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Applications of Advanced Technology for Prioritization of Watershed

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ABSTRACT

Prioritization of sub-watersheds is critical in strategic planning for incorporating management practices in delicate semi-arid regions. Geomorphometric as well as land use/cover data sets are essential for determining subwatershed priorities for integrated watershed management. Prioritizing watersheds entails ranking of sub-watersheds according to their susceptibility based on several variables, including the average yearly soil loss, the depletion of water resources, and ecological deterioration. The sub-watershed prioritization for the study area Muzaffarpur district was done by combining Principal Component Analysis (PCA) and Weighted Sum Approach (WSA). PCA was used to differentiate important parameters but WSA was used to measure compound values for priority ranking and determining weights for significant parameters. The PCA was effective in obtaining the most crucial values (i.e., WB, Dt, Re, and Rb). A load of each significant parameter was successfully defined by the WSA application. Traditional prioritizing procedures uses numerous criteria in a complex manner and presumptively contribute equally but PCA-WSA integration results in more dynamic, effective, and efficient solutions.

Keywords Geomorphology, PCA, Weighted sum approach, Land use/Land cover.

INTRODUCTION

A watershed refers to the region from which runoff from rainfall runs through a single point and into significant streams, lakes, rivers, and seas. A watershed is a naturally occurring hydrologic unit that can be classified according to the surrounding physical, climatic, and topographic conditions (Syed *et al.* 2017). Natural resource availability, such as land and water, is dwindling daily as a result of increasing population pressure. Therefore, these natural resources must be planned for and managed. Scientific management and control of these resources, huge amount of data were required. Therefore, when creating regional hydrological models to address a variety of hydrological issues with unmeasured watersheds or insufficient data conditions, the geomorphologic properties of a

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watershed are frequently used as input (Gajbhiye *et al.* 2014). The science of measuring and mathematically estimating the size, shape, surface, and dimensions of the earth's land formation is known as morphometric analysis (Sangma and Guru 2020). Geomorphometric factors are mostly used in prioritizing analysis to highlight the natural characteristics of the watershed that are referred to as the principal topic of concern. Perhaps the analysis method could be made more thorough by including management qualities (Setiawan and Nandini 2021). Numerous interrelated causes, including both geophysical and social aspects, contribute to the degradation of watersheds. Foley *et al.* (2005) stated that a region's socio economic and geophysical factors have an impact on land use/cover variation, which itself is recognized as the primary force behind climatic change. Because of this, it is desirable to employ a term of components of all factors contributing to watershed degradation to rank the importance of managing particular watersheds. Prioritizing watersheds entails ranking sub-watersheds according to their susceptibility based on several variables, including the average yearly soil loss, the depletion of water resources, and ecological deterioration. Prioritizing sub-watersheds makes it easier to create methods that effectively manage soil erosion by reducing the amount of sediment produced (Siddiqui *et al.* 2020). The LULC state of the watershed is given particular consideration in the prioritizing of sub-watersheds (Mishra *et al*. 2007). It has been determined that the main factor causing an environmental change in the watershed that accelerates soil erosion is mostly anthropogenic changes in land use or land cover (Malik and Bhat 2014). The morphometric parameters of the basin have been calculated and delineated using the geographic information system (Singh *et al.* 2013). Watershed prioritization has seen the widespread use of remote sensing and geographic information systems (GIS) (Martin and Saha 2007). The analytical method of prioritizing has primarily been employed in earlier research with a standard compound value, which is derived by averaging the initial ranks of priority across all parameters . Some investigations have been guided by Principal Component Analysis (PCA) and the Weighted Sum Approach (WSA) (Shinde *et al.* 2011). The WSA of geomorphometric factors was used by Aher *et al.* (2014) to prioritize sub-watersheds within the watershed Pimpalgaon, Ujjaini district in India. Sharma *et al.* (2014), Meshram and Sharma (2017) used principal component analysis to determine the sub-watershed, and it was deduced that the technique reduced the complexity of the data set by taking into account the correlation between the variables. According to these investigations, PCA and WSA were both more dynamic and effective compared to the standard compound value approach. To determine ultimate prioritizing, the traditional compound values technique presupposed that all of the factors were of alike weight. The fact that each sub-watershed has unique properties means that the significance of the parameters may not be the same in practice. As a result, the union of PCA and WSA demonstrated a promising method for watershed prioritizing. Prioritizing the sub-watersheds derived from the data incorporation of geomorphometric characteristics and land use in the Muzaffarpur district is the aim of the current study. To rank the sub-watershed last, the PCA and WSA approaches were combined by the analysis of SRTM DEMs. Precise analysis of ASTER DEMs, we can monitor more details about elevation (Mangan *et al.* 2019). ASTER, SRTM are estimated to study the changes between them and their impact on time of concentration (TC) of waterflow at Moolbari Experimental Watershed (Rawat and Mishra 2016). Executing the statistical analysis, non-linear regression and polynomial regression are used and for preparing data driven models artificial neural network (ANN) and fuzzy logic (FL) are used (Sahoo and Baitalik 2022). GIS techniques can monitor different morphometric parameter (Negi *et al.* 2021). Sediment Yield Index (SYI) is used to estimate soil loss, an important parameter for the planning and management of watershed (Sahu *et al.* 2020).

