Morphometric Characteristics of Beli Ul Oya Sub-basin of Mahaweli River Basin, Sri Lanka

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Abstract**:** *Beli Ul Oya, a main tributary of Mahaweli River in Sri Lanka, originates from the Pidurutalagala mountain and spans approximately 20 km. Although Beli Ul Oya plays a vital role in irrigation and tourism in the country, its watershed area is under a threat of soil erosion, especially due to unplanned development and agricultural activities. Therefore this study focuses on assessing the hydrological characteristics of Beli Ul Oya Sub-basin using morphometric analysis conducted under GIS environment. The required spatial data were collected using a DEM derived from a 20 m contour map. Various linear, areal, and relief morphometric parameters were estimated using the empirical methods avalable in the literature. The results showed that the Beli Ul Oya river network extends up to Strahler's 6th order, displaying a dendritic drainage pattern with 1,188 streams over 152.6 km². The mean bifurcation ratio of 3.9 indicates a strong structural influence on the drainage pattern. The drainage density of 3.04 km/km² places it in the coarse category, indicating a poorly drained basin with a slow hydrologic response, making it highly susceptible to flooding and gully erosion. The drainage texture of 17.5 km⁻¹ also suggests a high risk of soil erosion. The form factor of 0.32 and the elongation ratio of 0.63 indicate an elongated basin shape. The circulatory ratio of 0.42 reflects a less structural control within the watershed. The basin relief of 2.3 km and a relief ratio of 0.1 indicate lower relief, suggesting reduced susceptibility to soil erosion. on These findings of hydrological characteristics of this study area would be helpful in the proper planning and implementation of both development and agricultural activities without accelerating the potential risks of flooding and soil erosion in Beli Ul Oya Sub-basin of Mahaweli River Basin, Sri Lanka.*

Keywords: *GIS; Hydrological characteristics;Morphometric analysis; Soil erosion risk; Watershed management*

Introduction

A watershed known as a drainage basin, refers to the surface area drained by one or more water courses, constituting a fundamental erosional landscape element where land and water resources interact in a perceptible manner (Uniyal & Gupta, 2013). Watersheds provide a powerful unit for study and management integrating ecological, geographical, geological, and cultural aspects of the land. The watershed is also a useful concept for linking science with historical, cultural, economic, and political issues (Fu, 2016).

Watershed prioritization is the ranking of different sub watersheds according to the order in which they should undergo treatment and soil conservation measures (Biswas et al., 1999). This process is considered one of the most essential aspects of natural resource planning and development for water conservation techniques (Javed et al., 2011).

Morphometry is defined as the measurement and mathematical analysis of the earth's surface configuration, including the shape and dimensions of its landforms (Clarke, 1966). Morphometric analysis provides a quantitative description of the drainage system, a vital aspect of watershed characterization (Strahler, 1964). Morphometric analysis is particularly useful for prioritization of micro-watersheds by studying different linear and aerial parameters of the watershed even in the absence of soil maps (Biswas et al., 1999). The morphometric assessment helps provide a preliminery hydrological diagnosis in order to predict approximate behavior of a watershed if correctly coupled with geomorphology and geology (Esper, 2008). The morphometric characteristics at the watershed scale contain crucial information regarding its origins and development because all hydrologic and geomorphic processes occur within the watershed (Singh, 1992).

The combination of GIS and remote sensing is widely recognized as the most effective and adaptable technique available for environmental and natural resource monitoring, assessment, and management. This integrated, interdisciplinary approach enhances resource and environmental management and monitoring capabilities, leading to improved decision-making for watershed management. There is increasing recognition that enhancing the long-term sustainability of agricultural and rural communities and reducing non-point source pollution can be effectively achieved through locally-based planning and management at the watershed scale. The integrated resource management of a watershed requires simultaneous consideration of socioeconomic and physical elements. To address these issues, a significant amount of spatial data and knowledge from different fields must be incorporated (Javed et al., 2011).

