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APPLICATION OF REMOTE SENSING AND GIS TO IDENTIFY THE SUITABILITY SITES FOR WATER CONSERVATION STRUCTURES

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ABSTRACT:
The increasing water scarcity with running days has been one of the common problem over a period of time. On top of it, when the area is a part of rain shadow zone, water conservation activities are must. The study demarcates potential sites for water conservation structures. Using GIS and Remote sensing, thematic layers of slope, geology, geomorphology, soil texture, soil erosion, soil depth, stream density, lineament density and LULC have been produced. Using ranking weighted method, the thematic layers were ranked and weighted. The weighted sum gave suitability zones using which, the area with the scope of sites for water conservation structures were located. The area already had a few existing structures and the study added to a few more sites to it. This will contribute in increasing groundwater level thus, more irrigation to agriculture fields leading to well productivity as well as supply the water in areas with water scarcity.

KEYWORDS: *water scarcity , soil texture, soil erosion, soil depth.*

1. INTRODUCTION

Water storage is like an insurance mechanism and acts as a barrier against the variability of the rainfall regimes and therefore increases the resilience of the stakeholder against dry spell during the rainy season (payen et al., 2012; Kumar et al., 2017). Development of groundwater level is critically depending on the sources of water, fast altering climatic trend and land degradation. This research concentrates on selecting suitable sites for the implementation of water conservation structures and aims to choose tentative sites for the planning of water preservation activities i.e. continuous contour trenches (CCT), cement nala bund (CNB), loose boulder structure (LBS) and check dams using ranking method. Multicriteria decision making (MCDM) refers to screening, prioritizing, ranking or selecting the alternatives based on human judgement from among a finite set of alternatives in terms of the multiple usually conflicting criteria (Roszkowska, 2013). Is there, multi thematic geo spatial datasets of Baramati, Daund, Indapure and Purandar is considered. The inputs used are land use land cover (LULC), digital elevation model (DEM), drainage map, slope map, lineament map, Soil erosion, soil texture, soil depth and other topographical features. GIS tools allow users to get the results by forming geospatial queries on the spatial information and edit the data obtained to form maps to present the outputs of all the operations (Mukhopadhaya, 2016). These techniques of site suitability require measurements that are to be regenerated to values which are common and are to be converted to ease out the final selection of the sites (Bunruamkaew et al., 2011; Mukhopadhaya, 2016). Integrated analysis of all thematic maps and their respective weightage in GIS platform could be utilize to prepare a map showing potential zones for water conservation structures and their appropriate measures (Lohar et al., 2018; Anbazhagan et al., 2005; Varade et al., 2017).

This study focuses mainly to find out suitable sites for various government water conservation programs using GIS. The data analysis in this research is done using several GIS tools like spatial analysis, density tool, conversion tool and other advanced geo processing techniques and ranking method. The purpose behind this analysis is to find suitable locations which would help to check runoff of water, silt deposition in water conservation structures and promote soil conservation in the downstream sites.

2. STUDY AREA

Study area is a part of Deccan Basaltic Province and includes four talukas of Pune district namely Baramati, Daund, Indapur and Purandar (Figure. 1) with an aerial extent of 5250 sq.km. The study area is bounded by 73°53’13” E to 75°9’44” E Longitude and 17°53’41” N to 18°40’15” N Lati73°53’13” E to 75°9’44” E Longitude and 17°53’41” N to 18°40’15” N Latitude. The gradation elevation of the study area is from east to west, with the highest elevation of 1364m. from msl. And the lowest being 440m from msl. The area experiences sub-tropical to tropical temperate monsoon climate with a hot summer and general dryness throughout the year except during the south-west monsoon season. Geologically the western Maharashtrais covered by basaltic lava flows commonly known as Deccan trap of Cretaceous-Eocene age (Gaikwad, 1977).

