


Morphometric prioritization of semi-arid watershed for plant growth potential using GIS technique

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Abstract Watershed characterization and prioritization is carried out before taking up the task of management. Morphometric analysis plays significant role in prioritization of watersheds for proper use and various economic activities like animal husbandry. In the present study, morphometric investigations are used to ascertain plant growth potential of watershed for environmental management. Analysis was carried out in four sub-watersheds of Shivganga watershed using Geographic information system (GIS) technique for determining plant growth potential. The analysis includes linear aspects, aerial aspects and relief aspects. Exhaustive data requirements and individual biasness for assigning weights to various morphometric parameters affect the prioritization process. Thus, Weighted Sum Analysis (WSA) method is used in the present study for identifying sub-watersheds suitable for potential plant growth. The maximum elevation in Shivganga watershed is 1264 m in sub-watershed 1 (SW1) which increases stream flow velocity, erosion, minimized length of overland flow and quick water flow into streams contributing to hydrograph rise. It has been observed that sub-watershed 3 and 4 with low average slope

show significant plant growth and contribute less runoff, relatively less land erosion and low peaks in hydrograph. The SW3 has highest potential for plant growth as it matches with the lowest weighted sum analysis. Thus, SW1 is given rank 1 with least compound factor value 1.317. The result illustrated that 13.64 to 45.40% of total area, falls in the good potential growth zone. The results of the work may be useful for watershed administrators and managers while planning conservation measures in the area.

Keywords GIS · Morphometry · Shivganga watershed · Watershed prioritization · Weighted sum analysis

Introduction

Vast arid and semi-arid areas over the globe are not suitable for crop production because of slope, altitude or low rainfall factors but where the vegetation cover deserves to be properly assessed because they provide a range of ecosystem services. Such land use planning requires a sound platform of scientific knowledge to provide a basis for informed discussion. After evaluating the potential of natural resources within a watershed, there is a need to establish appropriate strategy. The selection of a particular watershed within a basin for evaluation and management is done on priority ranking basis. Watershed prioritization is one of the very significant and effective methods that lead to comprehensive management and conservation plan.

Various aspects such as geo-morphometric analysis (Patel et al. 2012), multi-criteria evaluation (Hlaing et al. 2008), site suitability indices (Jang et al. 2013), weighted sum analysis, multi criteria decision making (Aher et al. 2014), sediment yield index (Samal et al. 2015), compound parameter technique (Meshram and Sharma 2017),

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compound factor (Magesh and Chandrasekar 2014) and land use strategies (Sreedevi et al. 2005) are considered during prioritization of watersheds. In these approaches, decision making analysis is carried out by assigning weights to all the influencing parameters or morphometric variables. As a result, the biasness associated with weights leads to incorrect variation of compound or average ranking.

In present study, Shivganga (a semi-arid watershed) is taken as a case study where unique characteristics for sub watershed is assigned and demarcation can be done by considering weightage of the individual morphometric variable. Hence, a designed methodology is proposed for prioritization of watersheds wherein, geospatial technologies are coupled with statistical method to allow the appropriate ranking of sub-watersheds by avoiding the individual biasness associated with several influencing parameters. In view of the above, the study aims to estimate plant growth potential of Shivganga watershed using weighted sum analysis method (WSA).

Resource conservation and management practices in arid and semi-arid areas are run on watershed basis with the objectives to prevent soil erosion, to augment

availability of water resources and chiefly to enhance the plant growth.

Material and methology

Study area

The areal extent of Shivganga watershed is 173.93 km² (Fig. 1) which is a part of Pune district, Maharashtra, India. Its geographical coordinates are 73°44'1.13"E to 73°56'17.94"E longitudes and 18°13'36.05"N to 18°24'7.46"N latitudes. The study area is drained by River Shivganga. The elevation of the watershed ranges from 1264 m in western part to 590 m in easternmost part and it has mountainous middle order stream network. The area receives an average annual rainfall of 1323 mm from NW monsoon in June through September (IMD 2015).

The study area is composed of moderately weathered simple type basaltic flows of Deccan Volcanic Province having presence of thin tuffaceous layers (Beane et al. 1986). The lava flows in the study area have been divided into Diveghat formation exposed at the low lying areas and Purandargarh formation exposed at the low lying areas and Purandargarh

