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Planning of Appropriate Soil and Water Conservation Structures for Chhatra Sub Watershed in Raichur District, Karnataka

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Abstract Chhatra sub watershed lies between $76^0$24´ to $76^0$29´ East longitudes and $15^0$51´ to $15^0$55´ North latitudes in Raichur district of Karnataka and having an area of about 2134.60 ha. Study area falls under the arid tract and drought prone region of Karnataka. The mean annual rainfall of study region is 621 mm and ground water resources are also very scares. So, conservation of soil and water place prime importance for sustainable development of the agriculture. To adress problem of water scarcity, the check dam, percolation tank, nala bund and farm ponds were proposed for the various parts of the Chhatra sub watershed. Sol topomaps of 1: 50,000 scale was used for preparation of drainage order map and contour map. Later digitized contours were converted into DEM. The slope map was prepared from the DEM under GIS environment. Land use map was prepared from the IRS LISS-III satellite image under Erdas imagine software. For the present study area, 10 check dams, 5 percolation tanks, 8 nala bunds and 4 farm ponds were proposed.

Keywords Watershed, RS, GIS, DEM, LISS.

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Introduction

Land and water are essential for primary production system as well as for meeting needs such as food, fodder, fiber, shelter, communication and other requirements. Reliable and timely information on the available natural resources like soil and water are very much essential to formulate a comprehensive land use plan for sustainable development. The soil and water resources are currently under tremendous pressure in the context of highly competing and often conflicting demands of an ever-expanding population. Consequently, over exploitation and mismanagement of resources are exerting detrimental impact on environment. Serious consideration has to be given to the conservation and proper management of land and water to support the likely increase in population and provide a better standard of living (Saxena and Prasad 2010). Planning, assessment, management and utilization of natural resources, especially land and water at local level, assume prime importance. Owing to the synergistic effect of land and water resources within a watershed, the watershed approach is more rationally being employed in various developmental programs of the country. For giving practical shape to the systematic, scientific and rational approach of watershed as a unit of planning and development, a proper delineation of a watershed is a pre-requisite.

