Prioritization of Milli Watershed of *Kodar* River Catchment Based on Integrated Approach of Morphometric and LULC Analysis

Abstract

Watershed prioritisation is now important for effective natural resource planning and management in sustainable development, however, their implementation necessitates a careful examination of the morphometric and hydrological characteristics existing in the watershed. In the present study an attempts has been made to prioritize the *Kantori nala* mili watersheds of the *Kodar* river catchment using integrated approach of morphometric features and land use/landcover. Study area watershed was automatically delineated and divided into eleven micro watersheds MWS 1 to MWS 11 on the basis of topography from the Depression less DEM) prepared by Inverse Distance Weighted (IDW) interpolation technique. Morphometric analysis was done using DEM and each parameter has been assigned their ranks according to their value. Thereafter, an average value of the rank score for each of the micro watershed is calculated. The micro watershed with the lowest compound factor (C_p) was given the highest prioritized rank out of the group of micro watersheds, and vice versa. LULC analysis was also done using sentinel 2 satellite data. The result from the priority ranking of morphometric analysis shows that MWS 7 is having high priority ranking while MWS 8 is having low priority ranking, while the results of the LULC analysis-based prioritizing showed that the micro watersheds MWS 10 and MWS 5 micro watersheds are of are of highest and lowest priority respectively. It is observed that upon integration of morphometric and land use/ land cover compound factor values information, MWS 3 and MWS 10 found to receive common priority falls under the highest priority, though MWS 6 and MWS 8 falls under the lowest priority ranking. The results of the study can be employed for identifying the sub-watersheds that require immediate restoration and ultimately help in managing watershed resources for sustainable development.

Key words: Watershed prioritisation, morphometric analysis, LULC analysis, micro watershed

1. INTRODUCTION

Natural resources like water and land are depleting because of population growth, urbanisation, and other factors hence efficient resource management and utilization is essential for sustainable growth. Natural resource management have given greater importance for expansion of water and land resources as well as the prevention of land degradation in order to maintain environmental and ecological balance (Chakraborti, 2003; Nookaratnam *et al.*, 2005; Kudnar and Rajasekhar, 2020). Watershed is the hydrological, bio-physical and socioeconomic units where, people interact with land resources in a watershed; due to their socioeconomic activities. This indicates that a watershed is made up of both natural and social systems, creating distinctive and interdependent landscape hierarchies (Abdeta *et al.,* 2020). Watershed is considered as an ideal unit for proper management and effective planning of land and water resources (Abdeta *et al.,* 2020, Moore *et al.,* 1994), however successful management plan requires accurate evaluations of the hydrological behaviour of a watershed (Sharma *et al.*, 2014a and 2014b) and an understanding of the interrelationships between soil, slope, uplands, lowlands, land use, and geomorphology (Sebastian *et al.*, 1995). Watersheds have long been considered as the hydrological units for managing land and water resources, but different soil types, changing land use patterns, and different topographic features have made the need for micro level hydrological units for their better management, planning, and best utilization. Also due to its complexity and variable properties it is not feasible for the management of a watershed as a whole; hence watershed prioritization is necessary for the effective management of watersheds.

Watershed prioritization is a process that involves identifying and ranking environmentally damaged sub-watersheds in order to minimise soil erosion, control floods and drought, and apply various levels of conservation treatment (Shelar *et al.,* 2022, Moharir *et al.*, 2021). The most effective and logical method for prioritising watersheds is considered to be morphometric analysis using remote sensing and GIS tools (Nautiyal, 1994, Imran *et al.,* 2011). It is the most viability method and relatively simple approach to describe quantitative watershed characteristics (Mesa, 2006; Deepak, 2015; Umer *et al*,. 2015). The morphometric analysis is extremely helpful in situations with great soil variety, restricted data accessibility, and other resources (Meshram *et al.,* 2020; Sangma and Guru, 2020; Rahmati *et al.,* 2019). The measurement, dimensioning, and mathematical analysis of the earth's surface and landforms is known as morphometric analysis (Clarke, 1996; Agarwal, 1998; Reddy *et al.,* 2002). It calculates quantitative landscape characteristics including a watershed's linear, areal, and relief aspects that impart information about the watershed's properties and its hydrological process.

Since the drainage system and spatial relationships between streams are the only factors that influence watershed morphometric analysis, it has also been characterized by using other data, such as soil and land use maps (Kiran and Srivastava, 2012). Geomorphology, land use/land cover (LULC), and hydrology information are extremely helpful in understanding the watershed's drainage system (Bhattacharya *et al.*, 2020). Furthermore, land use and land cover have been regarded as important elements for prioritization since they have an impact on soil erosion and other aspects that affect the hydrological process (Pande *et al.*, 2021, Pande *et al.*, 2023, Javed *et al.*, 2011). In water-induced soil erosion, morphometric parameters have crucial role in understanding the geo-environmental characteristics of the terrain. Moreover, rainfall effects depend on the pattern of LULC change and each land cover responds differently to the raindrop energy it receives. Therefore, it requires integration of the geomorphological and hydrological characteristics of the sub-watersheds derived from their morphometric parameters with the LULC to generate compounded ranking-based prioritization of the sub-watersheds (Bagwan and Gawli, 2021). Several research have been carried out to establish the priority level of a watershed utilising GIS technology and tools, using morphometric parameters and land use and land cover datasets (Setiawan *et al.*, 2021, Javed *et al.*, 2011, Pathare and Pathare, 2021, Verma *et al.*, 2022, Thakur *et al.*, 2012). The goal of this study is to prioritise the mili watersheds of the *Kodar* river catchment using integrated approach of morphometric features and land use/landcover.