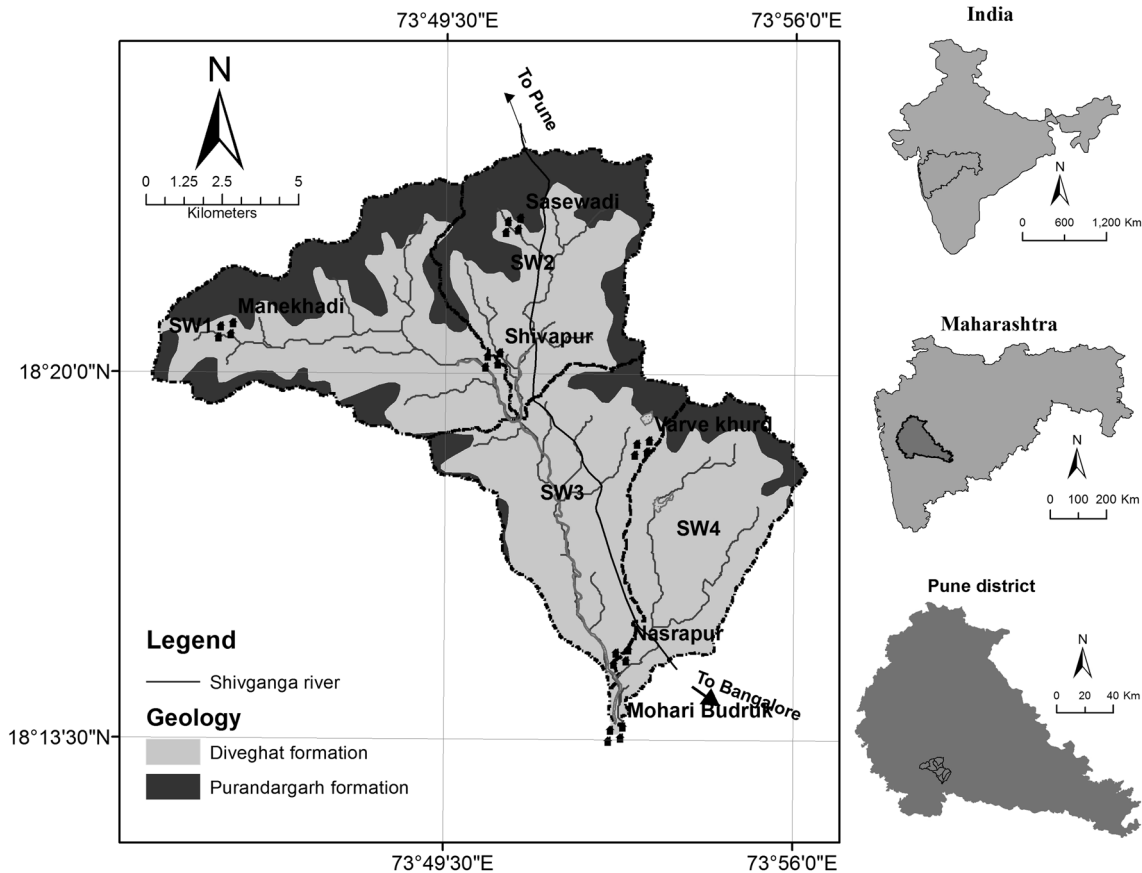


Fig. 1 Location map of study area showing major locations along with major drainage line

formation covering higher elevations (Fig. 1). The parent lithology, demonstrates that soil is derived from basaltic rocks with an alkaline nature. This fine grained basaltic soil is effective for plant growth that would help reducing water losses. Thus, the soil map generated by National Bureau of Soil Science and Land Use Planning was used as a reference map to delineate the soil classes of study area, based on USDA soil classification system (Fig. 3).

The study area comprises of HSG-B, HSG-C and HSG-D hydrological soil groups where HSG-B covers 49.63%, HSG-C covers 42.37% of total area and HSG-D group covers (8.01%) which is nearly impervious material (Fig. 2).