MATERIALS AND METHODS

Study area

The Muzaffarpur district is located between latitudes 25°54' 00" and 26°23' 00" north and 84° 53' 00" and 85° 45' 00" East (Fig.1). The city is located in a seismically active region of India. This low-centered, saucer-shaped settlement is situated on a bed of Himalayan sand and silt that was transported by the glacier and rain-fed meandering rivers of the Himalayas to

Fig. 1. Study area map of Muzaffarpur district.

the vast Indo-Gangetic plains of Bihar.The district's principal rivers are fed by the area's drainage system, which rises in the Himalayas. The rivers Burhi Gandak, Baghmati, and Baya, which typically run in a south-easterly direction, are the main drainage systems for the area. Even though the three rivers and all of their tributaries are perennial, they are exceedingly unpredictable during the rainy season and monsoon, when they become extremely destructive and cause flooding in this region. This unusual characteristic causes the sedimentation rate to be very high during the monsoon season close to the river banks, leading to the construction of raised upland, and gradually decreasing away from the river channels.

Input data and collection

In this study, ASTER Digital Elevation Model (DEM) data with a spatial resolution of 30m is used. Using the DEM information along the district border, the location of the network of the stream and sub-watershed was determined. Ridgelines, the water divide, and other morphological elements assist the subdivision of the sub-watershed. From the upstream to the watershed outflow, eight sub watershed were obtained and given the labels SW1, SW2, SW3, SW4, SW5, SW6, SW7, and SW8. Following Horton's law, a number was assigned to the stream network of each sub-watershed begineeing with the 1st order (Rawat *et al.* 2013).

Geomorphometric and land use land cover (LULC) analysis

Each parameter and sub-watershed were given a Preliminary Rank (PR) formed on the link between the variable and soil erodibility through geomorphometric and lulc analyses. The geomorphometric variables Lu, Lg, Rb, Dd, Dt, Fs, Rhl, Rn, and Rhp all directly affected soil erodibility. While the variables that show an inverse correlation to soil erodibility are Ff, Cc, Rc, and Re (Rawat *et al.* 2013, Rawat *et al.* 2014, Patil and Mali 2013). The geomorphometric factors that directly influence soil erodibility for each sub-watershed were ranked from 1 for the greatest value, then 2 for the next-greatest value, and so forth. A higher direct effect parameter value indicated a greater likelihood of soil erodibility. The parameter with the lowest value received rank 1, and similarly for each sub-watershed, to rank the factors that have anreverse association to soil erodibility. The minimum value of inverse relationship parameters suggested a strong possibility for soil erodibility by using a methodology used in a prior study, the preliminary rank for lulc was determined. The method involved ranking the regions with the greatest concentration of agricultural land and bushes. The least quantity of forest was described as being in the highest preliminary rank.

PCA and WSA analysis

PCA has been utilized to specify important geomorphometric and land use/land cover factors. PCA is used as a multivariate statistical technique to dimensionally simplify the parameters. It was necessary to normalize the dataset using the z-score approach before PCA calculation because the parameters had varied scales . After converting the data from the original, PCA generates two or more main components (Sharma *et al.* 2014, Meshram and Sharma 2017). The Kaiser criterion and varimax rotation of factor loading were used to choose principal components with eigen values greater than 1. To improve the correlation in defining the parameters that matter most, the factor loading rotation was carried out. The most important parameters derived from PCA were then subjected to WSA. Cross-correlation evaluation was used to obtain the weighted quantity of significant parameters represented as Wsp, which is shown in

Kumar *et al*. (2022).

$$Wsp = \frac{\text{Sum of correlation coefficient}}{\text{Total of correlation}} \quad (1)$$

The Wsp and PR of critical variables were used to produce the compound values (CV), which were then used to establish the final priority ranking. The following mathematical formula was used for the CV calculation

$$CV = PRsp \times Wsp \quad (2)$$

Where PRsp = Preliminary Ranking of significant parameter, CV = Compound value, Wsp = Weight of significant parameter. For all sub-watersheds, the CV with the lowest value received priority rank as 1, the very next value received priority rank as 2, and so on.