2. STUDY AREA

The study area is the part of Mahasamund district of Chhattisgarh state. The selected mili watershed falls within the middle Mahanadi basin and known as *Kantori nala* watershed. It belongs to *Kodar* river catchment of *Kodar* dam. It receives mean annual rainfall of about 1433 mm. The topography of the catchment almost flat and agriculture is predominant. The *Kantori nala* joins to *Kodar* river at *Achhridih* village in Mahasamund block of the district. Since references are not available regarding the name of the selected milli watershed therefore, on the basis of main channel i.e. *Kantori nala*, it is called as *Kantori nala* watershed. *Kantori nala* watershed lies between the 21°6'7.2"N to 21º12'39.6" N latitudes and 82º2'38.4" E to 82º6'14.4" E longitudes. The total catchment area of the Kantori nala watershed is reported to be 45.10 km2. It comprises of *Kharora, Belsonda, Bemcha, Paraswani, Kampa, Khatidih, Birkoni, Achhridih*, part of *Muski, Tumadabri* villages and Mahasamund town. The map of the study area is shown in Fig. 1. The size of *Kantori nala* watershed is less than 100 km^2, therefore it is called as *Kantori nala* mili watershed.

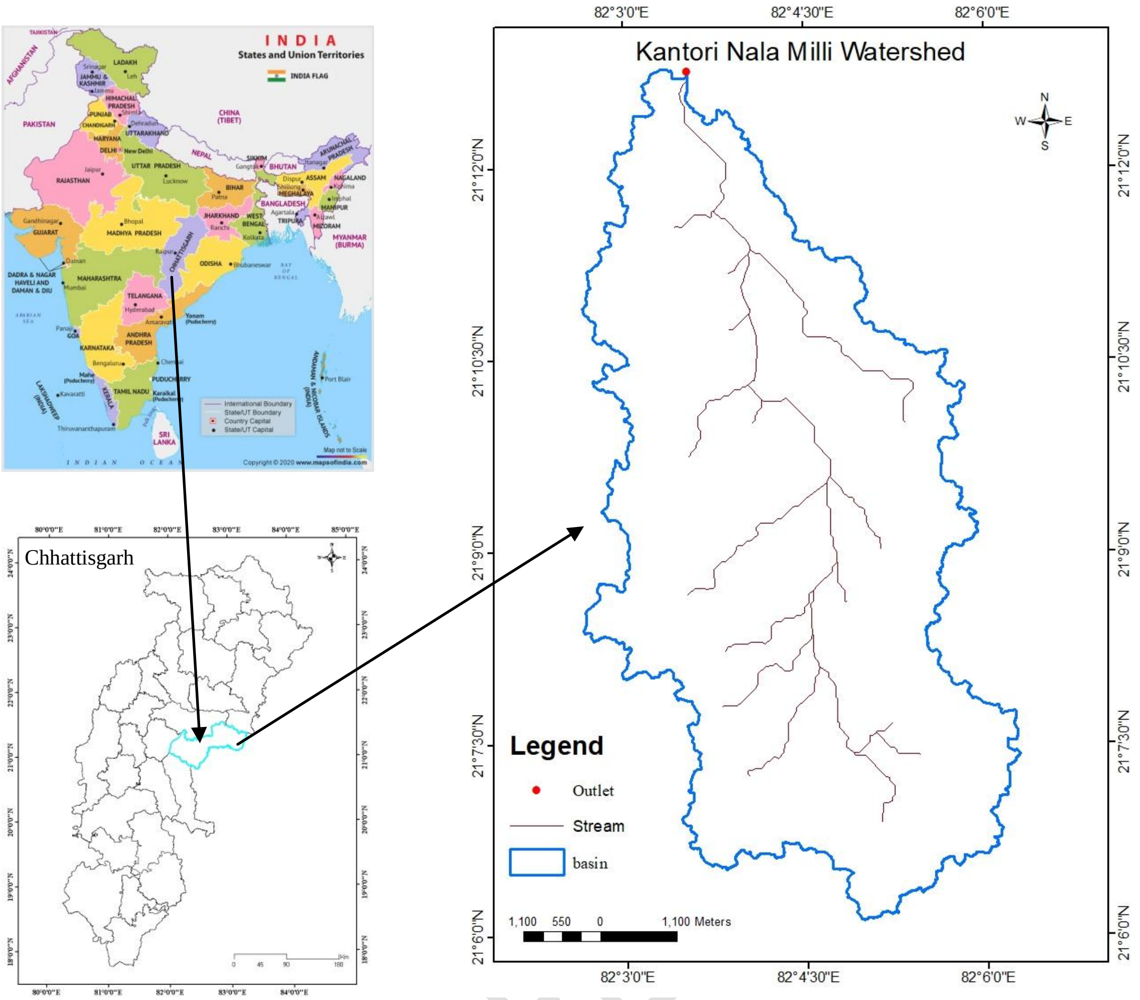

Fig. 1: Location map of *Kantori nala* milli watershed

3. MATERIAL AND METHODS

3.1 Generation of Depression less Digital Elevation Model (DEM)

GPS survey was done in the study area in gridded pattern and the values for XYZ dimensions (latitude, longitude and altitude respectively) are recorded in the field. These recorded gridded data were tabulated in excel and imported to the ArcGIS. The grids were interpolated using the inverse distance weighted (IDW) technique available in ArcGIS. The output after running the programme was the Digital Elevation Model (DEM) with 10 m resolution. DEM contains depressions that hinder flow routing which are considered as DEM errors. Therefore, these depressions in DEM were filled to route the flow and resultant DEM is depression less DEM of study area. This DEM was used for automatic delineation of drainage network and mili watershed and micro watershed in the study area.

