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Original Research Paper

# Studies on Land Use, Land Cover and Soil Texture of Harve Watershed, Chamarajanagar District, Karnataka, Using Remote Sensing and GIS Techniques

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## ABSTRACT

Land use, land cover, and soil texture studies are important for watershed characteristics. Most of the hydrological phenomenon depend upon these characteristics. Remote sensing is a powerful spin-off from space exploitation, and it has emerged as a tool for watershed characteristics, planning and management in recent times. The integrated approach of remote sensing and GIS has capabilities of data explanation, storage, retrieval and manipulation, and plays an important role for systematic analysis of various lithological, geomorphological, soil hydrological and land use characterization following the synoptic and multi-spectral coverage of terrain. In the present study, IRS-IB, 26 January 2004 satellite data have been analyzed in conjunction with topographical data of Harve watershed for land use, land cover and soil texture studies of a watershed under the GIS environment.

## INTRODUCTION

In recent trends, satellite remote sensing has become a versatile tool for a number of applications related to watershed development and management. Space technology inputs have been particularly successful in the areas of soil and water resources assessment including investigation and planning of watershed development project, flood and drought monitoring and management and groundwater targeting. The morphological studies, which relate to hydrology, as suggested by many investigators, consist of linear aspects of channel system with one dimensional overland flow length and length of stream etc., aerial aspects of catchment of watershed relating to watershed shape and drainage texture and relief aspects of channel network/catchments describing elevation difference, etc. Various measures are established by many investigators to represent these aspects of morphological characteristics. In present study, IRS-IB satellite data have been analysed in conjunction with topographical data of Harve watershed for land use, land cover and soil texture studies of a watershed under the GIS environment.

## STUDY AREA

The watershed considered for this study is the drainage area of small stream, comprising of number of villages occupying a total geographical area of 152 sq km.. The area is lying between the latitudes of 11°50' to 12° and longitudes of 76°50' to 77° (Fig. 1). Climatically, the area is semi-arid having mean maximum temperature of 15°C and mean minimum temperature of 33°C. Humidity varies from 54.12% to 68%. The average annual rainfall in the area is 765 mm. Topographically, the area is nearly flat to gentle sloping (1 to 5%) except some hilly patches. The elevation ranges from 600 m at the outlet to 658 m at the upper ridges of the watershed. Drainage network in the area consists of stream segments up to fifth order. The surface soil colour varies from red to black, which is moderately deep to very deep and low drained agriculture is major land use in the watershed area (Figs. 1 and 2).

## MATERIALS AND METHODS

For the present study, remote sensing data of IRS-IB, 26, January 2004 were used along with the SOI No. 58A/13 on a scale of (1:50,000). Field surveys were carried out to collect soil samples from various locations throughout the watershed. The samples were analysed in laboratory for texture characteristics. The remote sensing and toposheet data were first rectified by projecting them onto a plane by using Universal Travese Mercator (UTM) map projections method. A first order polynomial and everest spheroid through linear stretching using image-processing capability of GIS. The images were geo-referenced with respect to the above said co-ordinate system. The GIS utility was further used for the generation of base map of watershed boundary, contours, drainage, etc. Different thematic maps such as land use and soil texture etc. were prepared using the base map, remote sensing data and ground truth verification (Fig. 3). The systematic description of the geometry of a drainage network of the watershed requires the measurement of (i) linear aspects of the drainage network, (ii) areal aspects of drainage basins, and (iii) relief aspect of the channel network and contributing ground slopes. For all practical purposes, the quantitative study of channel networks used to begins with Horton's methods (Horton 1945) of ordering of channels. Later on, Strahler (1964) proposed a modification of Horton's ordering scheme, which was used in ordering the stream system. The methods given by Horton (1945) for the quantification of bifurcation ratio (Rb), stream length ratio (RL), drainage density (Dd), constant of channel maintenance (C), stream frequency (F), Miller (1953) for form factor (Rf), circularity ratio (Rc), Schum (1956) for elongation ratio (Re), watershed factor (Rs), total relief (H = maximum difference in elevation), relief ratio (Rn), unity shape factor (Ru) and Melton (1957) and Strahler (1964) for ruggedness number (Kn), etc. were used for quantifying the linear, areal and relief aspects of watershed channel network.