The main upper catchment areas of Sri Lanka's 103 major rivers and their tributaries are situated in the country's central highlands (National Atlas of Sri Lanka, 2007). These rivers play a significant role in agriculture, transportation, and electricity generation in Sri Lanka. Beli Ul Oya sub-basin is an area where tea plantations are extensively distributed. Growing tea along with many cultural practices (pruning, forking, pest and disease management, etc.) undoubtedly creates adverse environmental impacts such as soil erosion, water pollution, and habitat damage also within this sub-basin. Therefore, there is a need to identify such effects and protect the sensitive areas within the Beli Ul Oya sub-basin while promoting sustainable tea cultivation to contribute well to the GDP of the country. The current study aims to prioritize sub-watersheds in the Beli Ul Oya sub-basin based on morphometric and land use parameters using remote sensing and GIS techniques. In this context, watershed prioritization combined with morphometric analysis of the watershed area and its river network using a GIS technology, proves to be highly effective. The conclusions of this investigation will enhance the understanding the river's hydrological behavior, geomorphological evolution, and ecological significance.

Literature Review

Tea Cultivation in Sri Lanka

Tea cultivation in Sri Lanka predominantly occurs in the central highlands, where optimal environmental conditions foster the growth of high-quality tea. Agronomic practices such as specialized planting, pruning, and plucking methods are employed to enhance both yield and quality (Alahakoon et al., 2022). Approximately 83% of tea cultivation takes place in the high-grown region, while some low-grown estates have diversified into other crops, including timber, fuelwood, cinnamon, and more recently, coconut (Talawakelle Tea Estate PLC Integrated Annual Report, 2023). The total extent of tea cultivation across the country spans 267,186 hectares, with 60% of these lands under private sector management, and the remaining 40% managed by the state (Sri Lanka Tea Board [SLTB] Annual Report, 2023).

Watershed Area

A watershed, or drainage basin, refers to the surface area drained by watercourses, forming a vital landscape element where land and water resources interact (Uniyal & Gupta, 2013). It integrates ecological, geographical, geological, and cultural dimensions, serving as a framework for the study and management of natural resources (Fu, 2016). Watersheds operate as open systems, receiving energy from the sun and atmosphere and losing energy primarily through water and sediment discharge at the outlet (Strahler, 1964). Each basin is delineated by divides, functioning as distinct geomorphic systems concerned with water and sediment distribution (Wikramanayake & Wickramaratne, 2019).

The health of watersheds is crucial to environmental and economic sustainability. Physical, meteorological, and human factors influence their characteristics, with factors such as vegetation interception, surface storage, transpiration, and groundwater storage playing key roles (Rastogi et al., 1976). Elevation, slope, soil types, drainage density, and anthropogenic activities also contribute to watershed dynamics (Adhikari et al., 2020). Drainage patterns, especially dendritic patterns, form based on geological conditions, with tributaries branching unevenly across homogeneous rock formations (Garde, 2006).

Watershed studies are essential for managing water resources, offering insights into water quantity, quality, and availability. This knowledge is critical for sustainable water management, helping address issues like water scarcity, pollution, and drought (Naiman et al., 1992). The integrated management of watersheds can aid in flood mitigation, climate change adaptation, and resource conservation through a spatial approach (Fu, 2016). Remote sensing and GIS have become crucial tools in understanding watershed characteristics and prioritizing management interventions (Javed et al., 2011).

Tea Lands in Beli Ul Oya Sub-basin

The Beli Ul Oya Sub-basin, located in Sri Lanka's Central Province, is renowned for its ideal conditions for tea cultivation, including a cool climate, ample rainfall, and fertile soil. The landscape, characterized by slopes and valleys, facilitates effective drainage and the growth of high-quality Ceylon tea, which is noted for its distinct flavor and aroma (Karunaratne et al., 2015). Additionally, the sub-basin supports diverse flora and fauna, including endemic species, highlighting its ecological significance (Somasiri et al., 2022).