3.2 Morphometric Analysis

Morphometric analysis was used to evaluate the watershed's morphometric properties, such as its linear and form parameters as well as its relief characteristics, in order to priorities study area mili watershed. The DEM is opened in ArcGIS 10.4 software for morphometric analysis as raster format image. The Arc-Map 10.4 software has Spatial Analyst Tools with a sub-module for hydrology. This hydrology module is utilized for getting different layers of information such as fill, flow accumulation, flow direction, flow length, stream link, drainage network, stream order, and boundaries of mili watershed and micro watershed according to drainage network. Morphometric analysis sub-divided into three parameters i.e., linear, relief and aerial parameters. However, stream order, stream length, stream length ratio and bifurcation ratio are taken as under linear parameters, basin relief and relief ratio considered as relief parameter, and drainage density, stream frequency, form factor, circulatory ratio, elongation ratio, length of overland flow are considered under as aerial parameters, which has responsible for characterization of the watershed.

The soil loss in the watershed is either proportional or inversely proportional to these factors. For example, soil loss is proportional to bifurcation ratio, drainage density, stream frequency, texture ratio, relief ratio, and length of overland flow. It is inversely proportional to circulatory ratio, form factor, elongation ratio, and compactness coefficient. Micro watersheds are given score for each of the parameters accordingly. The micro watersheds which are more vulnerable to soil loss will have higher value of the directly proportional parameter and the rank will be lower (say 1) and the vice-versa. Thereafter, an average value of the rank score for each of the micro watershed is calculated. On the basis of this, the micro watershed with lower rank is identified as the most vulnerable to soil loss. Therefore, the micro watershed with lower rank score should be given top priority for soil conservation measures. Steps of the morphometric analysis are shown graphically in the form of flow chart in Fig 2.

