer of 20 m interval from Survey Department of Sri Lanka was used for the study. Digital elevation model (DEM) was derived from the contour layer. 1:50,000 Topographic maps (sheet no. 62 - Hanguranketha and sheet no. 69 - Badulla) covering the study area were used in advance. The main analysis was undertaken using ArcGIS 10.4.1 software, as an interface to derive the morphometric parameters from DEM. All digital data were brought to a common platform *via* a Projected Coordinate System; Kandawala Sri Lanka Grid.

Method

Using Topo to Raster tool the contour layer was converted into a Digital Elevation Model. The Fill tool was used to remove the irregularities in the DEM. Flow Direction and Flow accumulation tools were used to generate the drainage network of the study area. The generated stream network was used to get the stream orders of the drainage pattern. Using pour points, entire Badulu Oya sub-watershed was divided into 30 micro-watersheds (Figure 2).

Stream ordering was done using the method proposed by Strahler (1964). The order-wise lengths of streams, area, perimeter and length of each micro-watershed were measured with ArcGIS 10.4.1 software tools. Table 1 indicates the linear and areal aspects considered in morphometric analysis together with the methods proposed in the scientific literature.

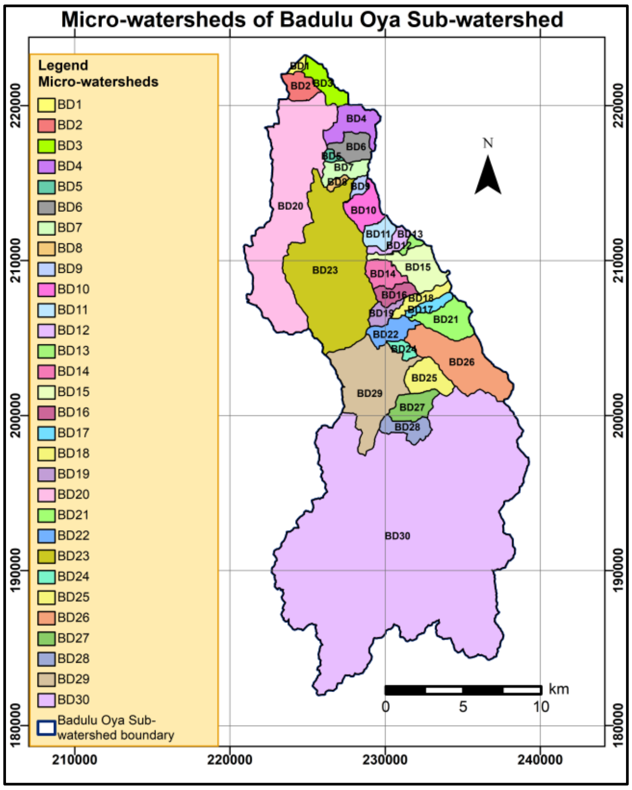

Figure 2: Micro-watersheds of Badulu Oya Sub-watershed

Watershed prioritization was carried out by assigning ranks each morphometric parameter adopting the method given by Uniyal and Gupta (2013). The linear parameters *viz*, drainage density, drainage texture, drainage intensity, length of overland flow, bifurcation ratio and infiltration number have a direct relationship with erodibility (Biswas, *et al*., 1999). Hence for prioritization of sub-watersheds, the highest value of linear parameters was rated as rank 1, the second highest value as rank 2 and so on, and the least value was rated last in rank. The areal parameters such as form factor, circulatory ratio and elongation ratio have an inverse relationship with erodibility (Uniyal and Gupta, 2013). Thus, the lowest value of shape parameters was rated as rank 1, the next lower value as rank 2 and so on and the highest value was rated last in rank.

Finally, a compound value (Cp) was calculated by averaging all ranked values for each micro-watershed. Watersheds with the highest Cp were of low priority while those with the lowest Cp were of high priority as explained by Uniyal and Gupta (2013) and thus all the 30 micro-watersheds were categorized as high, medium and low priority based on that explanation.