Fig. 1: Location of study area.

## RESULTS AND DISCUSSION

The land use/land cover map was prepared by using the supervised classification of the remote sensing data. The signatures for the supervised classification were generated based on the ground truth information and from expertise available. The distribution of various land use/land cover uses is described in Table 1. Agriculture is identified as major land use/land cover class throughout the entire watershed. The

Table 1: Land use pattern identified in the study watershed.

| Sr. No. | Land use/land cover | Area (ha) | Area % |
|---|---|---|---|
| 1 | Agricultural land | 3993.82 | 85.69 |
| 2 | Built-up land | 25.97 | 0.59 |
| 3 | Scrubs | 3.67 | 0.07 |
| 4 | Waste land | 646.24 | 12.86 |

Table 2: Soil texture identified in the study watershed.

| Sr No | Soil texture | Area (ha) | Area (%) |
|---|---|---|---|
| 1 | Clay | 1594.52 | 34.18 |
| 2 | Sandy clay loam | 3070.84 | 65.83 |

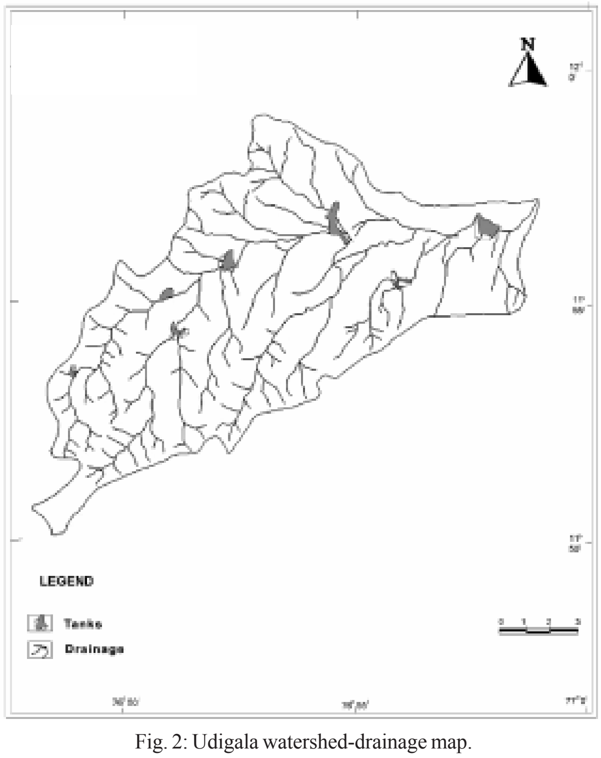


Fig. 2: Udigala watershed-drainage map.

laboratory analysis of soil samples from various locations was used for preparation of soil texture map, which can be further useful for site suitability analysis of water harvesting and conservation structures in the watershed. The distribution of the different soil textures is given in Table 2. Black with mixed red soil and red loam is the major soil texture in the watershed.

The morphological characteristics of the watershed were computed by using the various formulae and the results are presented in Table 3. The total length of the channels gives an idea of overland flow and channel flow in the watershed. Channel storage varies with stream length as a simple power function. It can be seen from the table that the total length of all order stream in equal to 109.39 km, which is supposed to be larger for the drainage area of 152 sq km. Due to this, the time of concentration for the channel flow and time to peak may extended, which may ultimately affect the peak rate of discharge of the hydrograph. It is an indication for the flood hydrograph of short peak flow. The mean length of the stream shows an increasing trend with increase in order, while number of streams are decreasing with increase in stream order. Thus, it follows the Horton's law of stream numbers and stream length. The bifurcation ratio is a useful index for hydrograph shape for watershed similar in other respect. For the present study watershed, the average value of it was found to be in the normal range of 3 to 5. The higher value of it

Table 3: Morphological characteristics of the study watershed.