Watershed Prioritization for Watershed Management

Watershed management aims to optimize the use of watershed resources while maintaining ecological sustainability. It involves balancing ecological, economic, and social conditions through adaptive, integrated multi-resource planning (Wang et al., 2016). Historical watershed management evolved to emphasize soil, vegetation, and water resource conservation, with notable milestones in the 20th century, such as the establishment of soil conservation districts and the Tennessee Valley Authority (Crumby, 1965).

Watershed prioritization is a critical process in natural resource planning. It involves ranking sub-watersheds based on criteria such as land degradation, water scarcity, and biodiversity protection to allocate resources efficiently (Biswas et al., 1999). Techniques such as multi-criteria decision analysis and hydrological modeling have been applied to determine priority areas (Javed et al., 2011). Watershed prioritization also plays a crucial role in supporting tea cultivation by managing water resources, reducing soil erosion, and protecting water quality through sustainable practices (Das et al., 2024; Patel et al., 2013).

GIS and Remote Sensing in Watershed Management

The use of GIS and remote sensing in watershed management has transformed the monitoring and assessment of natural resources, offering powerful tools for decision-making. GIS enables the collection, storage, and analysis of spatial data, providing insights into the past and present states of watersheds (Weiss et al., 2020). Remote sensing, particularly in the agricultural sector, is essential for crop monitoring, classification, and yield assessment, contributing to sustainable watershed management (Shanmugapriya et al., 2019).

Morphometric Analysis for Watershed Management

Morphometric analysis involves the quantitative study of the earth's surface and landforms, providing critical information for watershed prioritization and management (Clarke, 1966). This analysis aids in predicting watershed behavior by examining linear and areal parameters, which can be ranked to determine areas requiring immediate conservation efforts (Esper, 2008). Morphometric analysis is particularly valuable in soil and water conservation within watershed management frameworks, facilitating erosion control and natural resource conservation (Gajbhiye et al., 2015; Meshram & Sharma, 2017).

Methodology

Study Area

Beli Ul Oya is a tributary of the Mahaweli River (Figure 1). The Beli Ul Oya originates from the Horton Plains in the Central Highlands which flows into the Mahaweli River. The river is approximately 20 kilometers (12.42 miles) long. The predominant soil types found in the study area are Red Yellow Podzolic soils (RYP) and Mountain Regosols. The Beli Ul Oya is an essential source of water for irrigation in the area, supporting both tea plantations and agriculture.

Materials

A contour layer of 20 m interval from the 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. 61 - Gampola and sheet no. 62 - Hanguranketha) covering the study area were used in advance. The main analysis was undertaken using ArcGIS 10.8 software, as an interface to derive the morphometric parameters from the DEM. All digital data were brought to a common platform *via* a Projected Coordinate System; Kandawala Sri Lanka Grid.