Table 1: Methodologies Adopted for Morphometric Analysis

Morphometric Parameter		**Method**	**Reference**
Linear Aspects	Stream order (U)	Hierarchical rank	Strahler (1964)
	Stream length (Lu)	Lu = L1+L2 ………+ Ln	Horton (1945)
	Stream number (Nu)	Nu = N1+N2+….Nn	Horton (1945)
	Bifurcation Ratio (Rb)	Rb = Nu/Nu + 1	Schumm (1956)
	Stream length ratio (Rl)	Rl = Lu/Lu - 1	Horton (1945)
	Mean stream length (Lum)	Lum = Lu/Nu	Strahler (1964)
	Stream frequency (Fs)	Fs = Nu/A	Horton (1932)
	Drainage density (Dd)	Dd = Lu/A	Horton (1932)
	Drainage texture (T)	DT = Nu/P	Horton (1932)
	Drainage intensity (Id)	Id = Fs/Dd	Faniran (1968)
Areal Aspects	Area in km^2 (A)	Area calculation	Schumm (1956)
	Perimeter in km (P)	Perimeter calculation	Schumm (1956)
	Length of the basin in km (Lb)	Length calculation	Schumm (1956)
	Circulatory ratio (Rc)	$Rc = 4 * \pi * A/P^2$	Miller (1953)
	Elongation ratio (Re)	$Re = (4*A/\pi)\ 0.5/Lb$	Schumm (1956)
	Form factor (Ff)	$Ff = A/Lb^2$	Horton (1932)

RESULTS AND DISCUSSION

Linear Aspects

Stream Order, Number and Length

Number of streams and order are the most important parameters of drainage basin analysis and there are 13,505 total number of streams in the studied Badulu Oya sub-watershed extending up to 8th order stream network (Figure 3) according to Strahler's (1964) classification with a dendritic drainage pattern. It is also noted that first order streams are the highest in number (75.38% out of total 13,505) in all micro-watersheds while the last order has the lowest number (0.06%), confirming Horton's Laws (1932) on river networks. The highest number of stream segments can be found in BD30 micro-watershed (6,457), and the lowest number of stream segments in BD1 (09). Table 2 indicates the stream numbers and their respective lengths in different orders within 30 micro-watersheds of Badulu Oya sub-watershed.

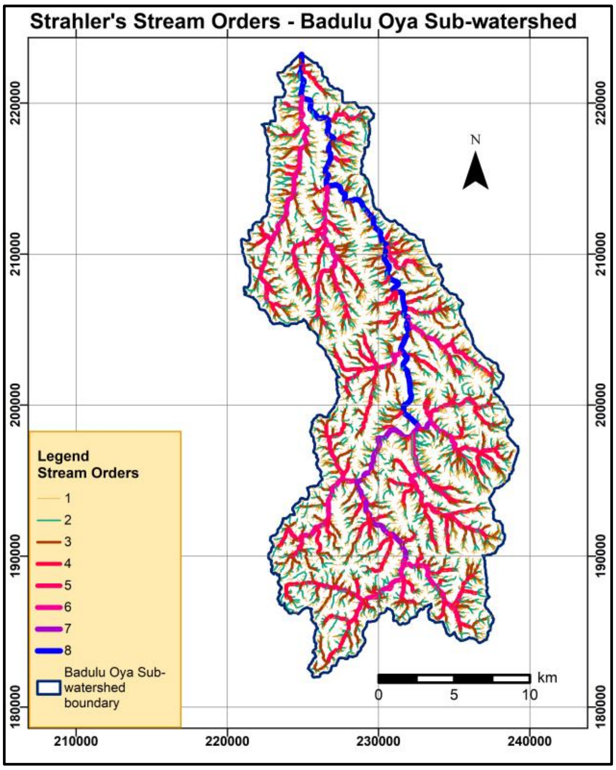

Figure 3: Stream Network of Badulu Oya Sub-watershed

Bifurcation Ratio (Rb)

The bifurcation ratio is a dimensional parameter that expresses the ratio of the number of streams of any given order (Nu) to the number of streams in the next higher order (Nu+1) (Horton, 1945). Generally, lower values of Rb are characteristic of a watershed in which the drainage pattern has not been distorted by structural disturbances and show fewer structural disturbances. Basins with higher Rbs have lower and extended peak flows**,** thus less risk of flooding within the basins (Chorley *et al.*,1957). In this study mean Rb value varies from 2.25 in BD1 to 6 in BD5 (Table 3). Higher mean Rb values are characteristics of structurally more disturbed watersheds with prominent distortion in drainage patterns (Nag and Chakraborty, 2003).