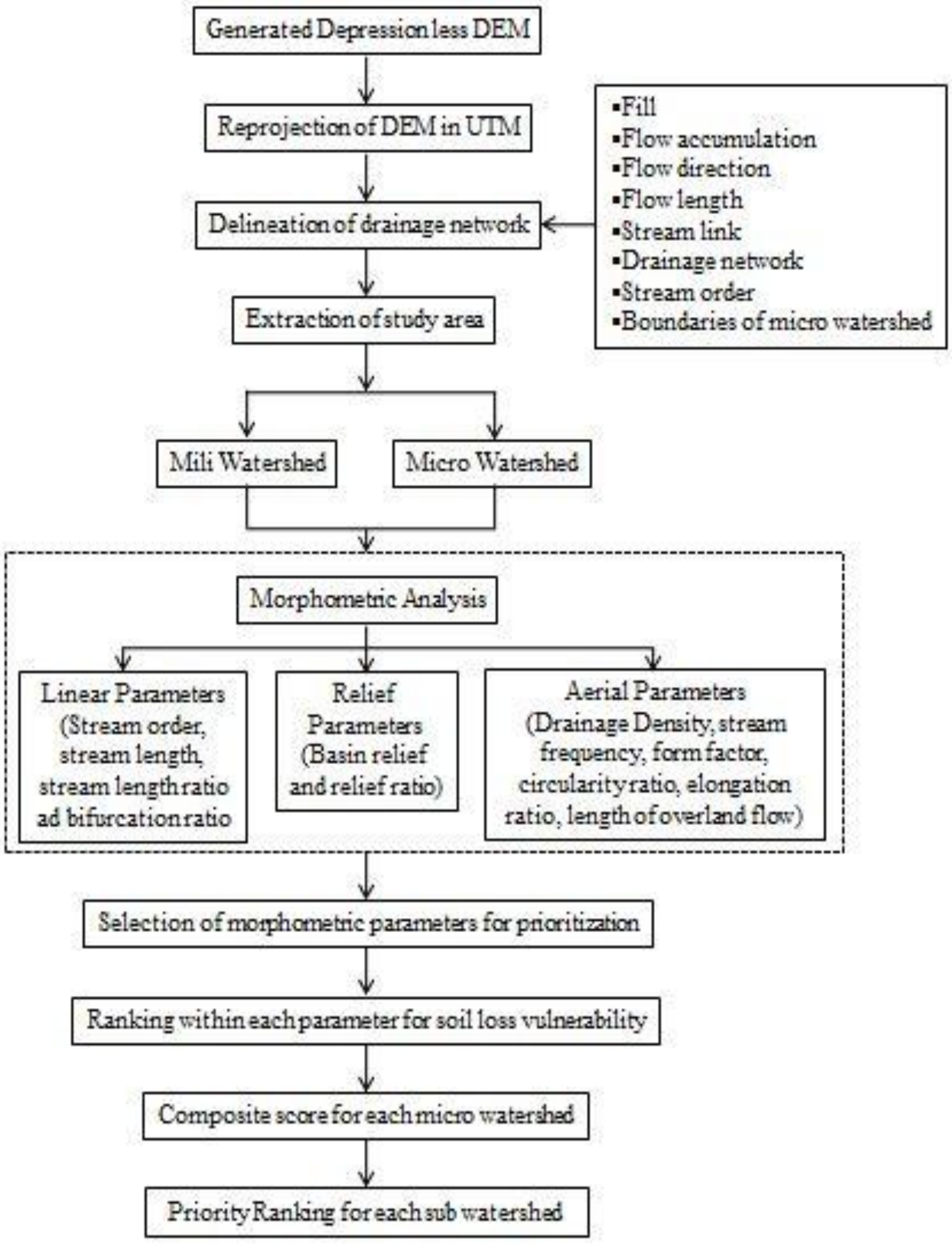

Fig. 2: Flowchart of methodology used in morphometric analysis

3.3 Land use Land Cover Analysis

The cloud free SENTINEL-2 imageries of the years 2019 were downloaded from USGS Earth Explorer of National Aeronautics and Space Administration (NASA). Bruzzone, *et al.*, 2017 cited land cover/use monitoring as one of the essential applications for Sentinel-2 data. Sentinel-2 data show promise and have the potential to contribute significantly towards land cover/use monitoring (Phiri *et al.*, 2020). The land use land cover map of the study area was prepared using ArcGIS software. In this study, the "supervised" approach, the most popular land use classification method, was employed. Supervised classification describes information about the data of land use as well as land cover for any region viz. soil, vegetation, water bodies, settlement, forest etc. This classification consists of three stages: training stage, classification stage and output stage. Accuracy assessment is required to get an accurate classification. In training stage, the identified representative training sites/areas (i.e., a particular land cover type), then system determines the spectral signatures of the pixels within each training areas and uses this information to define the mean and variance of each of the classes. In classification stage, each pixel in the image data set is categorized into the land cover class it most closely resembles. If the pixel is insufficiently similar to any training data set, it is usually labeled ‘unknown’. After all pixels in the input image have been categorized, the results are presented in the output stage. Output products are in the form of thematic maps, tables of statistics for the various land cover classes and digital data files amenable to inclusion in a GIS.

Before using the downloaded images, it is important to combine all bands into a single image and add the radiometric geometric corrections for accuracy. As a result, images are re-projected to a WGS-84 (Zone-44) Datum and the Universal Transverse Mercator (UTM) Co-ordinate system. The study watershed is extracted based on the boundary of *Kantori nala* mili watershed. Define the land-use/cover classes and made the signature file by selecting the supervised training samples from the supervised classification (sig). A class can be verified using Google Earth, sources (such as topographic maps, thematic maps, statistical data, and so on), visual interpretations, and field surveys. The final product i.e. LULC is determined by the nature of the signature file and the correctness of the user. The characteristics of the signature file and the accuracy of the user define the final result (LULC). A Maximum Likelihood Classifier (MLC) module was used for classifying the land uses. After the supervised classification, the confusion matrix and accuracy assessment must be completed. The prepared land-use map is satisfactory if the land-use land cover accuracy is satisfactory. The step involved in the process of land use land cover mapping is visually illustrated as a flow chart in Fig. 3.

Six LULC categories were identified and delineated using visual image interpretation methods and include agriculture, water, shrubs, barren land, forest and settlement. Land use land cover map of the year 2019 are shown in Fig. 4. LULC analysis in terms of area and percentage under each LULC category was done sub-watershed wise using ArcGIS.

For prioritization based on LULC analysis, categories such as agriculture, forest, barren land, shrub, settlement were considered. Based on average priority ranking value, the sub-watersheds were given priority ranks. During the prioritization analysis, the lower compound value is considered with higher priority for appropriate soil conservation measures.