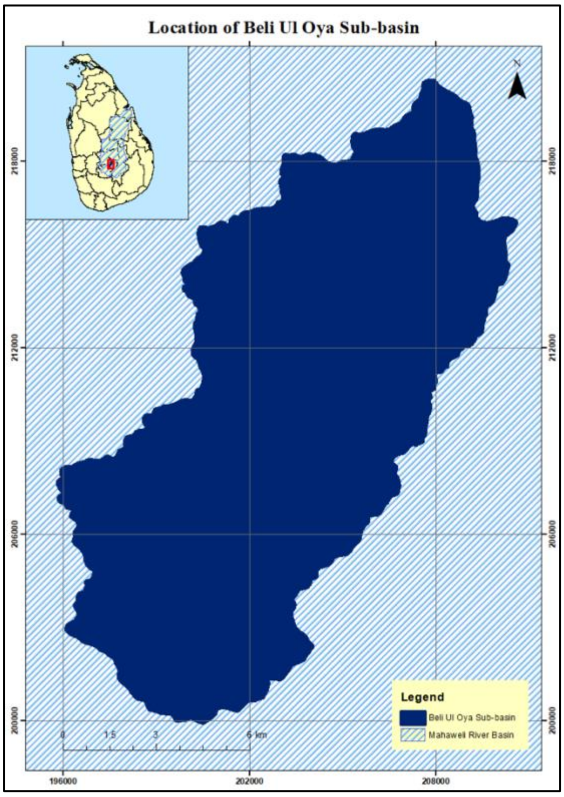

Figure 1: Location of Beli Ul Oya Sub-basin

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. The "Flow Direction" and "Flow accumulation" tools were used to generate the drainage network of the study area. The generated stream network was used to determine the stream orders of the drainage pattern. Using pour points, entire Beli Ul Oya sub-watershed was divided into 17 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 10.8 software tools. Table 1 indicates the linear and areal aspects considered in morphometric analysis together with the methods proposed in the scientific literature.

Watershed prioritization was carried out by assigning ranks to each morphometric parameter using the method given by Uniyal and Gupta (2013). Linear and relief factors, including drainage density, stream frequency, bifurcation ratio, drainage texture, and length of overland flow, basin relief, relief ratio and ruggedness number directly correlate with erodibility. Higher values indicate greater erodibility (Singh et al., 2021). 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. Areal characteristics, including elongation ratio, compactness coefficient, circularity ratio, basin shape, and form factor, have an inverse relationship with erodibility. Lower values indicate higher erodibility rates (Sreedevi et al., 2009). 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.

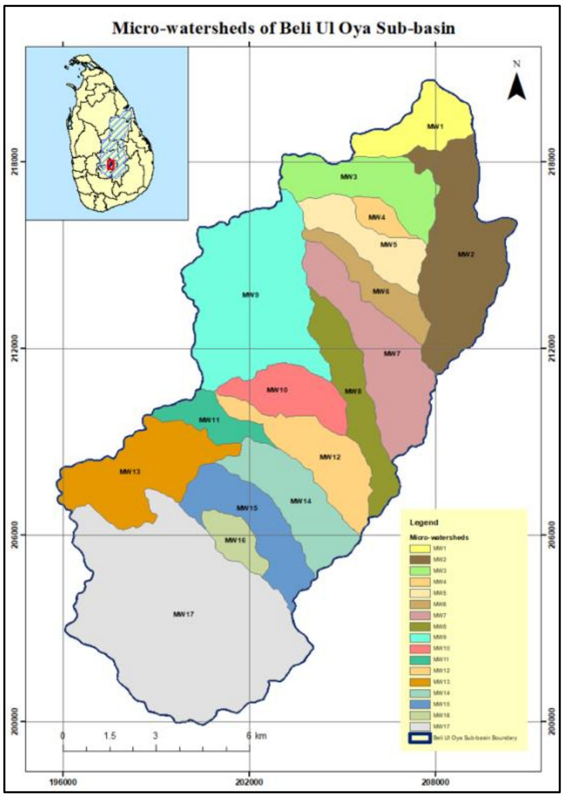

Figure 2: Microwatersheds of Beli Ul Oya Sub-basin

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 17 micro-watersheds were categorized as high, medium and low priority based on that explanation.

Table 1: Methodologies Adopoted for morphometric Analysis

	Morphological Parameters	**Methods**	**Reference**
		Linear Aspects	
01	Stream Order (U)	Hierarchical rank	(Strahler, 1964)
02	Number of Streams (Nu)	Gis analysis tools	(Horton, 1945)
03	Stream Length (Lu)	Gis analysis tools	(Horton, 1945)
04	Mean stream length (Lsm)	$Lsm = Lu/Nu$	(Strahler, 1964)
05	Stream Length ratio (RL)	$RL = Lu / (Lu – 1)$	(Horton, 1945)
06	Bifurcation ration (Rb)	$Rb = Nu / (Nu +1)$	(Schumm, 1956)
07	Drainage density (Dd)	$Dd = Lu /A$	(Horton, 1945)
08	Drainage texture (DT)	$DT = Nu/P$	(Horton, 1945)
09	Stream frequency (Fs)	$Fs = Nu/A$	(Horton, 1945)
10	Length of overland flow (Lg)	$Lg = 1/Dd \times 2$	(Horton, 1945)