Stream Frequency (Fs)

Stream frequency values of all micro-watersheds are shown in Table 3. Fs is the total number of stream segments of all orders per unit area (Horton, 1932). Fs have been related to permeability, infiltration capacity and relief of watersheds indicating high stream frequency are indicative of high relief and low infiltration capacity of the bedrock pointing toward the increase in stream population with respect to an increase in drainage density (Withanage, *et al*., 2015). The watersheds having a large area under dense forest have low stream frequency and the area having more agricultural land have high stream frequency (Uniyal and Gupta, 2013). The high value of stream frequency produces more runoff in comparison to others. In this study, Fs is maximum in BD13 (48.84 km/km^2) and minimum in BD30 (13.91 km/km^2).

Drainage Density (Dd)

Drainage density is defined as the length of streams per unit area (Horton, 1932). Maximum Dd value was noted in BD15 (9.76 km/km^2) and minimum in BD30 (3.56 km/km^2). It has been observed that low drainage density found to be associated with regions having highly permeable subsoil material under dense vegetative cover, and where relief is low and high value noted for the regions of weak or impermeable subsurface materials, sparse vegetation and mountainous relief. Rock type, run-off intensity, soil type, infiltration capacity, and proportion of rocky land all influence drainage density (Uniyal and Gupta, 2013).

Drainage Texture (DT) and Drainage Intensity (Id)

Drainage texture is defined as the total number of stream segments of all orders divided by the perimeter of the watershed. Smith (1954) classified drainage texture into five 5 classes. *viz*, < 2 is very coarse, between 2 and 4 is coarse, between 4 and 6 is moderate, between 6 and 8 is fine and < 8 is very fine drainage texture. According to Smith's classification (1954), BD1 shows, coarse drainage texture, BD8 shows moderate drainage texture, BD5, BD13 and BD18 show fine texture and other micro-watersheds show very fine drainage texture (Table 3).

Low Id indicates, surface runoff is not quickly removed and more water is infiltrated into the soil (Faniran, 1968). In this study, Id value range is 3.91- 6.20.

Length of Overland Flow (Lo)

Length of overland flow is one of the most important independent variables affecting the hydrologic and physiographic development of drainage basins. The average length of overland flow is approximately half of the average distance between stream channels and is therefore approximately equal to half of the reciprocal of drainage density (Horton, 1945). L_O is higher in semi-arid regions with less vegetation cover, thus generation of higher surface flow (Kale and Gupta, 2001). The Lo values of micro-watersheds are varying from 0.05 for BD15 to 0.14 for BD1. Low L_O values give evidences for the existence of good vegetation covers in these micro watersheds (Withanage, *et al*., 2015).

Areal Aspects

Form Factor (Ff)

Form factor is defined as a dimensionless ratio of basin area (A) to the square of basin length (Lb) (Horton, 1932). In this study area, maximum Ff is for BD28 (2.54) and minimum for BD20 (0.21). High value of Ff stating the circular shape of the basin while low one indicates elongated shape and states that the basin will have a flatter peak flow for a longer duration. Flood flows of such elongated basins are easier to manage than from the circular basin (Withanage, *et al*., 2015).

Circulatory Ratio (Rc)

Circularity Ratio is the ratio of the area of a basin to the area of a circle having the same circumference as the perimeter of the basin (Miller, 1953). Rc is helpful for assessment of flood hazard. Higher the Rc value, higher is the flood hazard at the peak time at the outlet point. Circulatory ratio in the study area found in the range of 0.25-0.70. The high value of the circulatory ratio indicates the maturity stage of topography (Withanage, *et al*., 2015).

Elongation Ratio (Re)

It is the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin. It is a very significant index in the analysis of basin shape which helps to give an idea about the hydrological character of a drainage basin (Uniyal and Gupta, 2013). The value of the elongation ratio in the study area was found in the range of 0.52-1.80 and it indicates high relief and steep ground slope. The shape of the micro watersheds found to be elongated (low elongation ratio) to less elongated (high elongation ratio) as explained by Biswas, *et al*. (1999).

Watershed Prioritization

The compound parameter (Cp) values and the prioritization rating of all 30 micro-watersheds of Badulu Oya sub-watershed are shown in Table 4.

In this study, micro-watershed BD20, BD22 and BD19 resulted with 9.2, 9.4 and 10 compound vales respectively and therefore they are under medium priority level. Figure 4 shows the final priority categories of 30 micro-watersheds of Badulu Oya sub-watershed. As per Uniyal and Gupta (2013) and Biswas, *et al*. (1999), watersheds falling under high priority are under very severe erosion susceptibility zone and they need immediate attention to take up mechanical soil conservation measures like gully control structures and grass waterways to protect the topsoil loss and watersheds falling under low priority have a very slight erosion susceptibility and may need agronomical measures to protect the sheet and rill erosion.