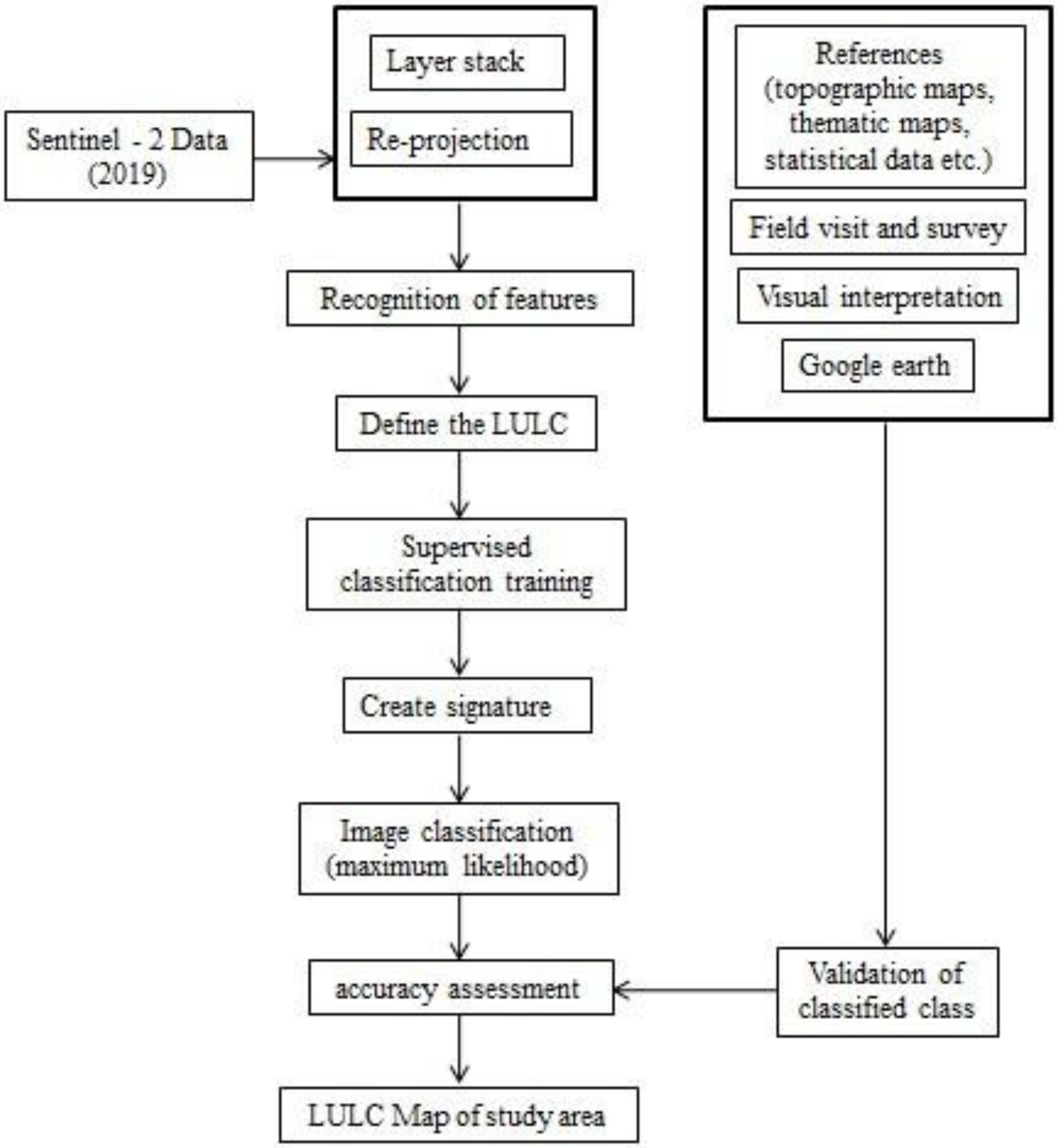

Fig. 3: Flowchart showing the methodology adopted for land use / cover classification

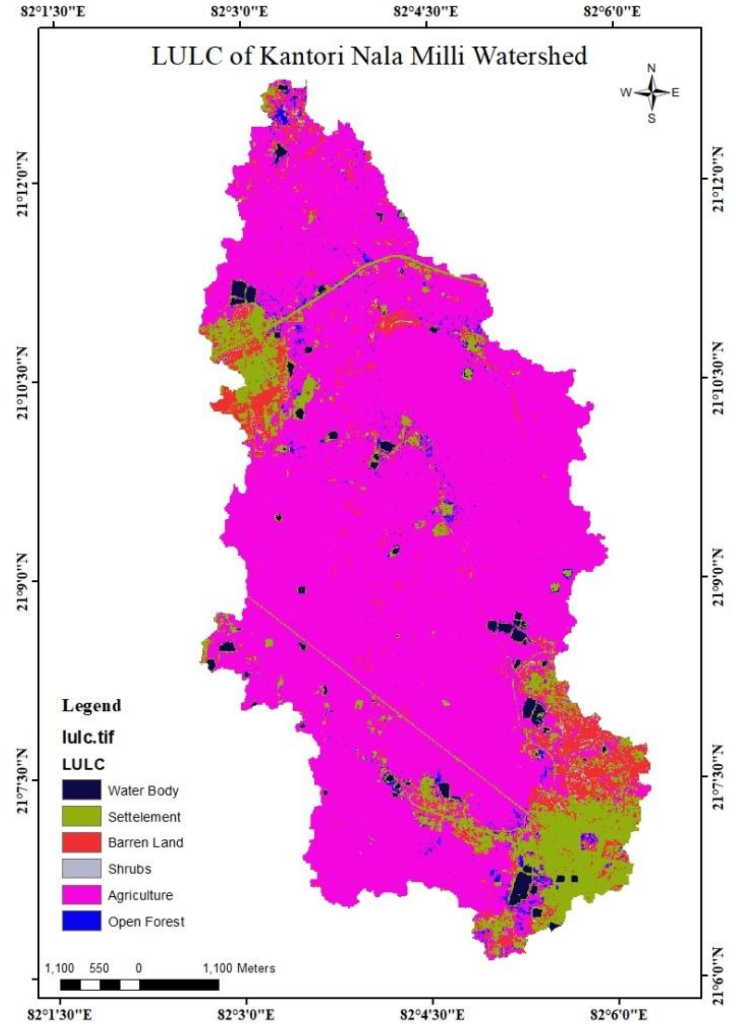

Fig. 4: LULC map of the study mili watershed

3.4 Integrated approach: Morphometric and LULC analysis

The compound value for priority ranking of both the morphometric and LULC analysis were then combined to get the final priority by integrated approach. Lowest compound value is ranked one and so on.

4. RESULTS AND DISCUSSIONS

Prioritization of the *Kantori Nala* Mili Watershed employs the fundamental components of morphometric and LULC analysis. Based on their association with erodibility, morphometric characteristics including linear and shape parameters were calculated and ranked in order of priority. Categories such as agriculture, forest, barren land, urban, and rice field were taken into consideration for prioritization based on LULC analysis.

4.1 Morphometric Analysis

The quantitative morphometric measurements give information on the catchment's hydrological features. The influence of climate on geomorphic processes among distinct landforms is revealed by the morphometry of a drainage basin. The watershed was divided into eleven micro watersheds. Morphometric analysis was utilized for prioritization of the *Kantori Nala* Mili Watershed by evaluating the basin's linear aspect, aerial aspect and relief aspect of each micro watershed. The watershed was divided into eleven micro watersheds and the information about basic morphometric parameters such as area (A), perimeter (P), length (L), and number of streams (N) was obtained from sub watershed delineated layer, and basin length (L_b) was calculated from stream length, while the bifurcation ratio (R_b) was calculated from the number of streams. Other morphometric parameters were calculated using the standard equations as earlier and the results are presented in Table 1.