	Morphological Parameters	**Methods**	**Reference**
		Areal Aspects	
01	Circulatory ratio (Rc)	$Rc = 4 \times \pi \times A/P^2$ $\pi = 22/7$ (3.141)	(Miller, 1953)
02	Elongation ratio (Re)	$Re = (4 \times A/\pi)$ $\pi = 22/7$ (3.141)	(Miller, 1953)
03	Form factor (Ff)	$Ff = A/Lb^2$ A	(Schumm, 1956)
04	Compactness constant (Cc)	$Cc = 0.2821$ P/A 0.5	(Horton, 1945)

	Morphological Parameters	**Methods**	**Reference**
		Relief Aspects	
01	Watershed relief (H)	vertical distance between the lowest and highest points of watershed	(Schumm, 1956)
02	Relief ratio (Rh)	$Rh = H/Lb$	(Schumm, 1956)
03	Ruggedness Number (Rn)	$Rn = H \times Dd$	(Schumm, 1956)

Results and Discussion

Linear Aspects

Stream Order, Number and Length

Number of streams and their order are the most important parameters of drainage basin analysis and there are 1188 total streams in the studied Beli Ul Oya sub-basin extending up to 6th 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 (76.93% out of total 1188) in all micro-watersheds while the last order has the lowest number (0.08%), confirming Horton's Laws (1932) on river networks. The highest number of stream segments can be found in MW17 micro-watershed (306), and the lowest number of stream segments in MW4 (13). Table 2 indicates the stream numbers and their respective lengths in different orders within 17 micro-watersheds of Beli Ul Oya sub-basin.

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 2.22 in MW4 to 5.17 in MW16 (Table 3). Higher mean Rb values are characteristics of structurally more disturbed watersheds with prominent distortion in drainage patterns (Nag and Chakraborty, 2003).

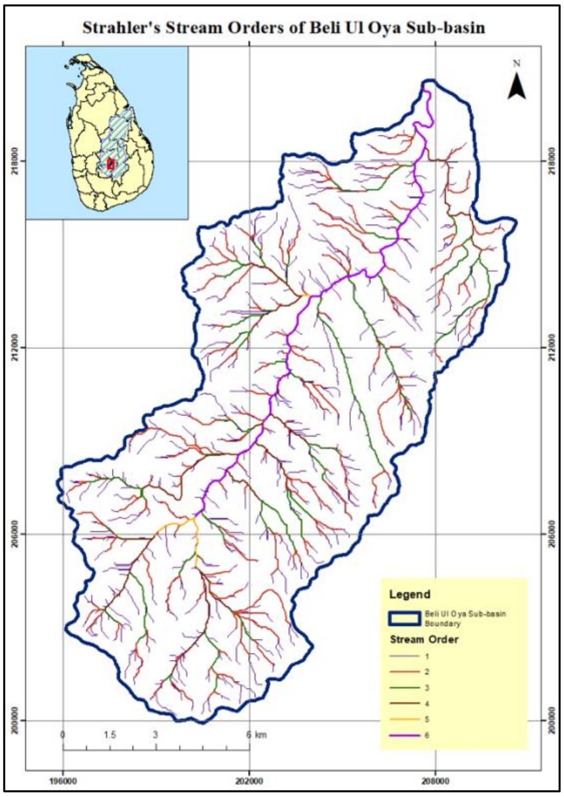

Figure 3: Stream Network of Beli Ul Oya Sub-basin

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 at a maximum in MW16 (11.02 km/km^2) and at a minimum in MW1 (3.45 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 MW16 (3.72 km/km^2) and minimum in MW1 (1.63 km/km^2). 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 and high value is 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), MW1and MW8 shows, very coarse drainage texture, MW3, MW4, MW5, MW6, MW10, MW11, MW15 and MW16 shows coarse drainage texture, MW2, MW7, MW12, MW13 and MW14 show modearte texture, MW9 shows fine drainage texture and other micro-watersheds show very fine drainage texture (Table 3).