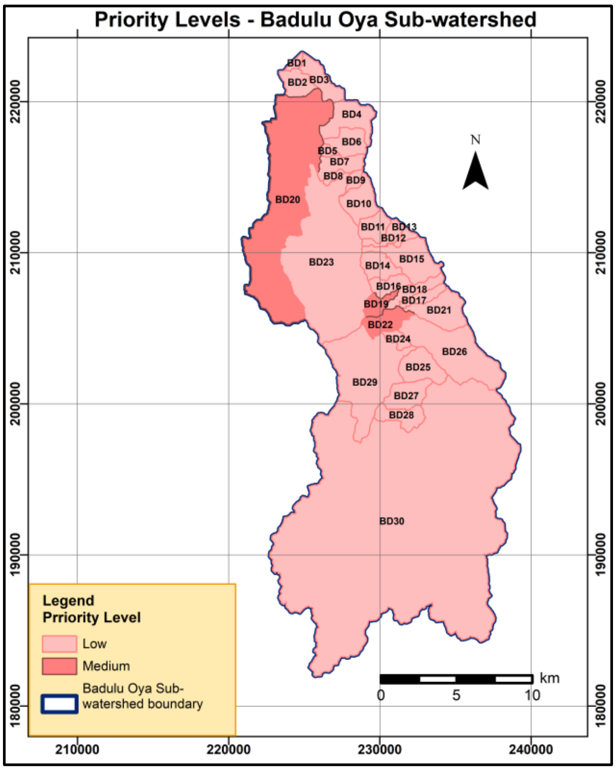

Figure 4: Micro-watershed Prioritization Levels of Badulu Oya Sub-watershed

CONCLUSION

The studied Badulu Oya sub-watershed which is a main tributary of Mahaweli River Basin in Sri Lanka spreads up to 8th order stream network with a dendritic drainage pattern. Drainage density of the sub-watershed varies from 3.56 km/km^2 – 9.76 km/km^2, along with a coarse to very fine drainage texture. Mean bifurcation ratio varies from 2.25 to 6 and high values clearly indicating the structural control on the drainage pattern. Form factor values range from 0.21 to 2.54 indicating BD28 is more circular in shape and has a flatter peak flow generation. Circulatory ratio varies from 0.25 to 0.70 and high value clearly indicating the late maturity stage of topography. The prioritization results showed that micro-watersheds BD20, BD22, and BD19 can be identified as medium priority and thus they are in the severe soil erosion susceptibility zone. Therefore, it can be suggested that, these three micro-watersheds need immediate attention to take up mechanical soil conservation measures to avoid further topsoil loss and erosion. The study demonstrates the reliability and flexibility of GIS techniques in prioritization of watershed management. Finally, the findings of this study elucidate vital information which may be helpful for planners and decision makers for planning the soil conservation measures in Badulu Oya sub-watershed at micro-watershed level.

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Table 2: Number and Lengths of Streams at different Orders of Badulu Oya Micro-watersheds