RESULTS

Geomorphometric and LULC analysis

The geomorphometric investigation of the eight SW of study area was done through GIS software. Three types of computations were done to calculate morphometrics viz. linear (Lu, Lg, Rb), areal (Ff, Cc, Dt, Re, Rc, Fs, Dd) and relief (i.e., Rhl, Rn, Rhp). Tables 1- 2 displays the numerical measure of the geomorphometric factors and LULC's factors in percent.

Although the stream length (Lu) differs, the sub-watersheds in the Muzaffarpur district typically are of fifth-order stream order. The largest and smallest sub-watersheds according to total stream length are SW5 (1041.44 km) and SW2, respectively. The initial stream order has the longest stream segment length, which then decreases as the stream order sequence continues. The watershed's hydrological process and the bifurcation ratio (Rb) are closely related. Higher overland flow is a sign of high Rb values, and it affects how much erosion is possible. The value of Rb is also influenced by the severity of the structural disruption.

The relationship between land use/land cover, geomorphometric parameters and erosion potential

Table 1. The geomorphometric qualities of the sub-watersheds.

		Linear					Areal					Relief	
	Lu	Rb	Lg	Ff	Dt	Cc	Rc	Re	Dd	Fs	Rhl	Rhp	Rn
SW1	481.41	7.435	66037.417	0.29	7.055	2.145	0.221	0.615	1.755	3.215	2.471	59.995	0.132
SW2	112.09	8.179	3606.496	0.26	3.236	2.178	0.214	0.575	1.742	3.092	4.005	102.456	0.11
SW3	503.19	8.29	114631.71	0.16	2.677	2.919	0.119	0.457	1.104	1.288	1.482	35.577	0.086
SW4	248.84	12.02	27746.904	0.29	2.43	2.287	0.194	0.608	1.116	1.309	2.311	53.262	0.071
SW5	1041.4	7.5	470762.12	0.23	4.546	2.591	0.151	0.552	1.152	1.378	1.189	26.632	0.084
SW6	169.63	12.2	13330.374	0.52	2.365	2.023	0.248	0.82	1.079	1.342	2.493	48.201	0.046
SW7	372.57	7.91	37970.472	0.41	1.748	2.403	0.176	0.727	1.828	1.035	1.897	34.799	0.077
SW8	185.68	9.32	8830.941	0.56	6.893	1.699	0.352	0.849	1.952	4.226	4.788	106.31	0.121

Note:- SW, Sub-watershed.

Table 2. The land use/land cover percentage of sub-watershed.

			LULC %			
SW	WB	FO	AG	UA	BA	SC
SW1	9.769	27.743	41.125	14.739	5.793	0.831
SW2	11.559	19.56	47.305	14.865	6.233	0.478
SW3	6.099	26.229	36.457	24.026	6.285	0.904
SW4	6.382	19.661	41.969	25.925	5.18	0.882
SW5	10.282	15.702	37.582	19.574	12.176	4.685
SW6	9.302	5.341	25.039	3.759	13.746	42.812
SW7	12.728	10.584	41.436	14.974	16.486	3.79
SW8	52.87	373.525	205.704	433.805	26.383	7.712

Note:- SW, Sub-watershed, WB, Water Body, FO, Forest, AG, Agriculture, UA, Urban, BA, Barran land, SC, Scrab.

Table 3. Preliminary rank (PR) of sub-watersheds.

