Identification of Suitable Sites for Water Conservation Structures in a Watershed using RS and GIS Approach

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Abstract— Geographical Information System is the technique which is used for preparation of thematic maps and combining all the layers and performance analysis. In the present study, an attempt has been made for identification of suitable site for water conservation structures in a watershed GV53 and GV54 of Aurangabad district of Maharashtra using Remote Sensing and Geographical Information System. Data such as toposheets, Landsat 8 satellite imagery, and soil map were used .The various thematic maps such as land use map, soil map, slope map and drainage map are integrated. Fourteen check dams and seven percolation tanks are proposed for construction according to guidelines for selecting suitable site for construction of water conservation structure as per Integrated Mission for Sustainable Development.

Key words: Geographical Information System, Remote Sensing, Water Conservation Structures, Check Dam, Percolation Tank

I. INTRODUCTION

The groundwater resources in the State of Maharashtra have various limitations, mainly attributed to typical physiographical, geological and hydro geological conditions coupled with with vagaries of monsoon [2].Geologically, most of the State (about 80 % areas) is covered by hard rock formation of Deccan trap basalt, and 33 % of geographical area is occupied by hilly portion [CGWB 2003]. As a result, the State experiences drinking water scarcity problem. The scarcity situation at a time is alarming and therefore demands adoption of appropriate water conservation techniques. To combat such situation, it has become necessary to identify, develop and implement the groundwater recharge systems. For this, implementations of appropriate water conservation measures to capture the rainwater runoff have become essential [2]. Realizing this fact, the Government of Maharashtra is embarked upon implementation of water conservation through watershed development programs. However, most of the time, the programs lack multidisciplinary approach due to which the desired impact is not achieved. Thus, there exists a demand for development of geospatial technique for estimating watershed characteristics.

Remote sensing technique provides a sound realistic database on resources, while the GIS technique not only helps in storage, retrieval and analysis of spatial database in computer system but also facilitates the spatial analysis through intersection and manipulation process. Remote sensing and GIS technologies permit rapid and cost effective natural resource survey and management. Moreover, remotely sensed data serve as vital tools in ground water prospecting in identifying landform features, drainage pattern and geomorphic indicators for location of recharge and discharge area. Analysis of geomorphologic condition is an essential prerequisite in understanding water bearing characteristic of most rocks.

The various researchers tried for finding the site suitability for water conservation structures viz. (V. V. Gavade, et. al., Abhay M. Varade et. al., JP Singh et. al., Umapathi BN et. al., Yogesh Bamne et. al.).

The maximum runoff water goes down without being used for any purpose due to steep slope and stones in the soil causing soil erosion and converted into degraded land. Due to steep slope water gets down with very high speed and it cannot be directly stored in the reservoirs. The surface runoff can be checked by constructing structures like check dams, farm ponds, nala bunds, percolation tanks, contour trenches etc. These structures may differ with different parameters viz., location, slope, soil type, rainfall intensity, land cover and settlement. Depending on these parameters, the construction of check dams, percolation tanks are to be proposed at appropriate sites in GV53 and GV54 watersheds. The planning about the required number and type of water conservation structure to be constructed in watershed and making decision on them is extremely important to avoid large investments on unproductive structures. The present study envisages the potential suitability for different water conservation structures in GV53 and GV54 watersheds with the help of Remote Sensing and Geographical Information System.

In the present study attempt has been made for finding the site suitability for water conservation structures using techniques such as RS and GIS.