Micro-watershed	1st Order		2nd order		3rd Order		4th Order		5th Order		6th Order		7th Order		8th Order		Total Nu	Total Lu (km)
	Nu	**Lu**	**Nu**	**Lu**	**Nu**	**Lu**	**Nu**	**Lu**	**Nu**	**Lu**	**Nu**	**Lu**	**Nu**	**Lu**	**Nu**	**Lu**		
BD1	5	0.7	2	0.29	1	1.31									1	0.01	9	2.3
BD2	65	12.27	21	7.52	6	1.23	2	0.34							1	1.83	95	23.19
BD3	80	10.13	21	3.87	4	1.86	1	2.69							1	1.22	107	19.77
BD4	150	20.32	32	9.45	10	2.71	2	1	1	2.16					1	1.55	196	37.19
BD5	20	2.19	2	0.45	1	0.58									1	0.65	24	3.87
BD6	108	20.98	25	6.04	6	2.47	2	2.49	1	0.05					1	0.63	143	32.66
BD7	86	13.53	20	5.37	6	2.09	2	0.8	1	0.73					1	1.44	116	23.96
BD8	14	1.99	3	0.4	1	0.43									1	0.81	19	3.63
BD9	35	4.98	8	2.03	2	1.89	1	0.13							1	0.05	47	9.08
BD10	120	17.09	26	5.16	6	3.37	1	0.01							1	2.89	154	28.52
BD11	67	10.05	19	5.55	3	1.37									1	1.73	90	18.7
BD12	63	9.45	12	3.61	4	2.12	1	0.63							1	0.52	81	16.33
BD13	32	4.16	6	1.7	2	0.95	1	0.83							1	0.06	42	7.7
BD14	91	12.84	25	5.39	7	4.13	2	0.64							1	1.62	126	24.62
BD15	251	46.76	58	10.99	17	8.05	4	2.55	1	3.19					1	0.69	332	72.23
BD16	61	7.65	17	4.73	5	1.51	2	0.8							1	1.5	86	16.19
BD17	55	7.25	11	2.02	3	1.59	1	1.2							1	0.34	71	12.4
BD18	65	10.19	14	3.23	3	2.37	1	0.59							1	1.03	84	17.41
BD19	64	7.94	13	2.4	3	1.55	1	1.6							1	0.17	82	13.66
BD20	1186	191.1	284	63.14	69	32.1	15	8.71	3	6.65	1	10.92			1	2.71	1559	315.3
BD21	166	23.41	42	8.47	11	6.62	2	0.55	1	2.51					1	0.37	223	41.93
BD22	112	13.38	28	4.52	4	3.19	1	2.07							1	0.45	146	23.61
BD23	1167	155.4	277	59.75	70	31.69	12	12.61	3	11.39	1	6.37			1	1.51	1531	278.71
BD24	38	5.03	7	1.5	2	0.55	1	0.46							1	0.91	49	8.45
BD25	133	17.27	33	7.22	6	2.4	1	2.44							1	2.1	174	31.43
BD26	395	60.96	105	22.49	26	8.5	5	1.41	2	6.04	1	1.42			1	1.56	535	102.38

BD27	99	17.06	21	7.37	5	3.08	1	0.25							1	2	127	29.76
BD28	90	14.45	19	5.24	4	2.54	1	0.77							1	1.48	115	24.48
BD29	521	68.9	128	25.44	25	14.45	7	13.04	2	1.81	1	2.25			1	0.54	685	126.43
BD30	4842	687.7	1224	292.61	287	141.03	78	78.13	17	33.38	6	23.64	2	15.26	1	0.0014	6457	1271.77

Table 3: Linear and Areal Aspects of Morphometric Parameters

Micro-watershed	**Linear Aspects**							**Areal Aspects**			
	Stream frequency (Fs)	**Drainage density (Dd)**	**Drainage texture (DT)**	**Drainage intensity (Id)**	**Infiltration number (If)**	**Length of overland flow (Lo)**	**Mean Bifurcation ratio (Rbm)**	**Area (km^2)**	**Form factor (Ff)**	**Circulatory ratio (Rc)**	**Elongation ratio (Re)**
BD1	13.91	3.56	2.22	3.91	49.5	0.14	2.25	0.65	0.22	0.49	0.53
BD2	30.45	7.43	12.29	4.1	226.32	0.07	3.3	3.12	0.87	0.66	1.05
BD3	28.23	5.22	9.97	5.41	147.27	0.1	4.53	3.79	0.27	0.41	0.58
BD4	33.5	6.36	14.13	5.27	213	0.08	3.94	5.85	0.63	0.38	0.9
BD5	36.92	5.95	6.09	6.2	219.83	0.08	6	0.65	0.94	0.53	1.1
BD6	37.43	8.55	16.03	4.38	320.06	0.06	4.24	3.82	0.81	0.6	1.02
BD7	35.15	7.26	12.26	4.84	255.22	0.07	3.82	3.3	0.67	0.46	0.92
BD8	26.76	5.11	4.79	5.23	136.82	0.1	3.83	0.71	0.67	0.57	0.92
BD9	43.52	8.41	8.1	5.18	365.88	0.06	4.19	1.08	0.3	0.4	0.61
BD10	32.7	6.06	14.75	5.4	197.98	0.08	4.47	4.71	1.45	0.54	1.36
BD11	29.41	6.11	12.11	4.81	179.74	0.08	4.93	3.06	1.87	0.7	1.54
BD12	39.9	8.04	9.38	4.96	320.98	0.06	4.13	2.03	0.76	0.34	0.99
BD13	48.84	8.95	6.4	5.45	437.26	0.06	4.17	0.86	1.09	0.25	1.18
BD14	35.2	6.88	14.33	5.12	242.04	0.07	3.61	3.58	1.07	0.58	1.17
BD15	44.86	9.76	21.28	4.6	437.92	0.05	3.87	7.4	0.64	0.38	0.9
BD16	32.95	6.2	10.59	5.31	204.39	0.08	3.49	2.61	1.67	0.5	1.46
BD17	37.97	6.63	8.98	5.73	251.77	0.08	4.33	1.87	0.69	0.38	0.94
BD18	30.22	6.26	7.89	4.82	189.23	0.08	4.65	2.78	0.34	0.31	0.66
BD19	39.05	6.5	10.76	6	254	0.08	4.63	2.1	0.3	0.45	0.62