Sl.		Linear				Areal						Relief	
No.	Lu	Rb	Lg	Ff	Dt	Cc	Rc	Re	Dd	Fs	Rhl	Rhp	Rn
SW1	3	8	3	4	1	3	6	5	3	2	4	3	1
SW2	8	5	8	3	4	4	5	3	4	3	2	2	3
SW3	2	4	2	1	5	8	1	1	7	7	7	6	4
SW4	5	2	5	5	6	5	4	4	6	6	5	4	7
SW5	1	7	1	2	3	7	2	2	5	4	8	8	5
SW6	7	1	6	7	7	2	7	7	8	5	3	5	8
SW7	4	6	4	6	8	6	3	6	2	8	6	7	6
SW8	6	3	7	8	2	1	8	8	1	1	1	1	2

was used to estimate the preliminary rank (PR) for every sub-watershed (Table 3). PR was calculated using the parameters' direct or inverse relationships to erosion (Table 3). Tables 3 - 4 show the PR of sub-watersheds that meet the geomorphometric and land use / land cover criteria, respectively.

Table 4. Preliminary rank (PR) of sub-watersheds according to land use/land cover.

		Land use %				
SW	WB	FO	AG	UA	BA	SC
SW1	4	7	5	2	7	7
SW2	6	4	2	3	6	8
SW3	1	6	7	6	5	5
SW4	2	5	3	7	8	6
SW5	5	3	6	5	4	3
SW6	3	1	8	1	3	1
SW7	7	2	4	4	2	4
SW8	8	8	1	8	1	2

Results from PCA and WSA

The PCA was used to determine the connection between all variables, including geomorphometric and land use/land cover data, to identify the main component, minimize the dimension of the parameters, and identify the most crucial variables. The correlation analysis for all variables is shown in Table 5. A strong correlation (r ≥ 0.9) is noticed b/w Lg and Lu, Re and Ff, Rc and Cc, Rhp and Rhl, FO and WB, AG and WB, and UA and WB. A good correlation ($0.75 \leq r \leq 0.9$) occurs between Cc and Ff, Rc and Ff, BA and Ff, Fs

Table 5. Correlation matrix of variables of Muzaffarpur district.

	Lu	Rb	Lg	Ff	Dt	Cc	Rc	Re	Dd	Fs	Rhl	Rhp	Rn	WB%	FO%	AG%	UA%	BA%	SC%
Lu	**1**																		
Rb	-0.53	**1**																	
Lg	0.96	-0.41	**1**																
Ff	-0.51	0.44	-0.45	**1**															
Dt	0.17	-0.37	0.12	0.16	**1**														
Cc	0.6	-0.35	0.51	-0.81	-0.48	**1**													
Rc	-0.56	0.3	-0.48	0.83	0.55	-0.96	**1**												
Re	-0.49	0.43	-0.44	0.99	0.17	-0.83	0.82	**1**											
Dd	-0.33	-0.48	-0.39	0.37	0.49	-0.54	0.54	0.39	**1**										
Fs	-0.34	-0.24	-0.31	0.31	0.81	-0.69	0.76	0.31	0.72	**1**									
Rhl	-0.7	0.13	-0.59	0.55	0.43	-0.82	0.86	0.54	0.65	0.85	**1**								
Rhp	-0.65	0.04	-0.54	0.37	0.45	-0.73	0.76	0.36	0.63	0.88	0.98	**1**							
Rn	0.00	-0.63	-0.08	-0.13	0.82	-0.28	0.34	-0.11	0.72	0.84	0.5	0.59	**1**						
WB%	-0.27	-0.02	-0.21	0.66	0.59	-0.67	0.83	0.63	0.6	0.73	0.75	0.66	0.45	**1**					
FO%	-0.26	0.02	-0.21	0.59	0.61	-0.62	0.8	0.55	0.52	0.73	0.72	0.65	0.47	0.98	**1**				
AG%	-0.28	-0.01	-0.22	0.58	0.6	-0.63	0.8	0.54	0.57	0.74	0.75	0.68	0.5	0.99	1	**1**			
UA%	-0.26	0.04	-0.2	0.6	0.58	-0.61	0.8	0.56	0.5	0.7	0.71	0.63	0.44	0.98	1	1	**1**		
BA%	-0.13	0.03	-0.07	0.81	0.3	-0.55	0.68	0.79	0.45	0.35	0.45	0.29	0.06	0.86	0.78	0.78	0.8	**1**	
SC%	-0.27	0.62	-0.16	0.62	-0.22	-0.35	0.32	0.61	-0.34	-0.2	0.03	-0.1	-0.61	0.00	-0.05	-0.1	-0.04	0.29	**1**