II. MATERIALS AND METHODS

A. Study Area

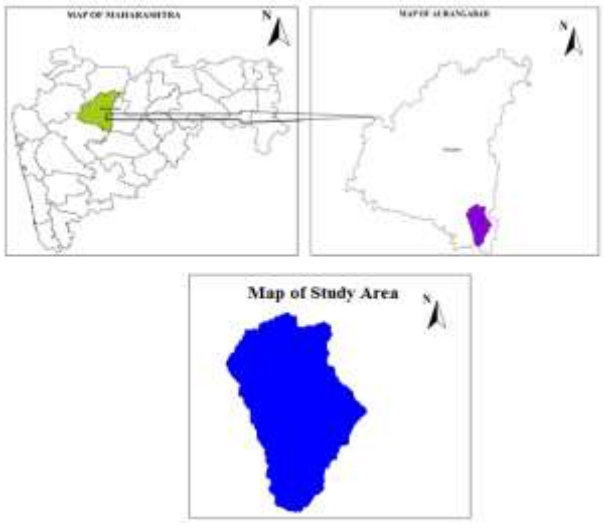

Fig. 1: Study area

A study area is GV-53 and GV-54 watershed lies in Aurangabad district of Maharashtra, as shown in fig (1)

having longitude 75° 43' and 76° east and between the latitude 19° 42' 03" and 19° 68' 27" North. Total area of the catchment is 313 km^2. The area falling under toposheets bearing no. 43-3 published by survey of India on a 1:50000 scale. Aurangabad district features a semiarid climate. Most of the rainfall occurs in the monsoon season from June to September. Thunderstorms take place between November to April. The district is frequently cloudy during the monsoon season and the cloud cover may remain throughout the days.

III. METHODOLOGY

The maps of GV53 and GV54 watersheds were delineated from Survey of India toposheet. The base map was prepared through visual interpretation of satellite data, showing various permanent structures, delineating watershed boundary, drainage network, etc. The digital analysis was carried out using GIS tool (Arc GIS Ver 10.1). The stepwise method for preparation of various maps is presented through flowchart fig (2).

A. Site Selection of Water Conservation Structures

The following criteria have been followed for making decision on selecting suitable site for various water harvesting structures as per Integrated Mission for Sustainable Development guidelines.

1) Check dams

- The slope should be less than 15 per cent.
- The land use may be barren, shrub land and riverbed.
- The infiltration rate of the soil should be less.
- The type of soil should be sandy clay loam.

2) Percolation tanks

- The slope should be less than 10 per cent.
- The infiltration rate of the soil should be moderately high.
- The land use / cover may be barren or scrub land.
- The type of soil should be silt loam

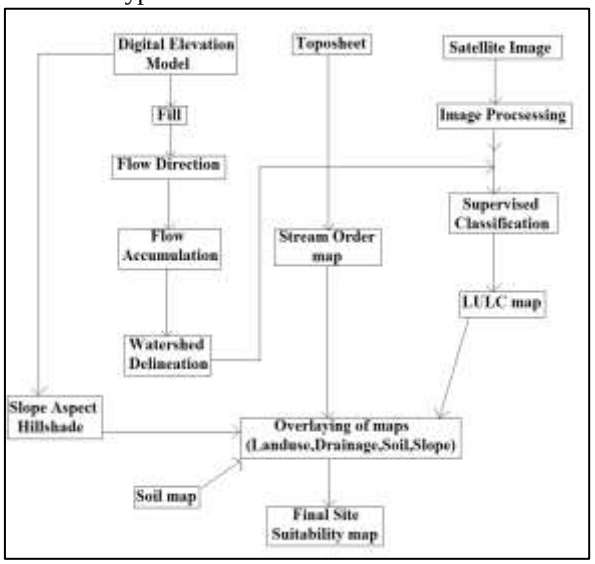

Fig. 2: Flowchart for Preparing Site Suitability Map

B. Geo-referencing and Digitization

Geo-referencing of scanned maps was carried out in Arc GIS using control points already established on the base map. The four latitude and longitude values of the control points located on top left, top right, bottom left and bottom right corners of the map were assigned corresponding latitude/longitude values are later converted into polygonic projected system using Arc/Info GIS software after performing rectification. On screen digitization of scanned maps was performed in Arc GIS software by creating various shape files

C. Thematic Maps

1) Land Use Map

Land use map (Fig 3) was prepared using Landsat 8 satellite data considering five different classes of land use. (i) Water body (ii) Urbanization land (iii) Forest land (iv)Agricultural Land (v) Barren land Land use map was further classified based on suitability for different water conservation structures.