Low Id indicates that surface runoff is not quickly removed and more water is infiltrated into the soil (Faniran, 1968). In this study, the Id value range is 1.97- 2.96.

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). Lo is higher in semi-arid regions with less vegetation cover, thus generating higher surface flow (Kale and Gupta, 2001). The Lo values of micro-watersheds vary from 0.13 for MW16 to 0.31 for MW1. Low Lo values provide 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 MW17 (0.47) and minimum for MW8 (0.11). 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 0.25-0.61. 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 0.38-0.78 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).

Relief Aspects

Ruggedness Number (Rn)

Ruggedness number is the product of drainage density and maximum relief in the basin and is used to measure the flash flood potential of streams (Patton & Baker, 1976). Ruggedness number in this study area found in the range of 1.12- 4.80.

Watershed Prioritization

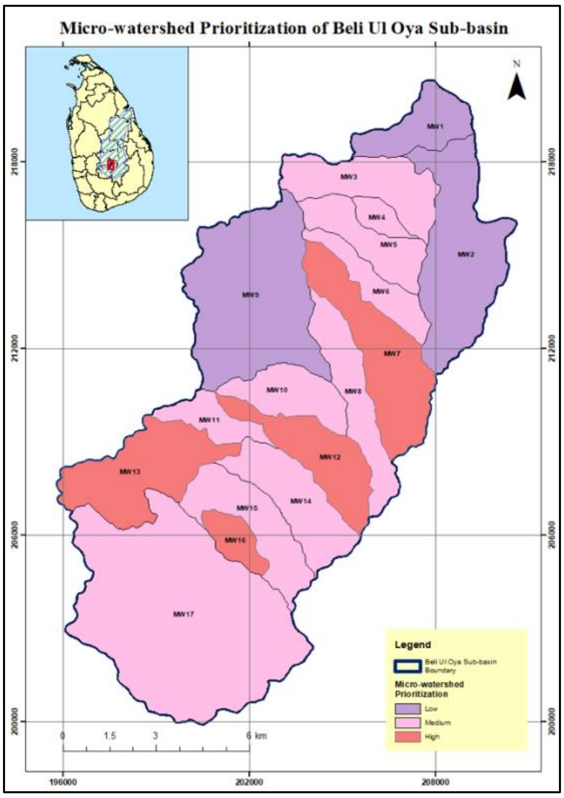

Figure 4: Micro-watershed Priritization Levels of Beli Ul Oya Sub-basin

The compound parameter (Cp) values and the prioritization rating of all 17 micro-watersheds of Beli Ul Oya sub-basin are shown in Table 4.

In this study, micro-watershed MW7, MW12, MW13, and MW16 resulted with 7.24, 6.85, 7.75 and 7.57 compound values respectively and therefore they are under high priority level. Figure 4 shows the final priority categories of 17 micro-watersheds of Beli Ul Oya sub-basin. 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.

Conclusion and Recommendation

The studied Beli Ul Oya sub-basin which is a main tributary of Mahaweli River Basin in Sri Lanka spreads up to 6th order stream network with a dendritic drainage pattern. Drainage density of the sub-watershed varies from 1.63 km/km^2 – 3.72 km/km^2, along with a coarse to very fine drainage texture. Mean bifurcation ratio varies from 2.22 to 5.17 and high values clearly indicating the structural control on the drainage pattern. Form factor values range from 0.11 to 0.47 indicating Beli Ul Oya Sub-basin is more elongated in shape and has a flatter peak flow generation. Circulatory ratio varies from 0.25 to 0.61 and high value clearly indicating the late maturity stage of topography. The prioritization results showed that micro-watersheds MW7, MW12, MW13 and MW16 can be identified as high priority and thus they are in the severe soil erosion susceptibility zone. Therefore, it can be suggested that, these four 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 Beli Ul Oya sub-basin at micro-watershed level.