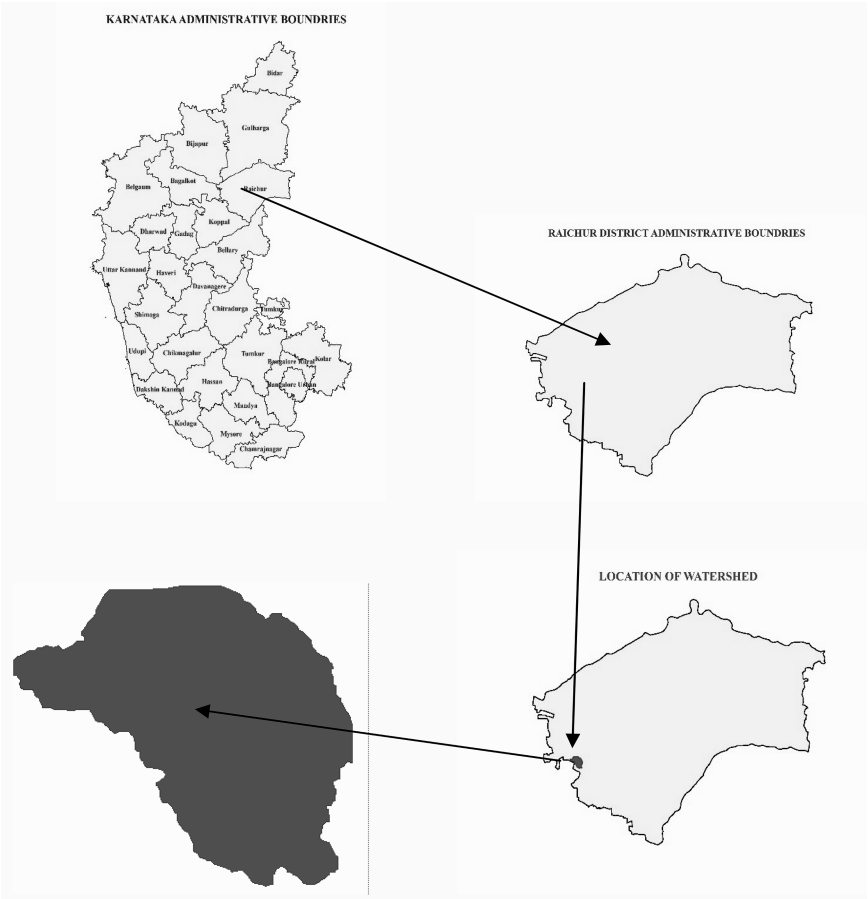

Fig. 1. Location map of Chhatra sub watershed.

The watershed management using remote sensing and GIS techniques were emerged as powerful tools in recent years. Remote sensing is used for detection and measurement of the spectral response and spectral signatures and enables identification of surface objects both from airborne and space borne platforms. GIS provides a digital representation of the watershed characterization used in the hydrologic modelling. During the systematic survey of watershed, factors like physiography, soils, vegetation, land use, slope and drainage pattern are considered simultaneously and huge amount of attribute data are required to be collected. One of the major advantages of GIS is its capability to overlay multi-thematic data, which could be used in hydrological models or in integrated watershed management planning. The results thus obtained are much more realistic, comprehensive and less time consuming.

Considering the importance of RS and GIS techniques in watershed management, the sub-watershed area in semi-arid region of Raichur district was selected for the present study. The objective of the present study is to digitize of streams and prepare a stream order map. To plan the suitable soil and water conservation measures for the selected sub watershed by integrating the stream order map with various thematic maps and relevant information. Remote sensing data provide exact information on land use and land cover, existing water bodies and its water stagnant area and geomorphic indicators like streams and vegetation. Survey of India (Sol)

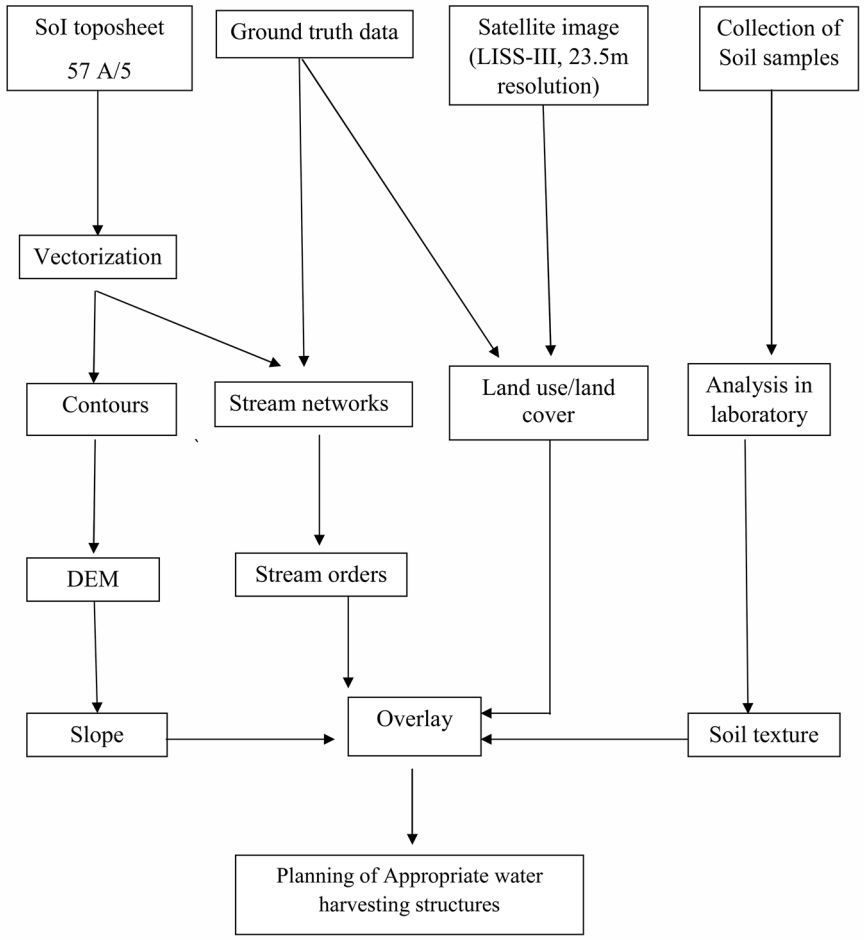

Fig. 2. The flow chart of methodology for planning of suitable soil and water conservation measures.