2) Drainage Map

Drainage map was prepared by digitizing drainage from Survey of India toposheet as shown in Fig 4

3) Soil Map

Soil map (Fig 5) was prepared using texture map of 1:50000 scale which is collected from National Bureau of Soil Survey and Land use Planning, Nagpur. Three types of soil are present in the study area viz. deep black soil, shallow black soil, and medium black soil.

4) Slope Map

The slope map was prepared from Digital Elevation Model map (Fig 6). The slope map is extracted (Fig 6) from DEM. The slope designated in value domain was prepared using filtering technique. The slope map was further classified for exploring potential suitable sites for several water conservating structures

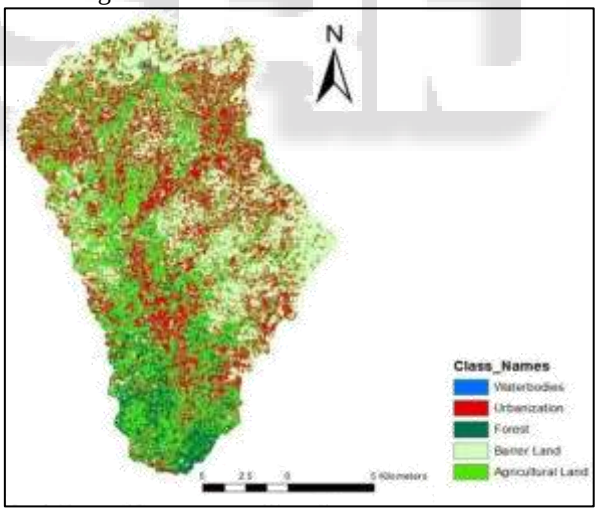

Fig. 3: Land Use Land Cover Map of Study Area

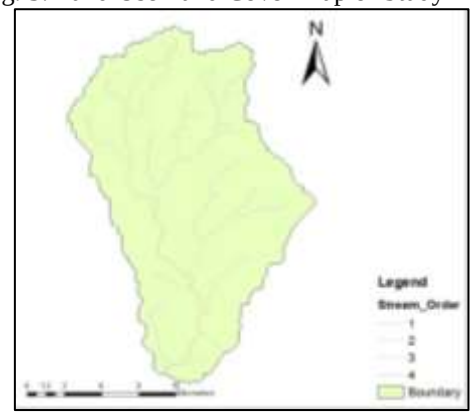

Fig. 4: Drainage Map of Study Area

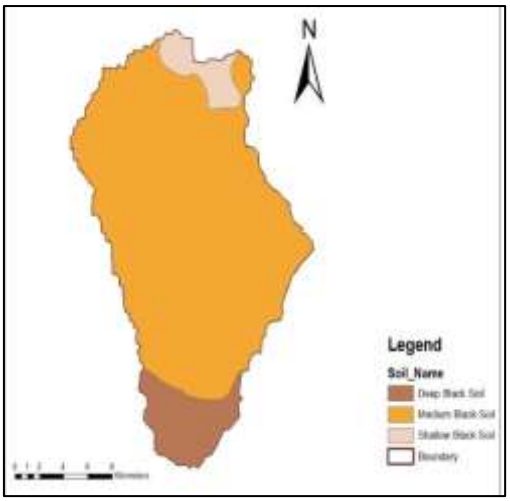

Fig. 5. Soil Map of Study Area

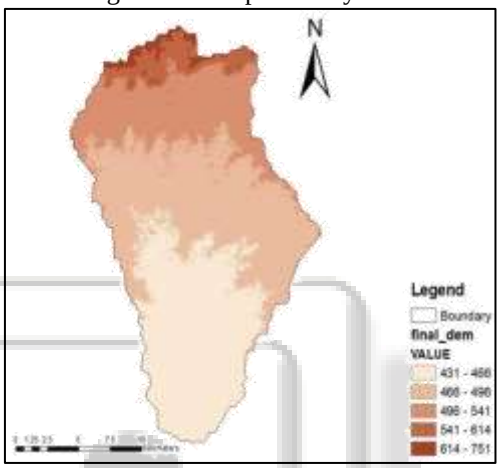

Fig.6. Digital Elevation Model

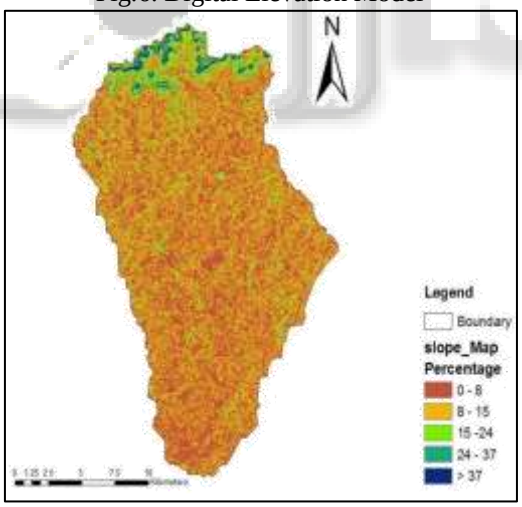

Fig. 7: Slope Map of Study Area

D. Site suitability map for water conserving structure

The cross operation was performed using classified land use map and Soil map.

In the next iteration suitable land use and infiltration rate, suitable soil feature and suitable stream order are intersected and overlaid on slope map for locating suitable sites for water consecrating structures. The site suitability map (Fig 8) for water harvesting structures was then obtained.

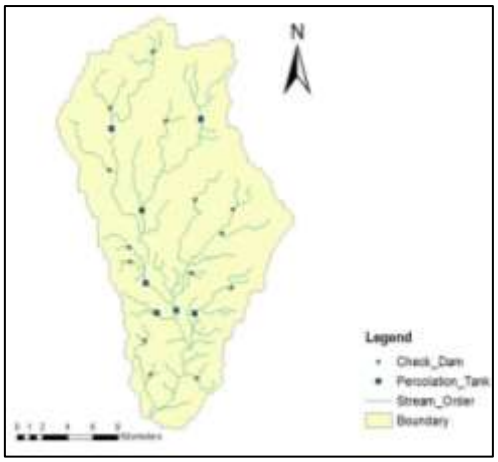

Fig. 8: Site Suitability Map for Check Dams and Percolation Tanks

IV. RESULTS AND DISCUSSION