BD20	35.99	7.28	33.42	4.94	261.93	0.07	4.15	43.32	0.21	0.25	0.52
BD21	35.79	6.73	18.44	5.32	240.91	0.07	3.89	6.23	0.67	0.54	0.92
BD22	39.25	6.35	14.51	6.18	249.09	0.08	5.5	3.72	0.42	0.46	0.73
BD23	36.1	6.57	43.58	5.49	237.24	0.08	4.09	42.41	0.38	0.43	0.7
BD24	35.51	6.12	8.51	5.8	217.42	0.08	4.46	1.38	0.67	0.52	0.92
BD25	33.72	6.09	18.03	5.54	205.4	0.08	4.77	5.16	0.55	0.7	0.84
BD26	33.73	6.46	26.01	5.23	217.75	0.08	3.9	15.86	0.28	0.47	0.6
BD27	28.93	6.78	13.4	4.27	196.11	0.07	4.46	4.39	1.76	0.61	1.5
BD28	32.58	6.93	11.42	4.7	225.92	0.07	4.74	3.53	2.54	0.44	1.8
BD29	31.52	5.82	26.07	5.42	183.41	0.09	4.6	21.73	0.47	0.4	0.77
BD30	31.91	6.29	74.4	5.08	200.55	0.08	4.11	202.35	0.9	0.34	1.07

Table 4: Micro-watershed Prioritization

Micro-watershed	Fs	DT	Dd	Id	If	Lo	Rbm	Ff	Rc	Re	Compound Value (Cp)	Priority Level	Priority Rank
BD1	30	30	30	30	30	1	30	2	18	2	20.3	Low	25
BD2	24	15	6	29	14	25	29	21	28	21	21.2	Low	27
BD3	28	21	28	10	28	3	9	3	11	3	14.4	Low	13
BD4	18	13	17	14	19	14	21	12	8	12	14.8	Low	14
BD5	9	28	26	1	16	5	1	23	21	23	15.3	Low	16
BD6	8	9	3	27	5	28	14	20	26	20	16	Low	19
BD7	15	16	8	22	7	23	26	16	16	16	16.5	Low	21
BD8	29	29	29	15	29	2	25	15	24	15	21.2	Low	28
BD9	3	25	4	17	3	27	15	5	10	5	11.4	Low	5
BD10	20	10	25	11	23	6	10	26	23	26	18	Low	22
BD11	26	17	23	24	27	8	3	29	30	29	21.6	Low	29
BD12	4	22	5	20	4	26	18	19	5	19	14.2	Low	12
BD13	1	27	2	8	2	29	16	25	2	25	13.7	Low	10

BD14	14	12	10	18	11	21	27	24	25	24	18.6	Low	23
BD15	2	6	1	26	1	30	24	13	7	13	12.3	Low	6
BD16	19	20	21	13	21	10	28	27	19	27	20.5	Low	26
BD17	7	23	13	5	9	18	13	18	6	18	13	Low	7
BD18	25	26	20	23	25	11	6	7	3	7	15.3	Low	17
BD19	6	19	15	3	8	16	7	6	14	6	10	**Medium**	**3**
BD20	11	3	7	21	6	24	17	1	1	1	9.2	**Medium**	**1**
BD21	12	7	12	12	12	19	23	17	22	17	15.3	Low	18
BD22	5	11	18	2	10	13	2	9	15	9	9.4	**Medium**	**2**
BD23	10	2	14	7	13	17	20	8	12	8	11.1	Low	4
BD24	13	24	22	4	18	9	11	14	20	14	14.9	Low	15
BD25	17	8	24	6	20	7	4	11	29	11	13.7	Low	11
BD26	16	5	16	16	17	15	22	4	17	4	13.2	Low	9
BD27	27	14	11	28	24	20	12	28	27	28	21.9	Low	30
BD28	21	18	9	25	15	22	5	30	13	30	18.8	Low	24
BD29	23	4	27	9	26	4	8	10	9	10	13	Low	8
BD30	22	1	19	19	22	12	19	22	4	22	16.2	Low	20