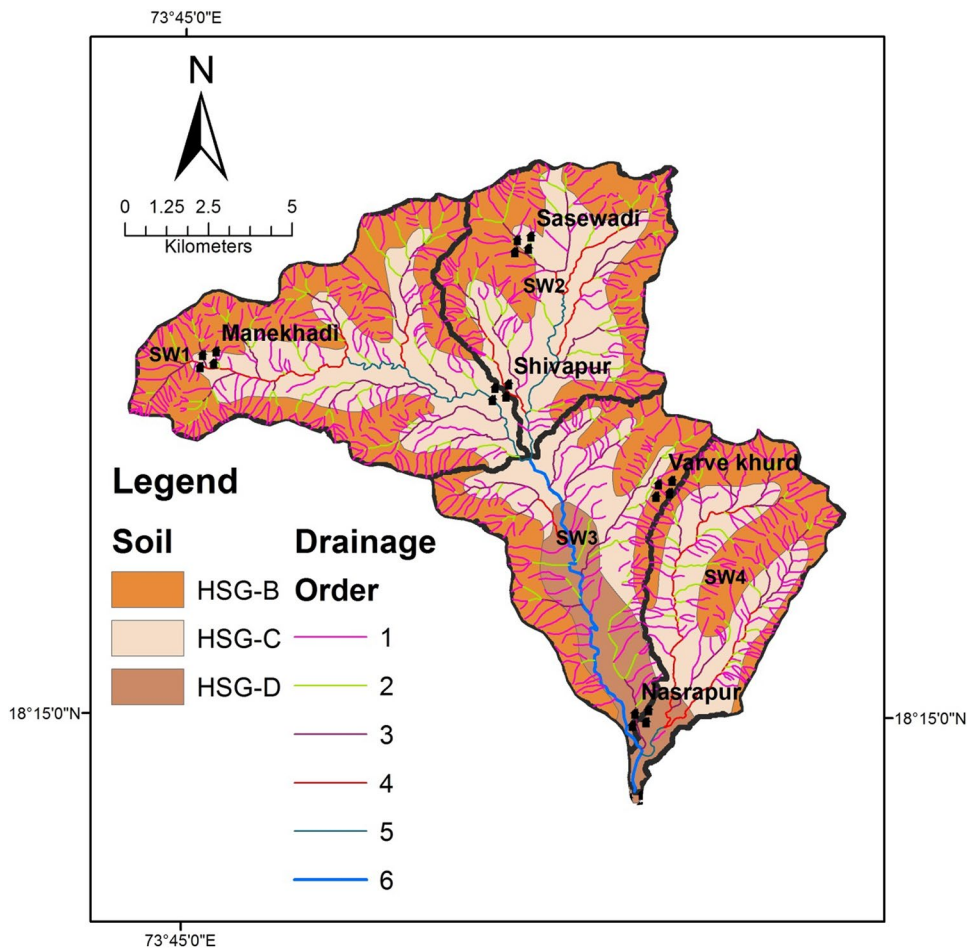
Methods

Survey of India (SoI) topographical sheets with 1:50,000 scale and ASTER DEM of 30 m spatial resolution were used to identify the drainage pattern in the study area. DEM was validated with survey points using global positioning system and survey of India toposheets for better vertical resolution. Further, the drainage network was extracted from DEM using automated method for delineating streams in River Tools 3.0. Stream ordering scheme

proposed by Strahler (1957) was adopted for assigning orders to drainage. Total basin was divided into four sub-basins SW1, SW2, SW3 and SW4 (Fig. 1). Thematic layers, such as basin and sub-basin boundary, drainage, relief and slope were projected to common spatial reference system (WGS-84/UTM) for overlay in Geographic information system (GIS) environment. Furthermore, relief and slope maps were prepared from DEM. Based on this dataset the geo-morphometric analysis of Shivganga watershed was carried out. Important linear, areal and relief parameters were computed using respective formulas.

The sub-watershed with the minimum WSA value was given the highest priority. Weighted Sum Analysis (WSA) means estimating relative significance of each parameter through analyzing the statistical correlation among each variable and assigning the weights to each input constraint according to its importance. For ranking and weightage, WSA is integrated with weighted overlay analysis (WOA) to find potential plant growth areas.

Fig. 2 Drainage layer overlaid on soil of Shivganga watershed for prioritization and appraisal of plant growth potential



Linear aspect

Linear aspects explain the role of basaltic terrain in stream network generation using Strahler’s stream ordering system (Table 1) related to the hierarchical position of stream within a watershed.

Areal aspects

The basic parameters were determined using GIS technique. These parameters are further used in the form factor and elongation ratio calculations (Table 2). The varying slopes of watershed are classified with the help of the index of elongation ratio, i.e. circular (0.9–0.10), oval (0.8–0.9), less elongated (0.7–0.8), elongated (0.5–0.7), and more elongated (less than 0.5). Values approaching 1.0 are typical of regions of very low relief whereas that of 0.6–0.8 are associated with high relief indicating steep ground slope (Strahler 1964).

Relief aspects

These are the key factors in understanding the denudational characteristics of the watershed and play a significant role in landform development, drainage development, surface runoff, recharge, permeability and erosional properties of the terrain (Table 3).

Results and discussion

The study area shows dendritic drainage pattern which is indicative of hard rock basaltic geology, undulating topography, and tropical conditions as it is characterized by irregular branching of tributary streams in many directions at any angle due to headword erosion. Quantitative description of the drainage network, basin characteristics and landform analysis have been worked out using geo-morphometry.

Table 1 Linear aspects with formulae and references

Sr. no.	Parameters	Formulae	References
1	Stream order (Su)	Hierarchical rank	Strahler (1964)
2	Stream Number (Nu)	Number of the stream	Horton (1945)
3	Stream length (Lu)	Length of the stream	Horton (1945)
4	Mean stream length (Lsm)	$Lsm = Lu/Nu$	Strahler (1964)
6	Bifurcation ratio (Rb)	$Rb = Nu/Nu+1$	Schumm (1956)
7	Mean bifurcation ratio (Rbm)	Rbm = average of bifurcation ratios of all order	Strahler (1957)

Table 2 Areal aspects with formulae and references. A basin area; Lb basin length; P basin perimeter

Sr. no.	Parameter	Formula	References
1	Form Factor (Rf)	$Rf = A/Lb^2$	Horton (1932)
2	Elongation Ratio (Re)	$Re = 2/Lb*(A/\pi)^{0.5}$	Schumm (1956)
3	Texture Ratio (Rt)	$Rt = Nu/P$	Schumm (1956)
4	Circulatory Ratio (Rc)	$Rc = 4\pi A/P^2$	Strahler (1964)
5	Stream Frequency (Fs) km	$Fs = Nu/A$	Horton (1932)
6	Drainage Texture (Dt) km	$Dt = Nu/P$	Horton (1945)
7	Drainage Density (Dd) km/km ²	$Dd = Lu/A$	Horton (1932)
8	Length of Overland Flow (Lg)	$Lg = 1/Dd \times 2$	Horton (1945)
9	Constant of Channel Maintenance (C) km ² /km	$C = 1/Dd$	Schumm (1956)

Table 3 Areal aspects with formulae and references

Sr. no.	Morphometric parameter	Formula	Reference
1	Relief Ratio (Rhl)	$Rhl = H/Lb$	Schumm (1956)
2	Compactness Coefficient (Cc) m	$Cc = 0.2841 * P/A^{0.5}$	Gravelius (1914)
3	Height of Watershed Mouth (z) m	–	–
4	Maximum Height of the Watershed (Z) m	–	–
5	Total Watershed Relief (H) m	$H = Z - z$	Strahler (1952)
6	Average Slope %	–	–

This approach has helped in characterizing the drainage pattern, comparative study of small sub-watersheds and also in evaluating lithological, structural and climatic controls on the drainage in the study area. For these purposes, methods given by Horton (1945), Strahler (1952, 1957, 1964) and others were followed. The details are given in the succeeding paragraphs.