toposheet provide information on drainage pattern, contours and other collateral data.

Study area

The Chhatra sub watershed lies between $76^0 24'$ to $76^0 29'$ East longitudes and $15^0 51'$ to $15^0 55'$ North latitudes in Raichur district of Karnataka. The climate is semi-arid and the region is characterized by high day temperature, low humidity and excessive evaporation during summer and pre-monsoon periods. The mean annual rainfall of the study region is 621 mm. The agricultural practices are majorly dependent on south-west monsoon and has limited surface water and ground water resources. So, irrigation potential of the watershed is low. Location map of Chhatra sub watershed is shown in Fig. 1.

Materials and Methods

Preparation of thematic maps

In the present study, drainage network and contours were generated from the Survey of India toposheets on 1:50,000 scale and digitized contours were converted into a DEM for the study area under GIS environment. Slope map for the study area is derived from DEM and for the slope classification is adopted from the guidelines of Soil Survey Manual (1962). The land use/land cover map was prepared

Table 1. Site selection criteria for water harvesting structure for Chhatra sub watershed.

Sl. No.	Structure	Slope %	Drainage order	Soil permeability	Land use	Catchment area
1	Check dam	Upto 10%	Upto 3rd	Moderately to highly permeable	Agriculture land	Upto 25 ha
2	Percolation tank	0-3%	2nd and 3rd	High permeability	Open scrub or waste land	> 5 ha
3	Nala bund	0-5%	Upto 3rd	Moderately to low permeability	Open scrub or waste land	> 20 ha
4	Farm pond	0-3%	1st order or sheet water harvesting	Low permeability	Agricultural land	> 2 ha

by supervised classification of LISS-III satellite image downloaded from Bhuvan official website. Soil texture map was done by collection of soil samples in the sub watershed and analyzed in the laboratory. The standard soil textural classes were adopted from Piper (1966) guidelines.

Planning of suitable soil and water conservation structures

In the present study, developmental structures such as, check dam, percolation tanks, nala bund and farm ponds were suggested in the watershed considering characteristics of the sub watershed into account. This approach involves preparation of different thematic maps (resource maps) viz., drainage network with drainage order, soil, slope and land use/land cover by using remote sensing data and/or by conventional sources under GIS environment. Combining these thematic layers under GIS environment using a set of logical conditions, conservation structures map was generated. The work flow chart for soil and water conservation structures and their location is shown in Fig. 2.

The guidelines for the selection of suitable sites for location specific activities are adopted from IMSD guidelines (1995), Chowdary et al. (2009), Pandey et al. (2011). The selection criteria for planning of soil and water conservation structures is presented in the Table 1, based on the stream order, land use type, soil and slope conditions of the watershed.

Results and Discussion

The results of the study conducted in Chhatra sub watershed on the planning of soil and water conservation structures by integration of various thematic maps viz., stream order map, slope map, soil texture map and land use/land cover map are presented below.

Stream order map

Drainage map was prepared by using Survey of India toposheet on 1:50,000 scale. The highest stream order is 4th order and 49 streams were found in the entire watershed. The stream number of 1st, 2nd, 3rd and 4th order streams were found to be 36, 9, 3 and 1 respectively. The Fig. 3 shows all number of stream segments with its length and their location in the sub watershed.