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Table 2: Stream Order, Number and Stream Length of Micro-watersheds in Beli Ul Oya Sub-basin

Micro-watershed	1st order		2nd order		3rd order		4th order		5th order		6th order		Total Nu	Total Lu
	Nu	Lu	Nu	Lu	Nu	Lu	Nu	Lu	Nu	Lu	Nu	Lu		
MW1	12	1.91	3	2.79	1	0.30					1	3.05	17	8.04
MW2	69	15.97	16	10.23	4	7.34	1	5.33			1	0.64	91	39.54
MW3	42	16.46	10	4.49	1	3.26					1	2.33	54	26.55
MW4	8	2.92	3	0.96	1	0.34					1	0.47	13	4.71
MW5	26	6.66	6	6.31	2	1.16					1	1.65	35	15.79
MW6	28	8.44	5	2.74	1	0.84					1	1.20	35	13.24
MW7	72	17.56	14	7.44	2	5.42					1	1.17	89	31.61
MW8	26	6.87	3	2.23	1	6.34					1	0.30	31	15.76
MW9	116	31.16	33	15.11	9	7.62	2	4.34	1	0.33	1	2.49	162	61.09
MW10	33	9.40	7	4.34	1	0.81					1	2.08	42	16.64
MW11	20	5.07	5	2.70	2	1.37	1	0.42			1	0.65	29	10.25
MW12	53	15.85	12	5.33	2	2.60	1	1.62			1	0.33	69	25.75
MW13	64	17.22	16	10.19	6	3.29	1	4.32					87	35.04
MW14	50	10.81	10	6.70	2	3.08	1	2.07			1	1.39	64	24.07
MW15	40	8.93	8	3.70	3	3.22	1	1.64			1	2.12	53	19.64
MW16	22	5.21	3	2.18	1	1.37							26	8.78
MW17	233	55.67	52	28.87	14	9.74	4	9.76	2	3.50	1	0.0002	306	107.56

Table 3: Estimated Linear Aspects of Morphometric Parameters of Micro-watersheds of Beli Ul Oya Sub-basin

Micro-watershed	Drainage Density (Dd)	Stream Frequency (Fs)	Length of Overland Flow (Lo)	Drainage Texture (Dt)	Bifurcation Ratio (Rb)	Mean Stream Length (Lum)	Infiltarion Number (If)	Drainage Intensity (Id)
MW1	1.63	3.45	0.31	1.50	2.67	0.47	5.62	2.11
MW2	2.80	6.44	0.18	4.09	3.33	0.43	18.01	2.30
MW3	3.56	7.24	0.14	3.58	5.07	0.49	25.76	2.03
MW4	3.12	8.62	0.16	2.21	2.22	0.36	26.90	2.76
MW5	3.06	6.78	0.16	2.78	3.11	0.45	20.76	2.22
MW6	3.40	8.98	0.15	2.78	3.87	0.38	30.52	2.64
MW7	2.91	8.20	0.17	4.76	4.71	0.36	23.90	2.82
MW8	2.35	4.63	0.21	1.70	4.22	0.51	10.90	1.97
MW9	3.12	8.27	0.16	7.36	2.94	0.38	25.76	2.65
MW10	3.21	8.09	0.16	3.70	4.24	0.40	25.94	2.52
MW11	3.43	9.72	0.15	2.76	2.38	0.35	33.36	2.83
MW12	3.55	9.51	0.14	4.28	3.35	0.37	33.75	2.68
MW13	3.36	8.34	0.15	4.69	4.22	0.40	28.02	2.48
MW14	3.20	8.52	0.16	4.39	3.25	0.38	27.30	2.66
MW15	2.78	7.51	0.18	3.22	2.92	0.37	20.88	2.70
MW16	3.72	11.02	0.13	3.72	5.17	0.34	41.02	2.96
MW17	3.02	8.60	0.17	10.58	3.14	0.35	26.03	2.84