Linear aspects

The main stream draining Shivganga watershed is of 6th order. The basin has the number of first, second and third order streams much higher than the fourth, fifth and sixth order streams (Table 4). This indicates rugged topography and presence of hard rock in the drainage basin. Most of the first order streams originate and occupy the peripheral part of the basin which merges with higher order streams in the low lying parts of the watershed.

The stream lengths of various orders have been computed in GIS environment and mean stream length (Lsm) by dividing the total stream length of any order to the number of stream segments in that order (Table 4). The mean stream length of second order streams is less than that of first order and goes on increasing as stream order increases. The Lsm values for the Shivganga watershed vary from 0.70 to 13.02 with a mean Lsm value of 3.91. The stream length is used to study surface flow discharge, helps in understanding soil

erosion in sub-watersheds. The Stream length ratio (RL) values for four sub watersheds vary widely from 0.72 to 11.47 (Table 4). The network of lower order streams is considered as the building block of the basins that delineates the watershed. The study area shows large number of first and second order streams of smaller length developed, as a function of basaltic terrain having low permeability.

Total 1063 stream segments were recognized in Shivganga watershed, out of which 72.34% (769) are 1st order, 18.91% (201) 2nd order, 6.77% (72) 3rd order, 1.60% (17) 4th order, 0.28% (3) represent 5th order, and 0.09% comprises 6th order stream (Table 4). Percentage wise the higher

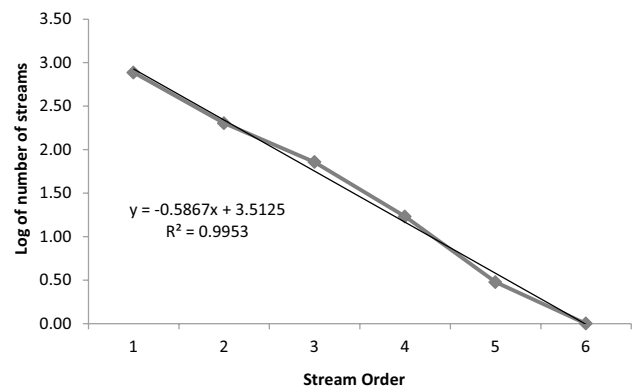


Fig. 3 Logarithmic plot of stream number against stream order

Table 4 Linear parameters of Shivganga sub-watersheds

Sub watershed	Morphometric character	Stream order characters					
		I	II	III	IV	V	VI
SW 1	Nu	264	71	24	6	1	–
	Lu	172.6	54.55	27.12	13.32	8.48	–
	Lsm	0.65	0.77	1.13	2.22	8.48	–
	Rb	–	3.72	2.96	4	6	–
Total		437.25	130.04	55.21	25.54	23.96	
SW 2	Nu	186	49	19	5	1	–
	Lu	135.64	31.42	22.33	11.23	5.99	–
	Lsm	0.73	0.64	1.18	2.25	5.99	–
	Rb	–	3.8	2.58	3.8	5	–
Total		322.37	84.86	45.09	22.28	17.98	
SW 3	Nu	155	39	13	2	1	1
	Lu	105.88	20.28	15.64	2.74	0.97	11.13
	Lsm	0.68	0.52	1.2	1.37	0.97	11.13
	Rb	–	3.97	3	6.5	2	1
Total		261.56	63.77	32.84	12.61	4.94	24.26
SW 4	Nu	164	42	16	4	1	1
	Lu	121.56	22.34	18.27	9.54	1.62	1.89
	Lsm	0.74	0.53	1.14	2.39	1.62	1.89
	Rb	–	3.9	2.63	4	4	1
Total		286.3	68.77	38.04	19.93	8.24	5.78

order streams share very less as compared to lower order streams. The number of streams counted for each order is plotted on logarithmic scale on the y axis against order on arithmetic scale on the x axis (Fig. 3). It is observed that greater the number of lower order streams like in sub-watersheds 1 and 2 more is runoff hence more will be the soil erosion and less will be the plant growth. In contrast with this, sub-watersheds 3 and 4 have comparatively less number of lower order streams which indicates good vegetation growth. Plot of logarithm of stream number against stream order is shown in the Fig. 3. It is seen that there is a linear relationship that follows the Horton's law.

The values of Rb and weighted mean bifurcation ratio are incorporated in the Table 4. It is observed from the table that the bifurcation ratio for the watershed ranges between 2.79 and 5.67. Rb is not same from one order to its succeeding order because drainage development depends upon climate, ecological and geological factors (Strahler 1964; Nag and Chakraborty 2003). Homogenous lithology represented by basalts and less variation in geologic set up is the main reason for values of bifurcation ratio falling between 3 and 6 (Kale and Gupta 2001). The mean bifurcation ratio (Rbm) is 3.90 for Shivganga watershed. Higher mean bifurcation value (> 4.0) obtained for sub-watershed 1 shows mountainous origin more prone to soil loss and less plant growth.