Slope map

The slope map was derived using the DEM for the study area. Five slope classes were generated. The slop gradient of the drainage line is a key factor for the selection of suitable locations of conservation structures in order to get the maximum storage capacity in the channel. It also affects the amount of runoff. The areal extent of nearly level, gently sloping, moderately sloping, strongly sloping and steep sloping lands were found to be 99.60 ha, 1020 ha, 902 ha, 103 ha and 10 ha respectively. The Fig. 4 represents slope map of the Chhatra sub watershed.

Soil texture map

In the study area, 4 textural classes were found and areal extent of each texture class were found to be clay (60.13 ha), sandy clay (23.32 ha), sandy clay loam (888.34 ha) and sandy loam (1162.81 ha) and

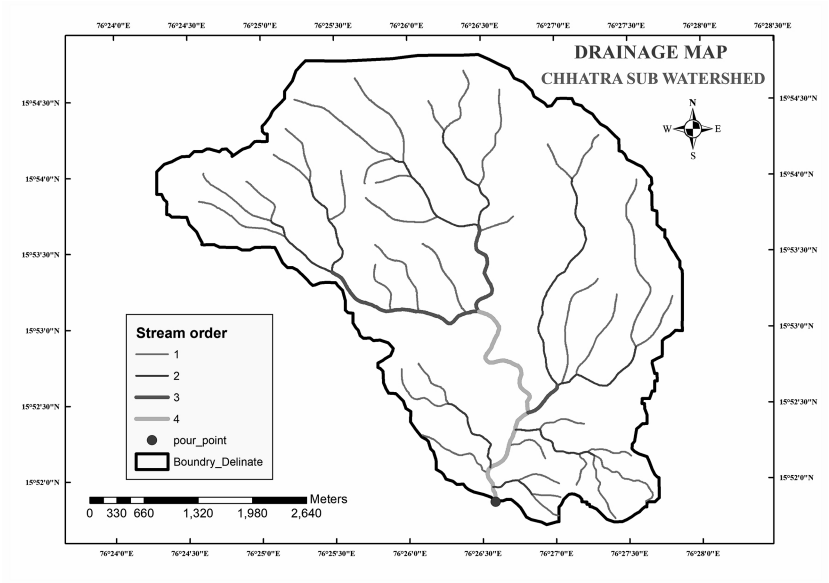

Fig. 3. Stream order map of Chhatra sub watershed.

the location with their areal extent of each obtained soil textural class is shown in Fig. 5. From analysis,it was found that, sandy loam and sandy clay loam distributed entirely throughout the watershed and it indicates watershed is having moderately to highly permeable sub soil geology.

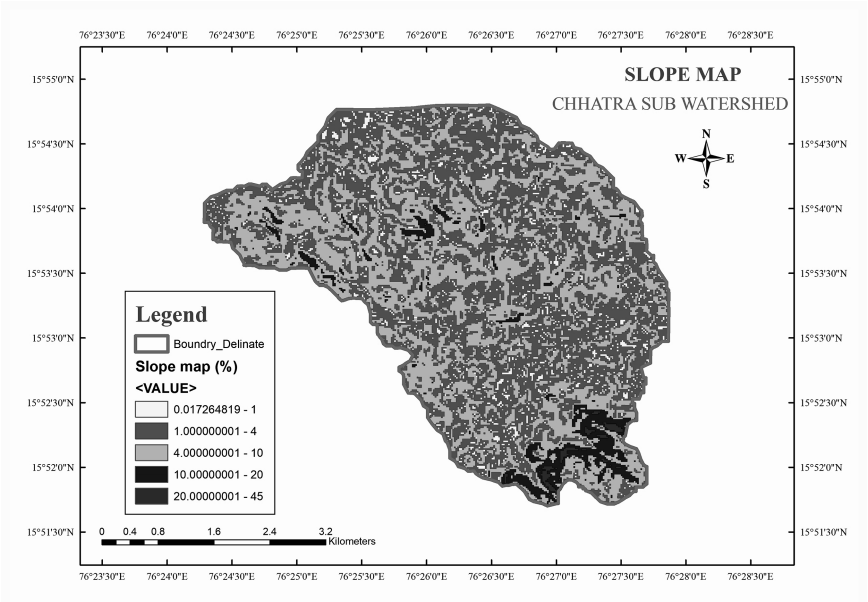

Fig. 4. Slope map of the Chhatra sub watershed.