and Dt, Rn and Dt, Re and Rc, Rhl and Rc, Rhp and Rc, WB and Rc, FO and Rc, AG and Rc, UA and Rc, BA and Re, Rhl and Fs, Rhp and Fs, Rn and Fs, WB and Rhl, AG and Rhl, BA and WB, BA and FO, BA and AG, and BA and UA. Some moderate correlation (0.60 ≤ , ≤ 75) exists between Cc and Lu, Rhl and Lu, Rhp and Lu, Rn and Rb, WB and Ff, UA and Ff, Sc and Ff, FO and Dt, AG and Dt, Fs and Cc, Rhp and Cc, WB and Cc, FO and Cc, AG and Cc, UA and Cc, WB and Re, SC and Re, Rhl and Dd, Rhl and Dd, Rhp and Dd, Rn and Dd, WB and Dd, WB and Fs, FO and Fs, AG and Fs, UA and Fs, WB and Rhl, FO and Rhl, AG and Rhl, UA and Rhl, WB and Rhp, FO and Rhp, AG and Rhp, UA and Rhp, and SC and Rn. The fact that certain parameters are correlated suggests that different parameters may contain different pieces of information. Therefore, utilizing PCA and the correlation matrix, parameter dimension can be reduced for practical reasons.

Four principal components (PCs) were produced by the application of PCA in this investigation (Table 6). These principal components could account for 95.202% of the variation in the starting data since they had eigen values > 1.

The initial factor-loading matrix produced by PCA also depicts the relationship between the variables in each principle component, shown in Table 6. The initial PC and AG exhibited a strong association (r ≥ 0.9), a good correlation (0.75 ≤ r ≤ 0.9) with Lu, Lg, Cc, Rc,Rhl, Rhp, WB, FO, UA, and BA and a moderate correlation (0.60 ≤ r ≤75) with Ff, Re, Dd, and Fs. The second PC had a strong correlation to Rn, a good correlation to Rb and Dt, and a moderate correlation to Fs. The third PC only had a moderate association with Ff, Re, and SC.

Table 6. First factor-loading matrix of all parameters.

	Component			
	1	2	3	4
Lu	**0.89**	0.34	0.28	-0.07
Rb	-0.33	**-0.77**	0.18	0.47
Lg	0.85	0.29	0.39	0.04
Ff	-0.69	-0.26	0.6	-0.2
Dt	-0.25	**0.81**	0.37	0.2
Cc	**0.85**	-0.08	-0.47	-0.06
Rc	**-0.84**	0.17	0.48	0.13
Re	-0.69	-0.24	0.62	-0.24
Dd	-0.63	0.58	-0.03	-0.52
Fs	-0.67	0.7	0.12	0.18
Rhl	**-0.89**	0.29	0.08	0.16
Rhp	**-0.83**	0.39	-0.04	0.24
Rn	-0.31	**0.93**	-0.16	0.01
WB	**0.88**	0.23	0.38	-0.09
Fo	**0.85**	0.41	0.03	0.23
AG	**0.95**	0.24	0.2	0.05
UA	**0.88**	0.29	0.17	0.2
BA	**0.86**	0.11	0.43	-0.14
Sc	0.29	-0.53	0.68	0.04

Table 7. Rotated factor-loading matrix of all parameters.

	Component			
	1	2	3	4
Lu	**0.96**	-0.11	-0.22	0.11
Rb	-0.42	-0.2	0.31	**-0.80**
Lg	**0.97**	-0.07	-0.14	-0.04
Ff	-0.3	0.13	**0.92**	-0.06
Dt	0.27	**0.88**	0.14	0.18
Cc	0.39	-0.55	**-0.70**	0.06
Rc	-0.35	0.65	0.67	-0.08
Re	-0.29	0.13	**0.94**	-0.03
Dd	-0.31	0.47	0.28	**0.77**
Fs	-0.23	0.93	0.16	0.22
Rhl	-0.56	**0.70**	0.33	0.05
Rhp	-0.54	**0.76**	0.15	0.06
Rn	-0.02	**0.81**	-0.22	0.52
WB	**0.96**	-0.18	-0.11	0.05
Fo	**0.81**	0.05	-0.53	-0.04
AG	**0.92**	-0.18	-0.33	-0.03
UA	**0.87**	-0.05	-0.39	-0.11
BA	**0.94**	-0.28	-0.01	0.01
Sc	0.41	-0.39	0.53	-0.48

The rotated factor-loading framework. Lu, Lg, WB, AG, and BA had the first PC's strongest correlation (Table 7). Fs, Ff, and Re, respectively, had the strongest correlations with the second PC and third PC. These factors are also recognized as essential variables and are utilized for sub-watershed prior-

Table 8. Cross-correlation between the crucial variables of Muzaffarpur district.