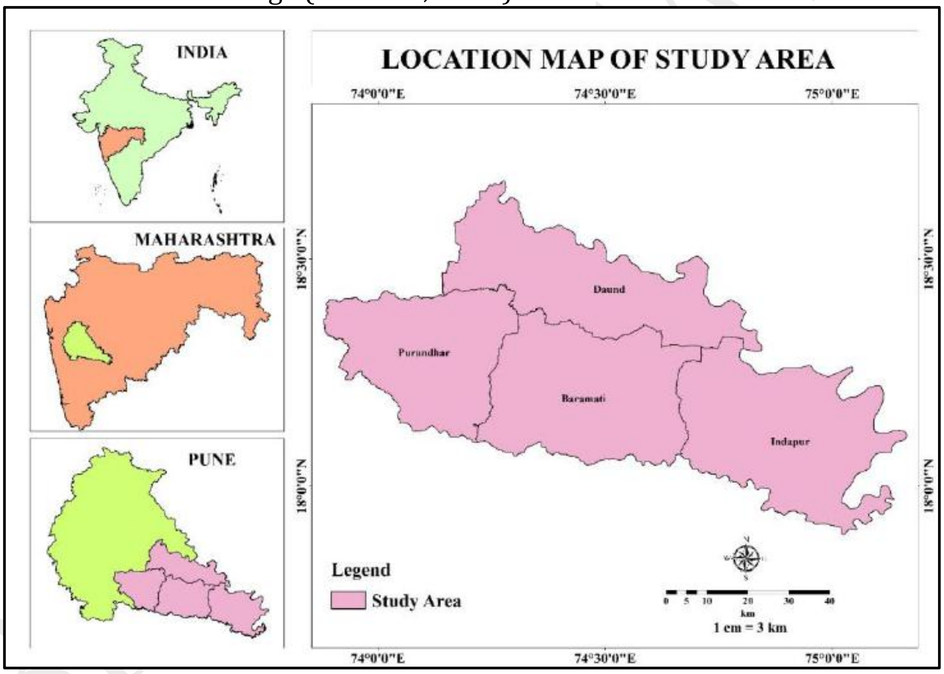

Figure 1. Location map

3. METHODOLOGY

Multi thematic dataset of nine layersare considered. The streams were created by digitizing from toposheets. Density of lineament and stream network was found out and reclassified. All the classes were rearranged by generating LULC from LISS IV image by using Iso cluster unsupervised classification. The ancillary data, after converting into raster from vector dataset, was reclassified for further process. Slope map that was generated from DEM was reclassified. After that, ranks were assigned based on cross parameter relationship on the importance of each parameter with reference to other parameters. Finally, the site suitability for water conservation structure is calculated.

As per the IMSD guidelines following criteria have been followed for selecting the suitable sites for water storage structures (Singh et al., 2009; Padmavathy et al., 1993; Kumar et al., 2017).

1. The slope should be less than 15%
2. The land use may be barren land, scrub land and river bed
3. The infiltration rate of the soil should be less
4. The type of soil should be sandy loam

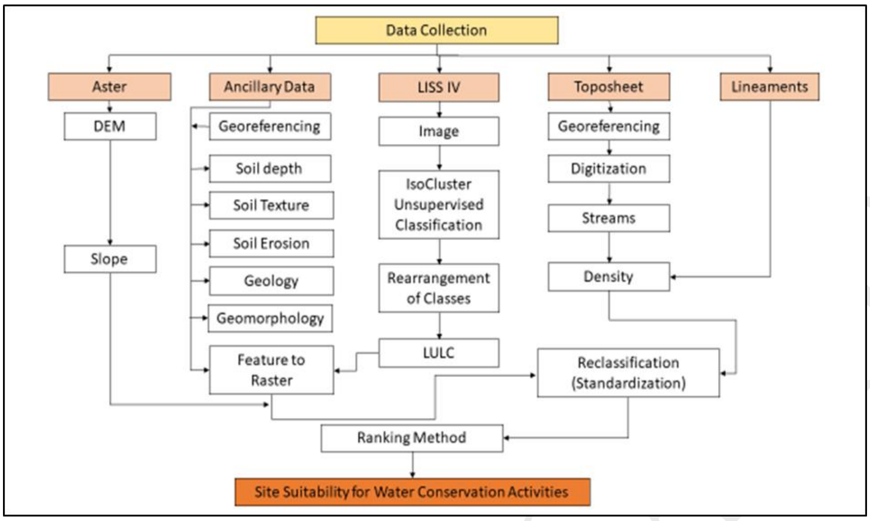

Figure 2. Methodology

3.1 Ranking Method and Reclassification of the layer

Site selection analysis can be performed with vector or raster data but one of the most widely used types selection, weighted site selection uses raster data. [https://www.gislounge.com/overview-weighted-site-selection-suitability-analysis]