Areal aspects

The smaller the value of form factor, the more elongated the basin will be. The basin with a high form factor has high peak flows of shorter duration, whereas the basin with a low form factor has lower peak flows of longer duration. The Sub-watershed 4 has minimum form factor 0.27 and sub-watershed 2 has maximum form factor of 0.45. Therefore, sub-watershed 4 will have long duration peak flows. However, subwatershed 1 will have shorter duration peak flows.

The Shivganga watershed has Rf value of 0.42 (Table 5) which indicates sub-circular to slightly elongated shape having low peak flows of longer duration (Magesh and Chandrasekar 2014). Thus SW4 has an inherent property of moisture availability for optimum plant growth.

The values of elongation ratio (Re) vary from 0.6 to 1.0 where, values close to 1.0 represent regions of very low relief and values above 0.6 represent high relief and steep ground slope. The elongation ratio of Shivganga watershed is 0.73 (Table 5), indicates that the watershed is less elongated with high relief and steep slope. The sub-watershed 2 is less elongated with maximum Re value, in contrast with sub-watershed 4 which is having elongated shape and less efficient in water discharge. Thus, SW3 and SW4 have more chances of water availability to support plant growth.

In sub-watershed 4 low texture ratio (Rt) of 3.78 depicts vulnerable soft and weak rocks with a fine texture to support vegetation (Sreedevi et al. 2013), whereas resistant rock ground in sub-watershed 1 has Rt value of 5.48. The Rt value for Shivganga watershed is 10.54 indicates texture which is a representative of basaltic terrain (Table 5). In general Rt decrease from source to mouth of river.

The circularity ratio (Rc) increases from 0.24 in SW1 to 0.36 for SW2 (Table 5). Its less value reveals that the basin is less elongated and characterized by moderate to high relief. High circularity ratio reflects rapid discharge from the watershed and less high yield delivery ratio (Singh 1992). It is influenced by the length and frequency of streams, geological structures, land use/land cover, climate, relief and slope of the basin.

The stream frequency (Fs) for the Shivganga watershed is 6.008 (Table 5). It ranges from 5.13 (sub-watershed 3) to 6.59 (sub-watershed 1). The stream frequency relates to permeability, infiltration capability and relief of watershed (Sreedevi et al. 2013).

Table 5 Areal parameters of Shivganga watershed to ascertain plant growth potential

Param-eter	Watershed	Watershed					Interpretation remarks
		SW	SW 1	SW2	SW3	SW4	
1	Rf	0.42	0.37	0.45	0.35	0.27	Low value, low peak flow and vice versa
2	Re	0.73	0.69	0.76	0.67	0.58	Low value, high relief and vice versa
3	Rt	10.54	5.48	4.87	3.95	3.78	Low value, fine texture and vice versa
4	Rc	0.42	0.30	0.36	0.34	0.24	Low circularity ratio, low discharge and vice versa
5	Fs	6.008	6.59	6.21	5.13	6.44	Low value, low permeability, infiltration capability, relief of watershed and vice versa
6	Dt	14.56	7.59	6.81	5.38	5.26	Low value, high thickness of soil and vice versa
7	Dd	4.60	4.97	4.93	3.81	4.95	Low value, low runoff with high flood peak and vice versa
8	Lg	0.43	0.40	0.41	0.53	0.40	Low value, more area and length of watershed and vice versa
9	C	0.26	0.22	0.20	0.20	0.20	Low values, Low thickness of soil and vice versa

The drainage texture (Dt) value of the Shivganga watershed is 14.56 (Table 5). Comparatively higher value of drainage texture has been obtained for sub-watershed 1 that depicts thin soil cover, steep to moderate land slope, poor vegetation cover and presence of sub surface hard rock, in contrast with sub-watershed 3 and 4 where low value of drainage texture favors plant growth (Som et al. 1998).

The drainage density (Dd) of Shivganga watershed is 4.60 km/km². It shows the lowest value 3.81 for SW3 and highest value 4.97 for SW1 (Table 5). High Dd values reflect high runoff with high flood peak, thin soil cover, low permeability of soil, steep to moderate land slope and low suitability for plant growth. Whereas the low Dd values are attributed to relatively permeable soil cover, good plant growth, land having gentle slopes and less runoff as in sub-watershed 3 and 4.

Low values of Overland Flow (Lg) are found in sub-basins 1, 2, and 4 which are associated with high relief and steep slope (Table 5). In contrast, sub-basin 3 has higher Lg value with relatively low relief and gentle slope. In general river basin like shivganaga, overland flow is a dominant hydrological process. In this study, the length of average overland flow is 0.43 km which shows high surface runoff.

The constant of channel maintenance (C) is extremely low in areas of close dissection whereas relatively larger basin area of lower order streams show high C values i.e. this characteristic is inverse to drainage density. The low C values are attributed to relatively permeable soil cover, good plant growth, land having gentle slopes and less runoff as in sub-watershed 3 and 4 (Table 5).