	WB	Dt	Re	Rb
WB	1	0.59	0.63	-0.02
Dt	0.59	1	0.17	-0.37
Re	0.63	0.17	1	0.43
Rb	-0.02	-0.37	0.43	1
Sum	**2.2**	**1.39**	**2.23**	**1.04**
Grand total	**6.86**	**6.86**	**6.86**	**6.86**
WSA	**0.321**	**0.203**	**0.325**	**0.152**

Table 9. Priority rank for sub-watersheds of Muzaffarpur district.

	Compound value (CV)	Priority rank
SW1	4.3	**1**
SW2	4.5	**5**
SW3	2.3	**2**
SW4	3.5	**3**
SW5	3.9	**4**
SW6	4.8	**6**
SW7	6.7	**8**
SW8	6	**7**

itization & WSA (Table 8). Strong correlation (r > 0.90), Good correlationi (0.90 ≥ r > 0.75), Moderate correlation (0.75 ≥ r > 0.60).

The CV value, which was produced using the initial order and weight of pertinent qualities, was employed in the ultimate sub-watershed prioritizing phase (WB, Dt, Re, Rb). An analysis of the four parameters' cross-correlations was used to establish the parameters' relevance (Table 8). An equation based on the weighted sum of the significant variables was used to calculate the CV.

$$CV= (0.321 \times PR\ of\ WB) + (0.203 \times PR\ of\ Dt) + (0.325 \times PR\ of\ Re) + (0.152 \times PR\ of\ Rb)$$

PCA and WSA are used to prioritize sub-watersheds Using CV values, Table 9 shows the ranking of the sub-priority watershed. The pattern of priority rank across the spatial watershed is shown in Fig. 2.

The priority rank was assigned as per CV values. The three groups of the priority category are divided as low (CV > 4.40), then medium for (3.40 ≤ CV ≤ 4.40) and high (CV < 3.30). SW3 is listed as the high category in Table 10. SW1, SW4, and SW5 are listed as the medium category, while SW2, SW6, SW7, and SW8 are listed as the low category. Muzaffarpur district's high category takes up in the area of 2.27 hectares. The priority category map for the Muzaffarpur district is shown in Fig. 3.

The high category of prioritizing not only reveals an area with a high potential for erosion but also where soil and water conservation might be applied. The low category, on the other hand, was shown to have an adequate geomorphometric characteristic and current land use/land cover. Structured soil and water conservation methods are used in the mitigation strategies for the high category to reduce the suscep-

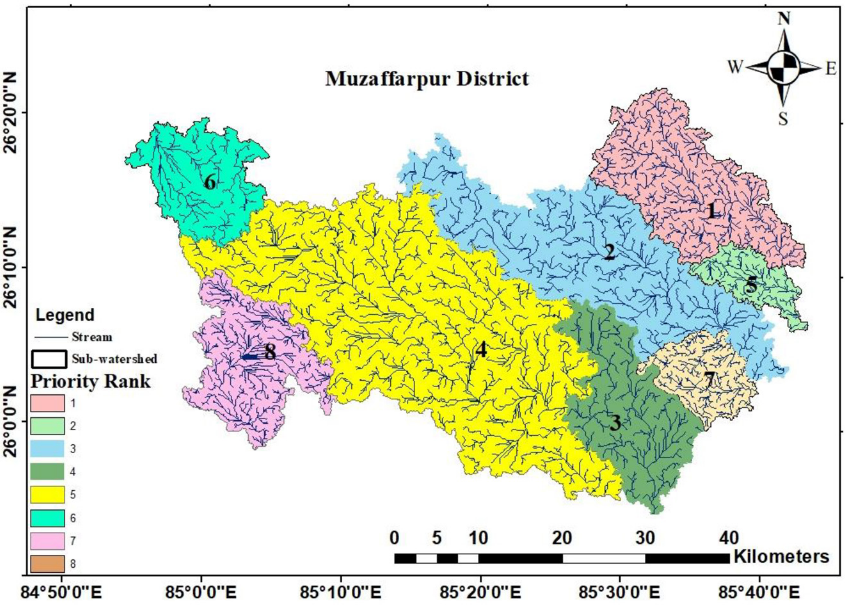

Fig. 2. Sub-watershed priority ranking map.