Basic parameters of *Kantori nala* mili watershed

I. Area of watershed (A)

It is one of the important parameters which can directly reflect the overall volume of water. The total geographical area of *Kantori nala* mili watershed is 45.1 km^2 and he largest and smallest micro watershed areas are 7.07 km^2 (MWS 7) and 2.17 km^2 (MWS 9), respectively.

II. The perimeter of a watershed (P)

The watershed perimeter is the outside limit that encloses the watershed's area (Khan *et al.*, 2021) and is designated by P. Out of the eleven micro watersheds, the largest and smallest micro watershed perimeters are 26.40 km (MWS 7) and 11.00 km (MWS 10), respectively.

III. Watershed length (L_b)

The watershed length, sometimes referred to as hydrologic length, is conceptually the distance travelled by the surface drainage. The watershed length is measured along the principal flow path from the watershed outlet to the basin boundary. The longest watershed length is of MWS 7 and smallest watershed length is of MWS 9.

Table 1: micro watershed wise morphometric parameters of *Kantori nala* mili watershed

Micro watershed Name	Bifurcation ration	Drainage density	Stream frequency	Circulatory ratio	Form factor	Elongation ratio	Texture ratio	Compactness coefficient	Relief ratio	Length of overland flow
MWS-1	0.50	0.76	0.53	0.207	0.458	0.764	0.161	2.20	5.54	0.66
MWS-2	-	0.74	0.18	0.152	0.459	0.765	0.046	2.57	3.50	0.68
MWS-3	0.67	1.00	1.43	0.206	0.490	0.790	0.342	2.20	7.24	0.50
MWS-4	-	0.57	0.33	0.245	0.499	0.797	0.080	2.02	5.38	0.88
MWS-5	0.67	0.80	0.93	0.188	0.462	0.767	0.264	2.31	5.55	0.62
MWS-6	-	0.79	0.28	0.213	0.488	0.788	0.069	2.17	3.68	0.63
MWS-7	0.75	1.01	0.99	0.127	0.445	0.753	0.265	2.80	4.42	0.49
MWS-8	-	0.84	0.37	0.147	0.508	0.804	0.066	2.61	4.35	0.60
MWS-9	-	0.69	0.46	0.209	0.523	0.816	0.088	2.19	8.47	0.72
MWS-10	1.50	0.64	1.07	0.292	0.505	0.802	0.273	1.85	7.29	0.78
MWS-11	-	0.49	0.29	0.247	0.491	0.791	0.075	2.01	5.58	1.03

IV. Stream order (U)

According to Strahler, 1964, the order of stream is termed as the calculation of the position of a stream in the hierarchy of streams. First stream order refers to the smallest finger type and any unbranched tributaries. Two first stream orders are combined to generate a second stream order. Following that, the second stream order combines the third, and so on. The *Kantori nala* mili watershed consists of eleven micro watersheds, in that 2th order for MWS 1, MWS 3, MWS 5, MWS 7, MWS 9, MWS 10 and 1st order for remaining micro watershed. Watershed is dominated by Overland flow.

V. Stream number (Nu)

The number of streams in a specific catchment is equal to the number of streams in each order (Horton, 1945) and is denoted by the symbol N_u. MWS 7 have highest (7) and MWS 2, MWS 4, MWS 6, MWS 8, MWS 9 MWS 11 have lowest (1), stream numbers.

Linear Aspects

I. Bifurcation ratio (R_b)

Bifurcation ratio describes the branching pattern of a drainage network and is defined as ratio between the total numbers of stream segments of a given order to that of the next higher order in a basin (Schumm, 1956). The range of bifurcation ratio is between 0.5 to 1.5, which indicates that there is minimum structure disturbance in this mili watershed.

II. Stream frequency (F_s)

Stream frequency is defined as the number of stream segments of all orders per unit catchment area, according to Schumm, 1956. In the current study, the higher stream frequency is at MWS 3 and the lower stream frequency is at MWS 2.

III. Drainage density (D_d)

It is an expression to indicate the closeness of spacing of channels. A fine drainage texture results from high drainage density, whereas a coarse drainage texture results from low drainage density. In this study, drainage density is higher at MWS 7 and lower at MWS 11.

IV. Length of the overland flow (L_o)

Horton (1945) defined length of overland flow as the amount of time that water remains above the earth before it concentrates into distinct stream channels. It is one of the most important independent variables, affecting both the hydrological and physiographical developments of the drainage basin (Horton, 1945). The length of the overland flow's maximum value corresponds to greater surface runoff, and its lowest value corresponds to shorter surface runoff. The length of the overland flow is higher at MWS 11 and lower at MWS 7.

V. Texture ratio (T)

The relative spacing of drainage lines is indicated by the texture ratio or drainage texture. Drainage texture is influenced by the temperature, rainfall, rock types, relief, and development stage. In this study, MWS 3 has a greater texture ratio than MWS 2.

Areal aspect

I. Circularity ratio (R_c)

The circularity ratio is influenced by geological structures, climate, relief, land cover and stream length and slope of the basin. Its ratio indicates the shape of the catchment. In the given area circulatory ratio varies from 0 to 1. In the current study, MWS 10 has a higher circulatory ratio and MWS 7 has a lower circulatory ratio.