Relief aspects

In the study area, the value of relief ratio is 32.92 (Table 6). High Relief ratio (Rhl) value indicates a hilly region and a low value of relief ratio represents pedi plain and valley region. It has been observed that areas with low to moderate relief and slope are characterized by moderate value of relief ratios. Low values of relief ratios are mainly attributed to the resistant basement rocks of the basin and low degree of slope. High relief ratio values indicate high rate of stream flow velocity and the terrain is vulnerable to erosion resulting high sediment yield as in sub-watershed 1 coupled with less plant growth potential (Table 6) in comparison with sub-watershed 2 and 4 having less sediment yield and high plant growth potential (Fig. 4).

Fig. 4 Relief map of the Shivganga watershed

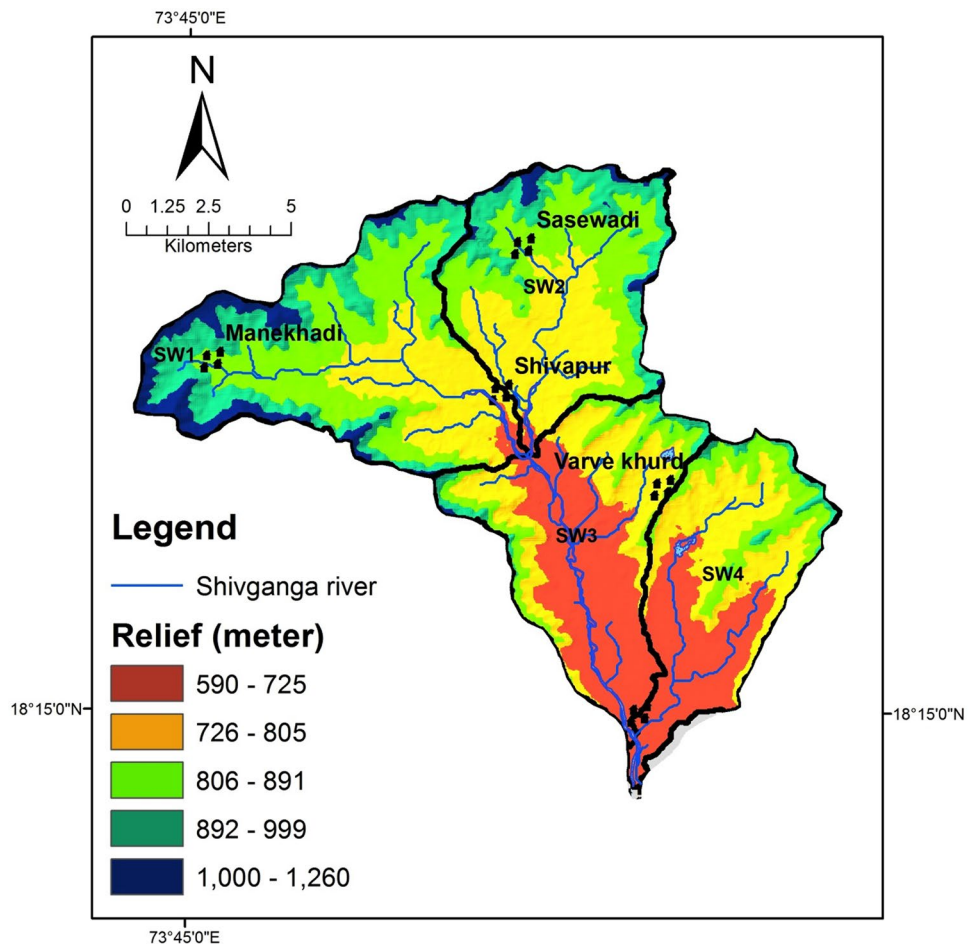


Table 6 Relief parameters for Shivganga watershed

Parameter	watershed					Interpretation remarks
	SW	SW1	SW2	SW3	SW4	
1 Rhl	32.92	27.89	20.89	22.17	21.65	Low value, plain area and vice versa
2 Cc	1.56	1.84	1.68	1.74	2.07	Low value, low plant support and vice versa
3 Average Slope	16.80	17.78	14.15	13.15	13.12	Low value, low erosion, high plant support and vice versa
4 z	606	714	717	622	606	
5 Z	1260	1260	1126	1056	1030	
6 H	654	546	409	434	424	

The compactness coefficient of Shivganga watershed is 1.56 (Table 6). Subwatershed wise SW2 has lowest compactness while SW4 has highest value indicating that SW4 has a potential to support the growth of plants. The entire watershed has compactness value less than its components which means that entire area can be easily used for proper grazing with a good potential for growth of flora.

The peripheral areas of sub watersheds in present study show steep slopes where first and second order streams are concentrated (Figs. 4, 5). High average slopes in sub-watershed 1 increases stream flow velocity, high erosion,

minimized length of overland flow and quick water flow into streams contributing to hydrograph rise (Samal et al. 2015). It has been observed that sub-watershed 3 and 4 have low average slope (Table 6) thereby, show significant plant growth and contributes less runoff, relatively less land erosion and low peaks in hydrograph.