Table 10. The sub-watershed of the Muzaffarpur district's priority category.

Sl. No.	Compound value (CV)	Priority category	Sub-watershed (SW)	Area (ha)	Percentage of area (%)
1	<3.300	High	SW3	2.27	6.29
2	3.40-4.40	Medium	SW1,SW4,SW5	11.71	32.52
3	>4.40	Low	SW2,SW6,SW8,SW7	22.03	61.19

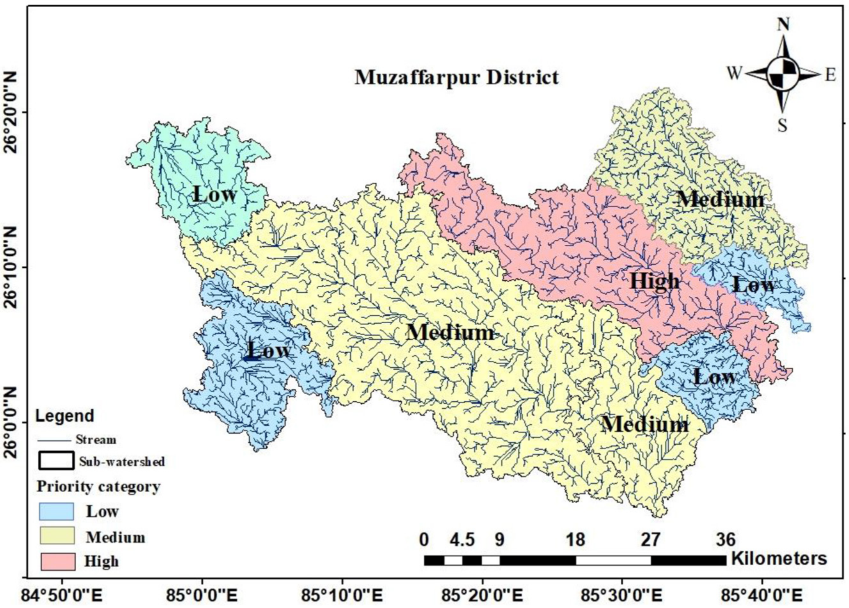

Fig. 3. Priority map for sub-watersheds.

tibility of the sub-watershed to erosion. Additionally, it is advised to maintain and safeguard the current vegetation coverage and high-category revegetation. It is necessary to conserve vegetation, soil, and water in the medium category sub-watersheds to prevent erosion, especially sheet and rill erosion.

DISCUSSION

The present research illustrates the holistic approach of remote sensing and GIS as well as advanced statistical techniques. In most research work RS data is integrated in GIS platform with simple weighted analysis in GIS platform for prioritization (Martin and Saha 2007, Meshram and Sharma 2017, Mishra *et al*. 2007, Rawat *et al.* 2014, Singh *et al.* 2013) while in present study we drive the morphometric parameters from earth observational data and then apply PCA and WSA statistical tools for the prioritization of the study area. Using PCA and WSA analysis makes precise results of prioritization.

CONCLUSION

The Muzaffarpur district has several measures to lessen soil erosion-related land degradation. Due to biophysical and socio-economic constraints, the sub-watershed unit needs to prioritize the implementation of the programs in terms of space. In this study, sub-watersheds were prioritized using geomorphometric variables that represent "natural" characteristics and land use/land cover that indicate "management" characteristics. PCA and WSA were combined as the calculation's approach. The PCA was effective at obtaining the most crucial values (i.e., WB, Dt, Re, and Rb). The weight of each significant parameter was successfully defined by the WSA application. It is consistent with the actual situation that the involvement of parameters does not equate to that of natural phenomena, such as erosion. Compared to traditional prioritizing procedures, which use numerous criteria in a complex manner and presumptively contribute equally, PCA-WSA integration results in more vibrant, useful, and efficient solutions. SW3 is assigned top priority in the Muzaffarpur district sub-watershed, under the methods used there. SW2, SW6, SW7, and SW8 are given low priority, whereas SW1, SW4, and SW5 are given medium priority. The Muzaffarpur district's decision-makers can use this useful knowledge to establish management methods that will lessen and prevent land degradation. It is advised to take socio-economic factors into account while setting priorities for future employment.

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