II. Elongation ratio (R_e)

An active denudational process with high infiltration capacity and low runoff is indicated by a basin's higher elongation ratio, and higher elevation and higher headward erosion along tectonic lineaments are indicated by a basin's lower elongation ratio (Reddy *et al.*, 2004; Yadav *et al.*, 2014). The values of the elongation ratio generally vary from 0.6 to 1.0 over a large variety of climatic and geologic types (Rudraiah, *et al.*, 2008). MWS 9 has a higher elongation ratio and MWS 7 has a lower elongation ratio in the study area watershed.

III. Form factor (F_f)

The form factor describes the flow rate of a basin for a specific area. The form factor value ranges zero to one. The basin will have a more elongated shape with the lower form factor value. MWS 9 has a greater form factor in this study, while MWS 7 has a lower form factor.

IV. Compactness coefficient (C_c)

It derives the relationship between the actual hydrologic basins and the exact circular basin with the same area as the hydrologic basin. MWS 10 has a lower compactness coefficient in this study than MWS 7, which has a greater compactness coefficient

Relief aspects

I. Watershed relief

Watershed relief is described as the elevation variation between the maximum value and outlet value on the perimeter of the catchment (Strahler, 1952). It is one of the morphometric variables that aids in understanding the basin's denudational characteristics. It also regulates the stream gradient and has an impact on surface runoff and sediment. In the study area watershed, MWS 10 has the maximum relief (20 m), and MWS 6 and 10 has the minimum relief (10 m).

II. Relief ratio (R_r)

It is actually influenced by rocks and slope of the basin. If the values of relief ratio are high it indicates hilly region and low ratio indicates pediplain and valley region (Kumar et al., 2011). In this study, MWS 9 has the larger relief ratio and MWS 2 has the lower relief ratio value.

According to Nookaratnam *et al.* (2005), linear parameters and erodibility are directly correlated; the greater the value, the more erodible the parameter. The highest value of the linear parameters was assigned as rank 1, the second highest value as rank 2, and so on, with the lowest value being rated last in rank for sub watershed priority. However, the shape parameters have an inverse relationship with the linear parameters, meaning that the more erodibility there is, the lower their value (Patel *et al.*, 2012; Patel and Dholakia, 2010). The lowest value of the shape parameters was therefore ranked as rank 1, the next lowest value as rank 2, and so on, with the highest value being ranked last in rank as shown in Table 2. Then, the compound factor was calculated by adding up all the ranks of the linear parameters and the shape parameters, and dividing by the total number of parameters. The micro watershed with the lowest compound factor (C_p) was given the

Table 2: Prioritized rank of sub-watersheds using the morphometric parameter

Micro watershed Name	Bifurcation ration	Drainage density	Stream frequency	Circulatory ratio	Form factor	Elongation ratio	Texture ratio	Compactness coefficient	Relief ratio	Length of overland flow	Composite score	Final priority
MWS-1	5	6	5	6	2	2	5	6	6	6	4.9	5
MWS-2	1	7	11	3	3	3	11	8	11	5	6.3	8
MWS-3	4	2	1	5	6	6	1	6	3	10	4.4	2
MWS-4	1	10	8	9	8	8	7	3	7	2	6.3	6
MWS-5	4	4	4	4	4	4	4	7	5	8	4.8	4
MWS-6	1	5	10	8	5	5	10	4	10	7	6.5	6
MWS-7	3	1	3	1	1	1	3	10	8	11	4.2	1
MWS-8	1	3	7	2	10	10	9	9	9	9	6.9	10
MWS-9	1	8	6	7	11	11	6	5	1	4	6.0	9
MWS-10	2	9	2	11	9	9	2	1	2	3	5.0	3
MWS-11	1	11	9	10	7	7	8	2	4	1	6.0	7

highest prioritized rank out of the group of micro watersheds, and vice versa (Patel *et al.*, 2012). It was found that according to morphometric analysis MWS 7 is on top priority ranking while MWS 8 is at lowest rank.

4.2 LULC Analysis

Five LULC categories namely shrubs, forest, barren land, urban, and rice field were considered for sub-watershed prioritization in the study area. Table 3 shows the details of the various LULC categories with percentage area comes under the different classes.

Table 3: Sub-watershed wise % area under different LULC class

Micro watershed Name	**Area, Km^2**	**Area, %**					
		Shrubs	**Barren**	**Forest**	**Agriculture**	**Urban**	**Water**
MSW1	5.69	0.41	6.59	1.78	81.91	6.95	2.12
MSW2	5.63	0.24	3.83	0.91	91.21	3.34	0.19
MSW3	3.51	0.55	14.51	1.26	63.77	18.87	0.93
MSW4	3.05	0.29	4.02	0.52	89.35	4.56	1.09
MSW5	5.39	0.11	1.56	1.27	92.96	2.83	1.23
MSW6	3.60	0.03	1.45	0.22	93.40	3.23	1.57
MSW7	7.06	0.15	2.12	0.18	93.04	3.03	1.37
MSW8	2.68	0.18	1.63	0.85	92.14	4.34	0.70
MSW9	2.17	0.55	6.50	1.18	75.69	11.95	4.12
MSW10	2.81	2.80	36.17	0.91	29.43	30.27	0.30
MSW11	3.45	0.67	8.82	3.59	37.48	45.01	4.25

Sub-watersheds with a higher percentage of barren land and urban or a lower percentage of shrubs, forest and rice field were given high priority and vice versa. Then, the compound factor was calculated by adding up all the ranks and dividing by the total number of LULC classes (Table 4). The micro watershed with the lowest compound factor (C_p) was given the highest prioritized rank out of the group of micro watersheds, and vice versa. Based on LULC analysis MWS 9 is at top most priority and MWS 5 is at lowest priority ranking.