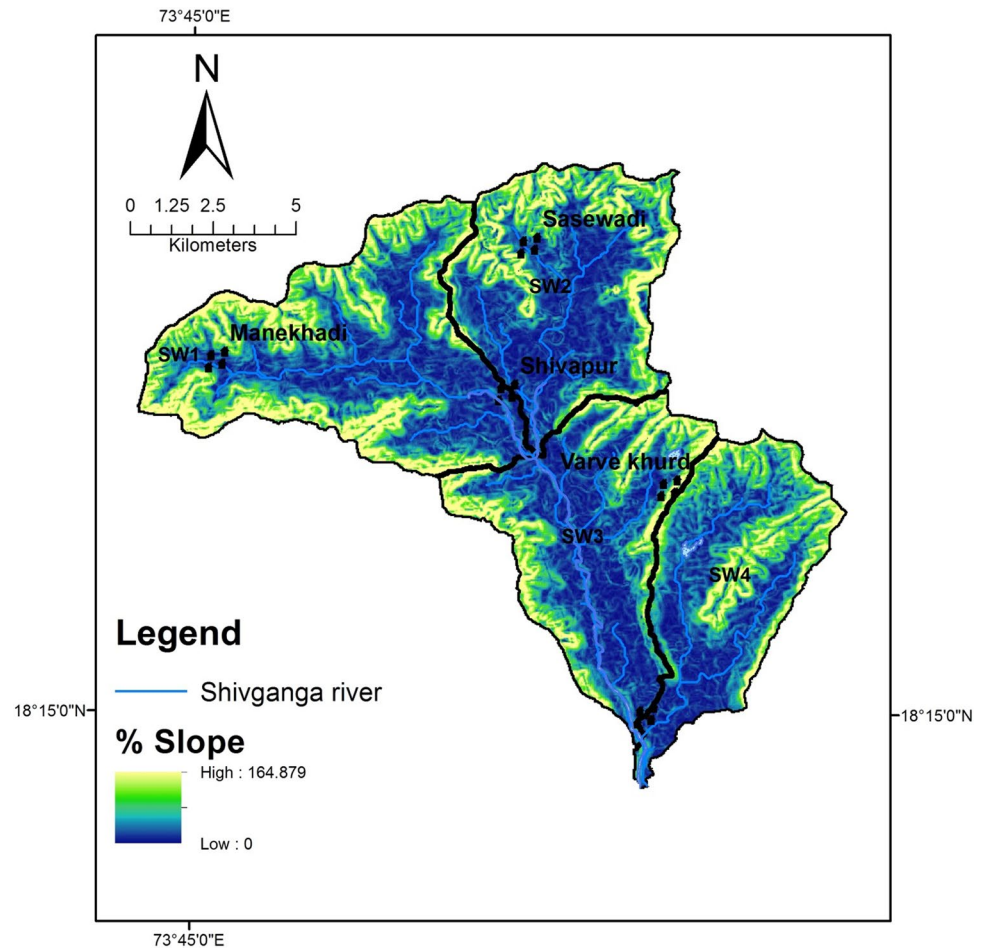
Fig. 5 Sub-watershed wise slope in percentage

Table 7 Preliminary ranking of sub-watersheds

Sub-watershed	Rb	Rf	Re	Rt	Rc	Fs	Dt	Dd
SW1	1	2	2	1	3	1	1	1
SW2	2	1	1	2	1	3	2	3
SW3	3	3	3	3	2	4	3	4
SW4	4	4	4	4	4	2	4	2

Table 8 Correlation matrix of morphometric properties for the sub-watersheds

Correlation parameter	Rb	Rf	Re	Rt	Rc	Fs	Dt	Dd
Rb	1.00							
Rf	0.13	1.00						
Re	0.80	-0.13	1.00					
Rt	1.00	0.13	0.80	1.00				
Rc	0.67	0.64	0.13	0.67	1.00			
Fs	0.40	-0.40	0.00	0.40	0.40	1.00		
Dt	1.00	0.13	0.80	1.00	0.67	0.40	1.00	
Dd	0.40	-0.40	0.00	0.80	0.40	1.00	0.40	1.00
Sum of correlations	5.41	1.10	3.40	5.81	4.60	3.20	5.41	3.20
Grand total	32.13	32.13	32.13	32.13	32.13	32.13	32.13	32.13

Sub-watershed wise prioritization on the basis of morphometric parameters for appraisal of plant growth

The parameters such as bifurcation ratio, stream frequency, form factor, elongation ratio, drainage texture ratio, circulatory ratio, drainage density, compactness constant and basin shape were used for the prioritization of sub-watersheds for preferential treatments. Linear parameters have an inverse relationship with plant growth potential i.e. higher the value, less the growth (Al-Rowaily et al. 2012). The highest value of the linear parameter was ranked 1, second highest value ranked 2 and so on as shown in Table 7.

After the ranking of the above mentioned plant growth influencing parameters, the correlation matrix was designed by using WSA technique (Table 7). Correlation analysis also shows that bifurcation ratio (Rb) bears highest correlation coefficients value with drainage texture (Dt) and texture ratio (Rt) followed by elongation ratio (Re). Similarly, the correlation between stream frequency (Fs), form factor (Rf), drainage density (Dd), circulatory ratio (Rc), drainage texture ratio (Rt), bifurcation ratio (Rb), and elongation ratio (Re) were also computed (Table 8).

The final weightages were calculated for each parameter by dividing the sum of correlation coefficient of each parameter by grand total of correlations. The grand total obtained from sum of correlations is 32.13. By assigning the weightages obtained to various parameters, a priority model is formulated (Eq. 1).