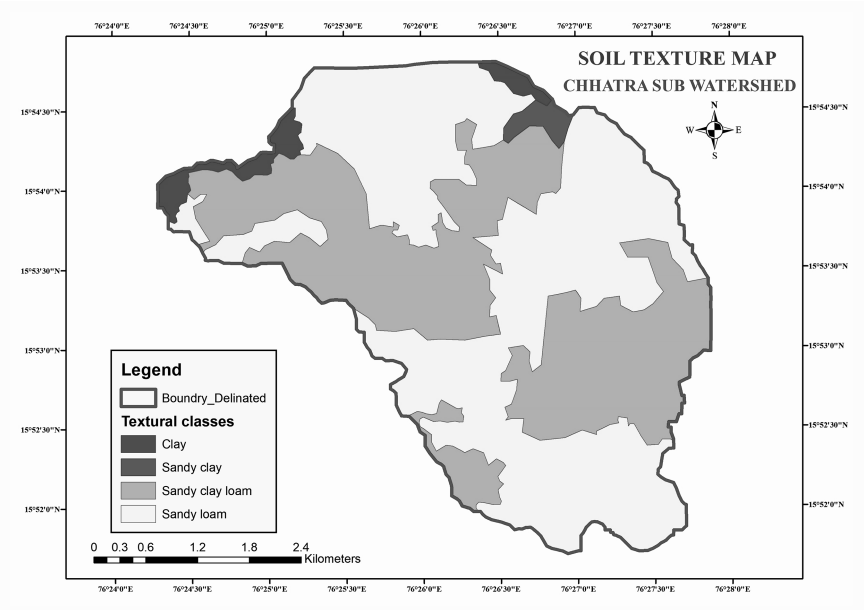

Fig. 5. Soil texture map of Chhatra sub watershed.

Land use/land cover map

The FCC of remote sensing images prepared for the present study was done with band combinations as 3-2-1. This is best band combination for the land use/land cover classification. Supervised classification was done using some training sets. The results obtained under this were very close to the ground truth

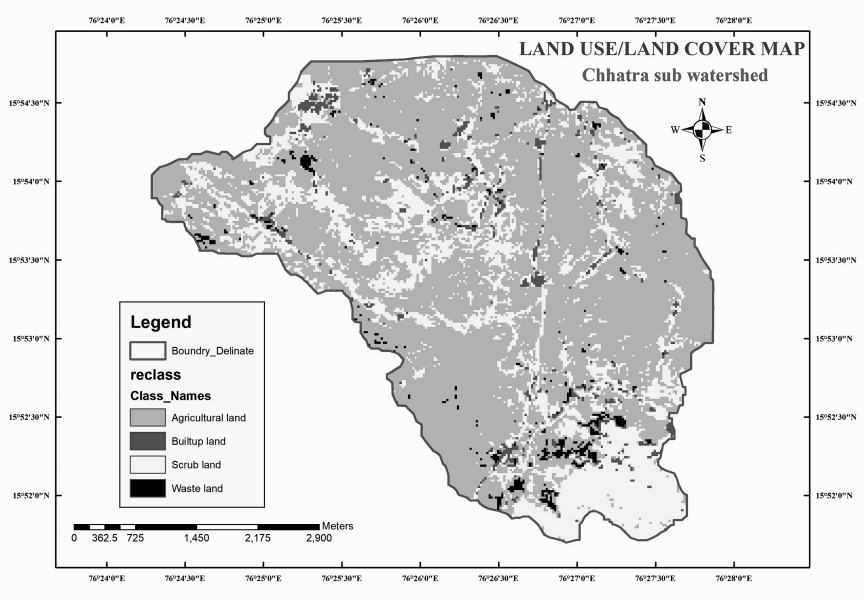

Fig. 6. Land use/land cover map of Chhatra sub watershed.