4.3 Integration of Morphometric and LULC Analysis

The priority ranking of both the morphometric and LULC analysis were then combined to get the final priority by integrated approach and given in Table 5 and presented in Fig.

5. The result indicates that MWS 3 and MWS 10 found to receive common priority falls under the highest priority, though MWS 6 and MWS 8 falls under the lowest priority ranking.

Table 4: Sub-watershed wise priority ranking based on LULC analysis

MWS Name	Area, km^2	Shrubs	Barren	Forest	Agriculture	Urban	Composite score	Rank
MSW1	5.693	7	4	10	5	5	6.2	5
MSW2	5.629	5	7	5	7	8	6.4	6
MSW3	3.506	8	2	8	3	3	4.8	2
MSW4	3.047	6	6	3	6	6	5.4	3
MSW5	5.390	2	10	9	9	11	8.2	8
MSW6	3.601	1	11	2	11	9	6.8	7
MSW7	7.064	3	8	1	10	10	6.4	6
MSW8	2.675	4	9	4	8	7	6.4	6
MSW9	2.167	8	5	7	4	4	5.6	4
MSW10	2.809	11	1	6	1	2	4.2	1
MSW11	3.450	10	3	11	2	1	5.4	3

Table 5: Sub-watershed wise ranking by integrated approach of land-use and morphometric analysis

Micro watershed Name	Ranking		Composite score	Final ranking
	Morphometric	LULC		
MWS-1	4.9	6.2	5.55	3
MWS-2	6.3	6.6	6.45	8
MWS-3	4.4	4.8	4.6	1
MWS-4	6.3	5.4	5.85	6
MWS-5	4.8	8	6.4	7
MWS-6	6.5	6.8	6.65	9
MWS-7	4.2	6.4	5.3	2
MWS-8	6.9	6.4	6.65	9
MWS-9	6	5.6	5.8	5
MWS-10	5	4.2	4.6	1
MWS-11	6	5.4	5.7	4

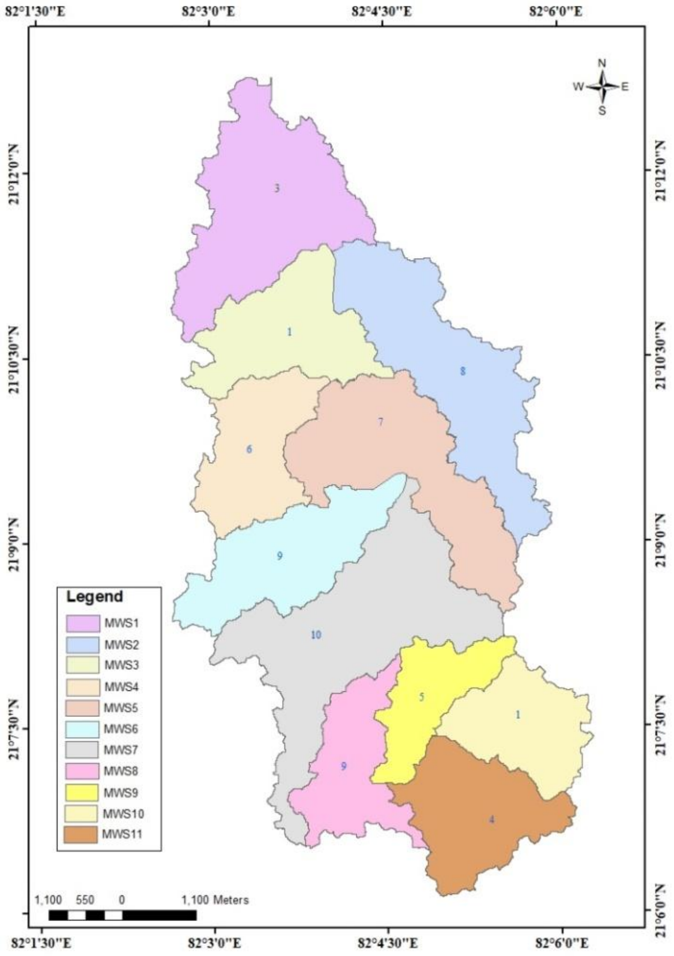

Fig. 5: Prioritized ranking of micro watersheds by integrated approach

5. CONCLUSION

The present study provides an illustration of an integrated approach using GIS and remote sensing techniques to prioritise sub-watersheds in the *Kantori nala* mili atershed based on drainage morphometry and LULC analysis. The results of morphometric analysis-based prioritization showed that the MWS 7 and MWS 8 micro watersheds are of are of highest and lowest priority respectively while the results of the LULC analysis-based prioritizing showed that the micro watersheds MWS 10 and MWS 5 micro watersheds are of are of highest and lowest priority respectively. It is observed that upon integrating of both the morphometric and land use/ land cover compound factor values information, MWS 3 and MWS 10 found to receive common priority falls under the highest priority, though MWS 6 and MWS 8 falls under the lowest priority ranking. Basin morphometric analysis, when combined with LULC analysis, enables sub-watershed level prioritisation and characterization, providing an assessment of the risk potential of sub-watersheds.

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