Land use map shows agricultural land 92 km^2, forest land 24 km^2, urbanization land 89 km^2, barren land 85 km^{2}and water body having less than 1 km^2. From drainage map it is found that drainage is of fourth order. soil map indicate deep black cotton soil 30 km^2, medium 269 km^2 and shallow soil 15 km^2 . slope of the study area categorized in to 0-8, 8-15, 15-24, 24-37 percent and above. The overlay operation of land use map, soil map, stream order map and slope map was carried out for water conservating structures and presented through site suitability map.

A. Suitable Sites for Check Dams

The suitability of check dam sites confirmed as the site is located on second and third order drainage and satisfies the conditions of land use, soil type and slope.

As per guidelines 14 suitable sites were proposed to construct the check dam. Since it is located in suitable land class (barren land), slope (less than 15%) and soil type (sandy clay loam).

B. Suitable sites for percolation tanks

The suitability of percolation tanks sites confirmed as the site is located on third and fourth order drainage and satisfies the conditions of land use, soil type and slope.

As per IMSD guidelines in GV53 and GV54 watersheds there are 7 suitable sites were proposed to construct the percolation tank. Since it is located in suitable land class (barren land), slope (less than 10%) and soil type (sandy clay loam).

V. SUMMARY AND CONCLUSIONS

Water conservating structures are extremely important to conserve precious natural resources like, soil and water, which is depleting day by day at alarming rate. Keeping this in view, GV53 and GV54 watershed is selected for planning suitable sites for construction of water conservating structures using remote sensing and GIS techniques. The potential sites for water conservating structures in GV53 and GV54 watersheds were identified through modern technologies of remote sensing and GIS and 14 check dams and 7 percolation tanks at appropriate sites are proposed.

Proposed check dam could be useful for protective irrigation and percolation tank augument ground water table.

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