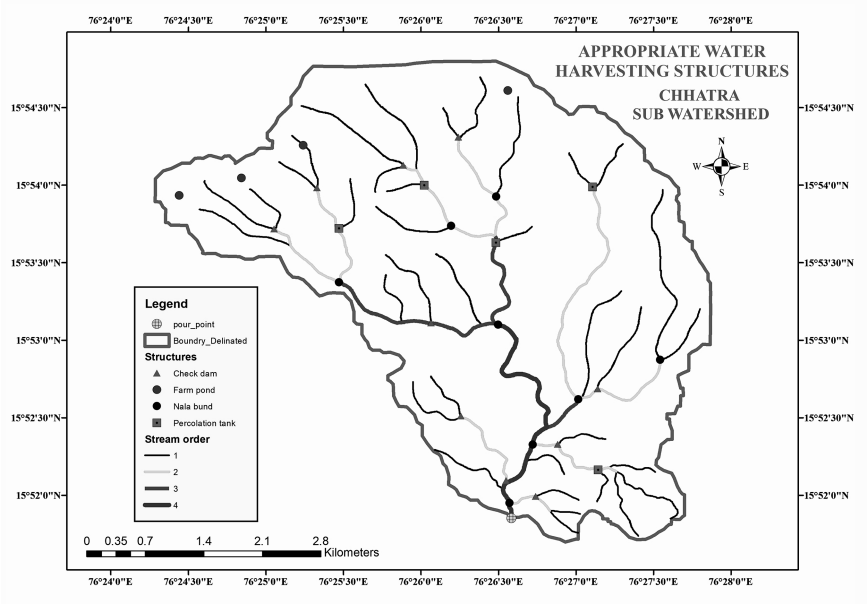

Fig. 7. Location sites of water harvesting structures for Chhatra sub watershed.

data. After the supervised classification of LISS-III satellite image under ERDAS-imagine software, the areal extent of land use types viz., agricultural land, open srub land, waste land and built up lands were found to be 1434.2 ha, 604.3 ha, 67.1 ha and 1.3 ha respectively. The obtained results indicates that, watershed is having more crop land area followed by scrub land and there is only a small portion of built up land. The Fig. 6 shows location and areal extent of obtained textural classes within the sub watershed.

Planning of soil and water
conservation structures

The proposed locations of soil and water conservation structures for Chhatra sub watershed is shown in Fig. 7. The location and structures were selected based on the drainage order, land use, soil texture and slope conditions of watershed. For the Chhatra sub watershed 10 check dams, 5 percolation tanks, 8 nala bunds and 4 farm ponds were proposed for drainage line treatment.

The similar study on planning water conservation structure for drainage line treatment was conducted by Chowdary et al. (2009), Mayurakshi watershed of Jharkand; Gavade et al. (2011) in Solapur district of Maharastra; Pandey et al. (2011), in Karso watershed which lies with in Damodar Barakar catchment and Rejani et al. (2017), in Goparajpalli watershed of Warangal district.

Conclusion

A study was conducted for planning of appropriate water harvesting structures for Chhatra sub watershed using remote sensing and GIS techniques. The project area lies $76^{0}24'$ to $76^{0}29'$ East longitudes and $15^{0}51'$ to $15^{0}55'$ North latitudes. Chhatra is a Village in Lingasuru taluk in Raichur district of Karnataka State. In the present study, an effort has been made to highlight the use of remote sensing and GIS for the watershed planning. Remote sensing data of study area was used from satellite imagery LISS-III satellite data for October 2014, downloaded from the official Bhuvan website and toposheet was collected from the Survey of India, Bengaluru. Thematic maps viz., stream order map,slope map, soil texture map and land use/ land cover maps were prepared and integrated for the planning of suitable water harvesting structures.

Based on all suitability criteria, 10 check dams, 5 percolation tanks, 8 nala bunds and 4 farm ponds were planned for the Chhatra sub watershed and RS and GIS place a significant role in conserve the soil and water conservation measures.

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