Reclassification of the thematic layers was done by ranking the various classes contained in each map. This gives an output which is far easier and accurate to analysis the suitability for water conservation structures. Also, in the reclassification certain classes were merged together to form a single class. For example, under geomorphology, from seven classes, two classes were merged together and classified into single class. Likewise, based on necessities the number of classes are reduced for other theme. All the thematic maps which were vector polygons were rasterized. According to the factor's influence, it was ranked from ten to one, i.e. the highest with ten and the lowest with four (Table.1). After determining the relative importance, values of the entities from the highest to the lowest priorities, the score range of the entire entities is set by considering the relative importance difference between the highest priority entity and the lowest priority entity (Song and Kong, 2016). All the nine thematic maps used for analysis were reclassified and ranked based on expert's opinion. The scale for ranking is of descending naturei.e. 10 to 1. This means that ranking of 10 for a class within a theme will be having a higher suitability for water conservation structures compared to the one with a ran of 9. A rank of one means that the suitability for water conservation structures is very poor. Reclassification is basically done by giving a "Weight" for each class for various thematic maps (as given in the Table. 1).

Streams were reclassified into three classes from the prior four classes and the ranks were given.

Table 1.Reclassification and Ranking to Thematic Map (Author)

Thematic maps	Classes with each map	Overall ranking	Weightage	Total weight
Stream	High	10	3	30
	Moderate		6	60
	Low		9	90
Lineament	High	9	9	81
	Moderate		7	63
	Low		5	45
	Very Low		3	27
Slope	High	8	3	24
	Moderate		8	64
	Low		6	48
Soil depth	Waterbody Mask	8	3	24
	Shallow to very shallow (< 25 cm)		5	40
	Very deep (> 100 cm)		9	72
	Moderately deep (25 to 50 cm)		7	56
	Shallow (10 to 25 cm)		4	32
	Habitation Mask		3	24
	Deep (50 to 100 cm)		8	64
	Very shallow (< 10 cm)		3	24
Geology	10-15"aa" and simple basaltic lava flows (50-350 m)	7	6	42
	11-16"aa"and simple basaltic lava flows (100-300 m)		4	28
	5"aa" basaltic lava flow (50-180 m)		5	35
	3 compound pahoehoe flow M3 (50-220m)		5	35
	5"aa"and compound pahoehoe basaltic lava flows (50-220m)		7	49
	1"aa" basaltic lava flow (80-100 m)		7	49
	Megaphenocryst "aa" flow M4 (50-70 m)		7	49
Soil texture	Waterbody Mask	6	3	18
	Gravelly sandy loam		8	48
	Clayey		4	24
	Gravelly sandy clay loam		7	42
	Habitation Mask		3	18
	Clay loam		6	36
	Loamy sand		7	42
	Sandy clay loam		6	36
	Gravelly clay loam		7	42
	Sandy loam		6	36
	Gravelly clay		7	42
Geomorphology	Water Body Mask	6	3	18
	Habitation Mask		3	15
	Flood Plain/Alluvial Plain		5	40
	Denudational Hill		8	32
	Plateau		6	36
LULC	BUILT-UP	6	3	18
	Wastelands		5	30

Thematic	Classes with each map	Overall	Weighta	Total
	Agriculture		7	42
	Grassland/Grazing land		8	48
	Forest		7	42
	Water bodies		3	18
Soil erosion	Waterbody Mask	4	3	12
	Severe to very severe		3	12
	None to slight		9	36
	Slight to moderate		7	28
	Severe		5	20
	Habitation Mask		3	12
	Slight		8	32
	Moderate		6	24
	Moderate to severe		6	24