Table 4: Estimated Areal Aspects of Morphometric Parameters of Micro-watersheds of Beli Ul Oya Sub-basin

Micro-watershed	Circulatory Ratio (Rc)	Elongation Ratio (Re)	Form Factor (Ff)	Compactness Coefficient (Cc)
MW1	0.48	0.61	0.30	1.44
MW2	0.36	0.58	0.26	1.67
MW3	0.41	0.61	0.29	1.56
MW4	0.55	0.54	0.23	1.35
MW5	0.41	0.51	0.21	1.56
MW6	0.31	0.42	0.14	1.80
MW7	0.39	0.49	0.19	1.60
MW8	0.25	0.38	0.11	1.98
MW9	0.51	0.72	0.40	1.40
MW10	0.51	0.59	0.28	1.41
MW11	0.34	0.52	0.21	1.71
MW12	0.35	0.47	0.17	1.69
MW13	0.38	0.60	0.28	1.62
MW14	0.44	0.63	0.31	1.50
MW15	0.33	0.57	0.26	1.74
MW16	0.61	0.61	0.29	1.28
MW17	0.53	0.78	0.47	1.37

Table 5: Estimated Relief Aspects of Morphometric Parameters of Micro-watersheds of Beli Ul Oya Sub-basin

Micro-watershed	Relief Ratio (Rh)	Ruggedness Number (Rn)
MW1	0.17	1.12
MW2	0.16	3.28
MW3	0.25	4.56
MW4	0.25	2.04
MW5	0.19	2.97
MW6	0.18	3.15
MW7	0.17	3.71
MW8	0.17	3.05
MW9	0.16	3.48
MW10	0.23	3.24
MW11	0.27	3.48
MW12	0.17	4.02
MW13	0.21	4.36
MW14	0.22	3.56
MW15	0.22	3.17
MW16	0.31	3.23
MW17	0.18	4.80

Table 6: Prioritization Results of Morphometric Analysis

Micro-watershed	Rb	Lg	Dd	Dt	Fs	Ff	Re	Rc	Cc	Rh	Rn	Compound Rank	Priority	Priority Class
Weightage			**45%**				**35%**			**20%**				
MW1	15	1	17	17	17	14	14	12	6	13	17	13.06	17	Low
MW2	9	4	14	7	15	9	9	6	12	17	9	10.16	15	Low
MW3	2	16	2	10	13	12	12	10	8	4	2	8.15	7	Medium
MW4	17	9	9	15	5	7	7	16	2	3	16	9.65	12	Medium
MW5	12	7	11	12	14	5	5	9	9	9	15	9.89	14	Medium
MW6	7	13	5	13	4	2	2	2	16	11	13	8.11	6	Medium
MW7	3	5	13	3	10	4	4	8	10	14	5	7.24	2	High
MW8	5	2	16	16	16	1	1	1	17	15	14	9.60	11	Medium
MW9	13	8	10	2	9	16	16	14	4	16	8	10.56	16	Low
MW10	4	11	7	9	11	10	10	13	5	5	10	8.61	8	Medium
MW11	16	14	4	14	2	6	6	4	14	2	7	8.03	5	Medium
MW12	8	15	3	6	3	3	3	5	13	12	4	6.85	1	High
MW13	5	12	6	4	8	11	11	7	11	8	3	7.75	4	High
MW14	10	10	8	5	7	15	15	11	7	6	6	9.00	10	Medium
MW15	14	3	15	11	12	8	8	3	15	7	12	9.83	13	Medium
MW16	1	17	1	8	1	13	13	17	1	1	11	7.57	3	High
MW 17	11	6	12	1	6	17	17	15	3	10	1	8.89	9	Medium