Table 9 Prioritization and final ranking of sub-watersheds for plant growth potential

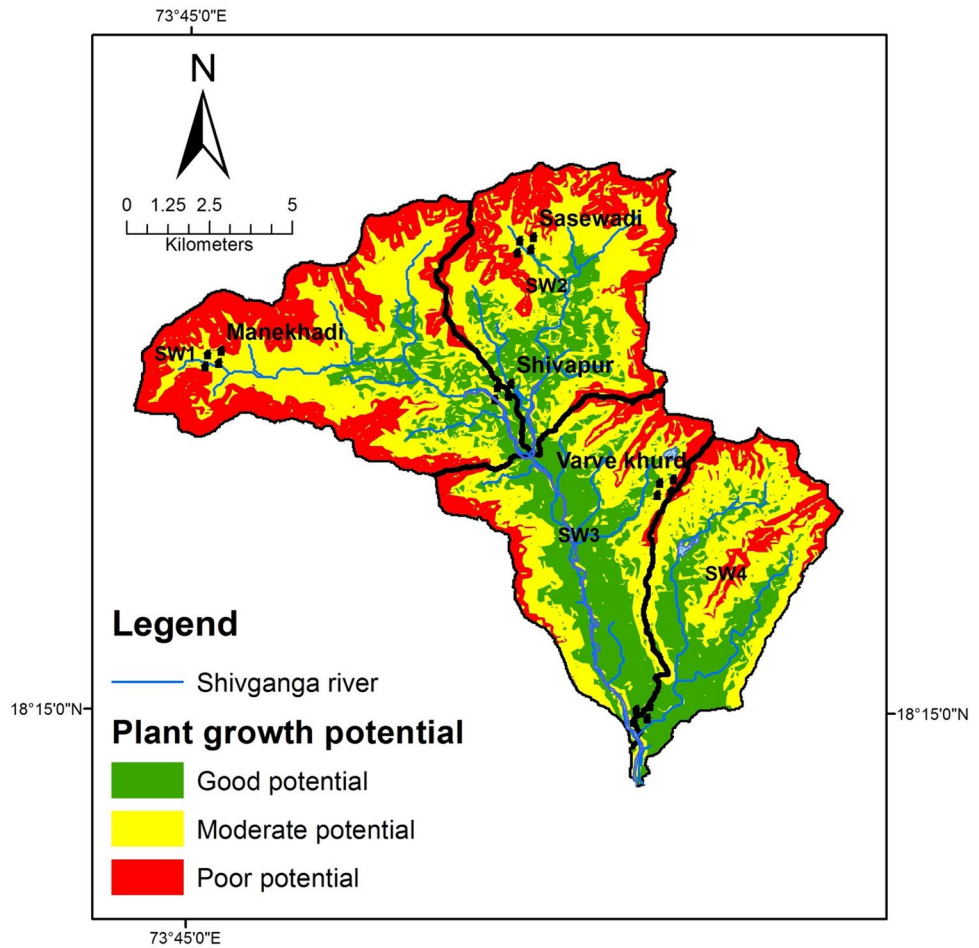
Watershed no	Compound parameter constant	Rank	Growth potential
SW1	1.317	1	Poor
SW2	2.448	2	Moderate
SW3	3.165	3	Good
SW4	3.601	4	Good

$$\begin{aligned}
 \text{Prioritization} = & (0.17 \times Rb) + (0.03 \times Rf) + (0.11 \times Re) \\
 & + (0.18 \times Rt) + (0.14 \times Rc) \\
 & + (0.10 \times Fs) + (0.17 \times Dt) + (0.10 \times Dd).
 \end{aligned}
 \tag{1}$$

Finally, the WSA values of all the four sub-watersheds were estimated on the basis of weightages of each morphometric component (Table 9). Thus, SW1 is given rank 1 with least compound factor value 1.317.

The spatial modeler tool in Arc GIS has been used to identify the suitable areas to delineate the potential areas for plant growth using thematic layers generated (soil, drainage density, steam frequency, relief and slope from DEM). The priority is given to the areas which have the combination of low weighted sum analysis values with low drainage density, gentle slopes, and a lower relief. The SW3 has highest potential for plant growth as it matches with the lowest weighted sum analysis (Table 10; Fig. 6).

Fig. 6 Potential green growth area map of Shivganga watershed



Conclusions

The study area is representative of basaltic lithology from Western Ghat with ample rainfall, but high drainage density/frequency along with high relief which warrants the need for identification of potential plant growth areas. The efforts were made to show the essential function of GIS and statistical tools in morphometric characterization as well as assigning priorities to all the sub-watersheds of the study area for watershed prioritization with focus on the plant growth potential. Weighted Sum Analysis (WSA) technique has been applied for identification and classification

of potential zones for management. The sub watershed wise accuracy correlation between weighted sum analysis and overlay analysis has shown upto 90% match with the plant growth potential areas. Weighted Sum Analysis method has proved to be effective technique, particularly over the data hungry prioritization approaches. Thus, the method would effectively be used in areas where primary and secondary data is scarce for assessment of the plant growth potential.

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Table 10 Sub-watershed wise potential plant growth identification

Plant growth area*	Sub-watershed			
	1	2	3	4
Poor	41.07	31.43	15.94	15.26
Moderate	45.29	45.79	38.66	46.84
Good	13.64	22.78	45.40	37.91
Total	100.00	100.00	100.00	100.00

* Area in percentage

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