3.2 Weight Assignment

Equal weightage approach assigned of relative importance which is simple map overlay method of GIS in which all parameters are treated to be of equal importance (Prasad, 2014). A weight can be defined as a value assigned to an evaluation criterion which indicates its importance related to other criteria under consideration. There are four different techniques when assigning the weights: ranking, rating, pairwise comparison, and trade of analysis method (Al-Anbariet al., 2018). The reclassification thematic maps were assigned ranking based on cross parameter relationship on the importance of each parameter with reference to other parameters. The weight for all sub classes are given according to experience, expert opinions, and information from various sources. Knowledge acquisition has been accomplished through discussions with expert of related fields of study and previous literatures related to the topic. The weight is selected according to the professional expert's opinion. Total weight is obtained by multiplying overall ranking to the weightage of each subclass respectively. The total weight is assigned to the thematic layers resulting into thematic maps (Figure. 3 to 11).

Overall rank of stream is ten, and the weightage, based on knowledge, of three for high stream density, six for moderate and nine for low (Table. 1). Same criteria for overall ranking and weightage is applied to all the thematic maps.

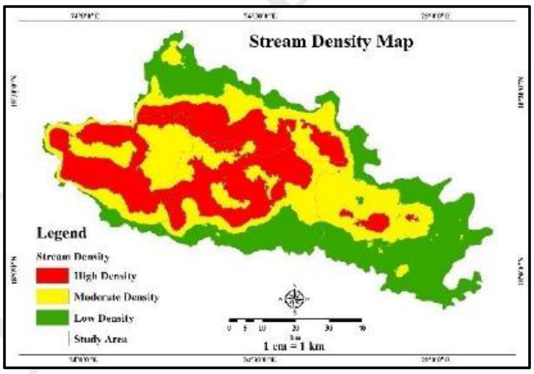

Figure 3. Stream density map

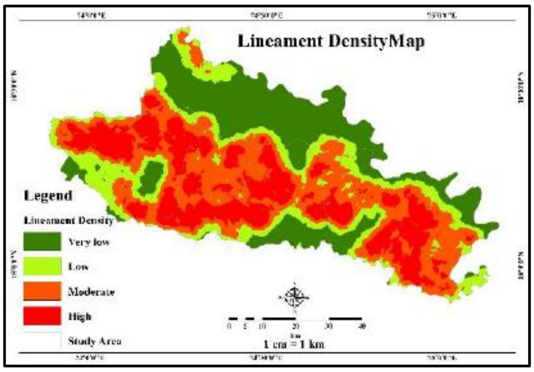

Figure 4. Lineament density map

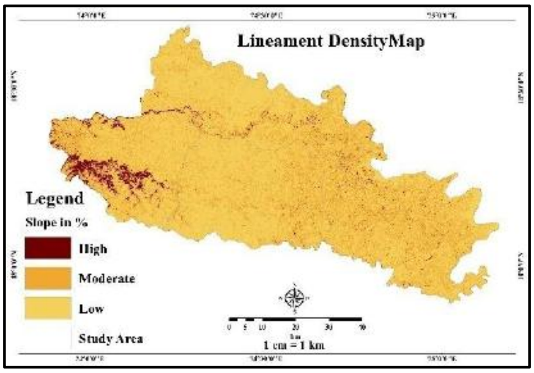

Figure 5. Slope map

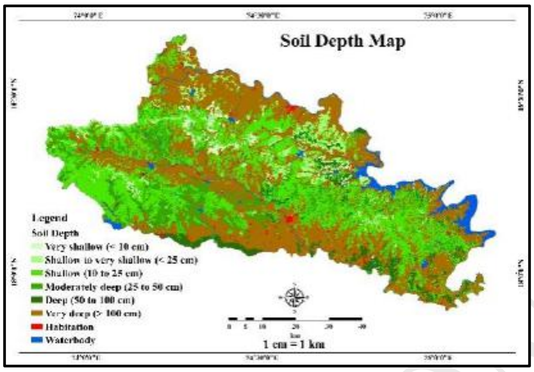

Figure 6. Soil depth map

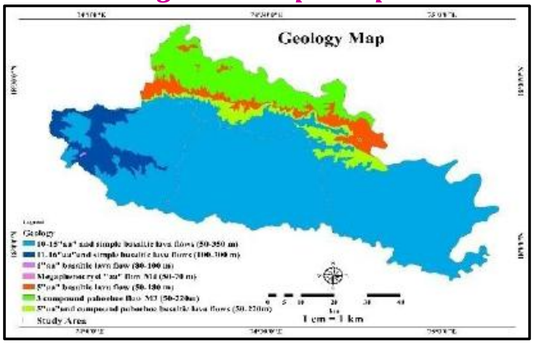

Figure 7. Geology map

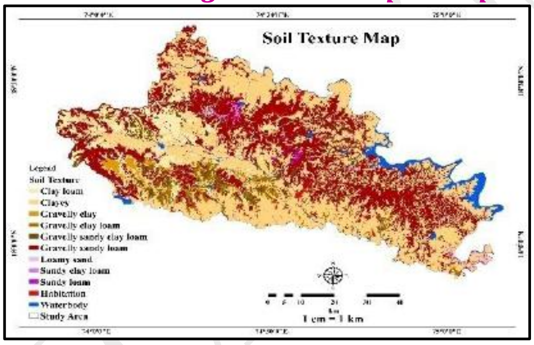

Figure 8. Soil texture map

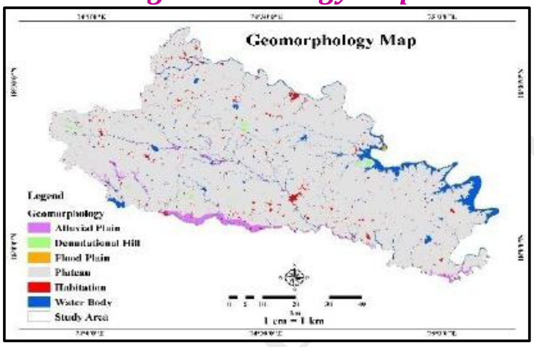

Figure 9. Geomorphology map

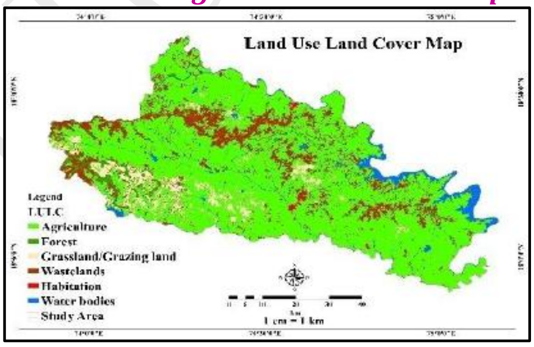

Figure 10. LULC map

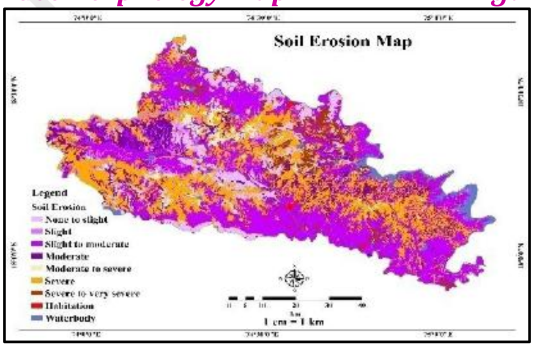

Figure 11. Soil erosion map

4. RESULT AND DISCUSSION

The assessment of spatial and non-spatial factors is done using the decision making method i.e. ranking weighted overlay method. The final output showing suitable zones is the result of weight ranks assigned.

The result implies that maximum area falls under moderate suitable zone and not suitable zone. The result helps to find out suitable sites for implementation of water conservation activities, which will help to improve soil moisture as well as groundwater level. Some of the water conservation structures already exist in the study area. On addition to it, some more new structures can be added into this area as shown in Figure. 13. This study will help to save money and time which is required to implement government policy or water conservation programs in this region.

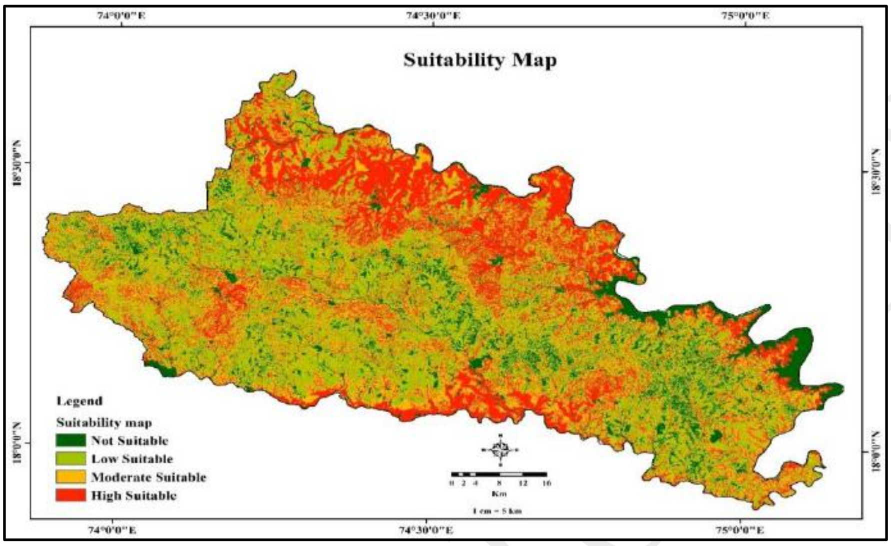

Figure 12. Suitability Map

4.1 Suggested Water Conservation Structures

Table 2.Site selection criteria for water conservation structure (Pandey et al., 2011)

Sr. No	Type of Structure	Stream Order	LULC	Slope
1	CNB	3rd order stream	Scrub land	Moderate slope
2	CCT	2nd and 3rd order stream	Barren land	Moderate slope
3	LBS	2nd order stream	Barren land	Steep slope
4	Check dam	3rd and 4th order stream	River (nearby Agricultural land)	Gentle slope

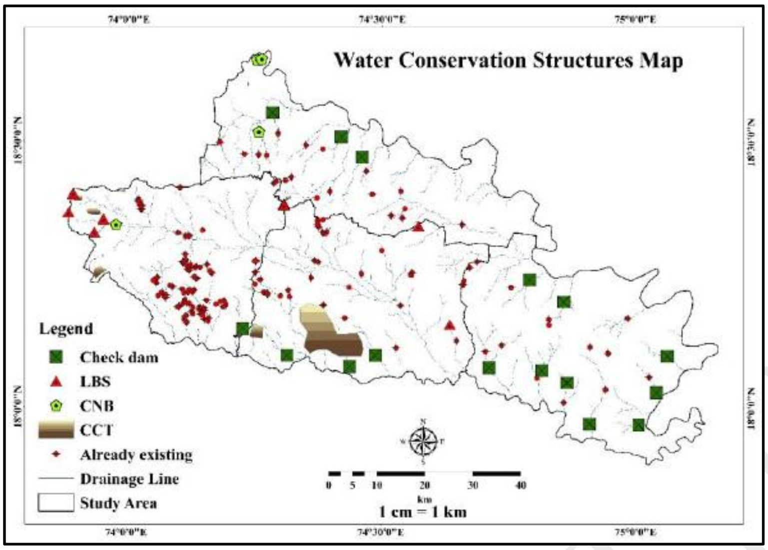

Figure 13. Suitability Map

5. CONCLUSION

Integrated GIS has provided theappropriate platform for analysis of multi-disciplinary data. Produced map will help in theselection of the suitable location of water conservation structures and hence, help in waterconservation in water depleted area. The study area has full scope for construction of contour trenches, check dams, loose boulder structures and cement nala bund. As the selected study area falls under rain shadow zone, it is necessary to conserve water as much as possible in all possible ways. This will help to improve ground water level, and irrigation facility which will bring out the best outcome of the agricultural productivity. This will also solve the issues related to water scarcity for domestic use as well. The water conserved will help in overall sustainable development of the area.

The final result or suitability map represents abilities of GIS and ranking techniques.The majorproblem of this technique was assigning proper weights for each criterion and thus, has strongly affected the suitability result. The final resulthighlights water conservation sites in the study area. The same technique can be appliedfor another region having similar properties as of the selected study area.

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