| Sr.No. | Description of the morphological parameters | Equations | values |
|---|---|---|---|
| **A** | **Linear aspects** | | |
| 1. | Basin perimeter (p) in km | | 30, 49 |
| 2. | No. of streams of various order | | |
| | First order (N1) | | 111 |
| | Second order (N2) | | 29 |
| | Third order (N3) | | 6 |
| | Fourth order (N4) | | 2 |
| | Fifth order (N5) | | 1 |
| 3. | Total number of all order streams (N) | | 149 |
| 4. | Length of streams of various orders in kmFirst order (L1) | | 66.65 |
| | Second order (L2) | | 22.56 |
| | Third order (L3) | | 11.32 |
| | Fourth order (L4) | | 6.37 |
| | Fifth order (L5) | | 2.50 |
| 5. | Total length of all order streams (L) in km | | 109.39 |
| 6. | Mean length of channel in km | | |
| | First order (L1) | | 0.60 |
| | Second order (L2) | | 0.78 |
| | Third order (L3) | | 1.89 |
| | Fourth order (L4) | | 3.19 |
| | Fifth order (L5) | | 2.50 |
| 7. | Length of basin (L1) in km | | 11.37 |
| 8. | Length of main stream (Lm) in km | | 9.70 |
| 9. | Bifurcation ratio (Rb) | Rh=Nu/Nu+1 | 3.40 |
| 10. | Stream length ratio (R1) | Rl=Lu/Lu+1 | 1.55 |
| **B** | **Areal aspects** | | |
| 1 | Drainage area (A) in km2 | D=L/A | 46.65 |
| 2 | Drainage density (D) in km/km$^2$ | C=A/L | 2.34 |
| 3 | Constant of channel maintenance (C) km$^2$/km | F=N/A | 0.43 |
| 4 | Stream frequency (F) in no./km$^2$ | Rf=A/Lb$^2$ | 3.19 |
| 5 | Form factor (Rf) | Rc=A/Ac | 0.36 |
| 6 | Circulatory ratio (Rc) | Re=d/Lb | 0.63 |
| 7 | Elongation ratio (Re) | Rs=Lm/d | 0.85 |
| 8 | Watershed shape factor (Rs) | Ru=Lb/sqrt(A) | 1.00 |
| 9 | Unity shape factor (Ru) | | 1.66 |
| **C** | **Relief aspects** | | |
| 1 | Total relief (H) in m | Rh=H/Lb | 58 |
| 2 | Relief ratio (Rh) | Rp=H/P | 0.0051 |
| 3 | Relative relief (Rp) | Rn=HD | 0.0019 |
| 4 | Ruggedness number (Rn) | | 0.136 |

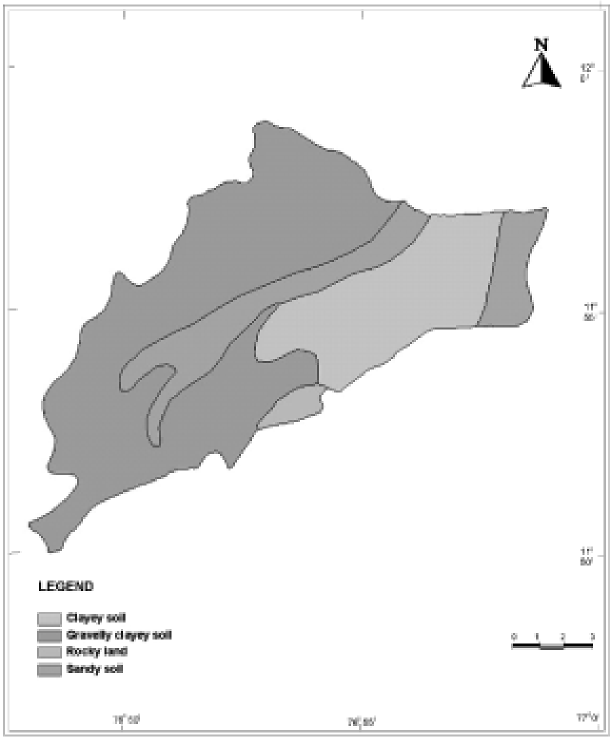


Fig. 3: Udigala watershed soils.

indicates an extended peak flow, whereas the lower indicates a short peak flow. The variables involved in the relief aspects of the watershed are the most significant parameters in hydrological studies of the watershed. The slope is related to rate at which the potential energy of the water at higher elevation in the headwater of the catchment is converted into kinetic energy. The total relief of a basin of the watershed is a measure of the potential energy available to move water and sediment downstream.

## CONCLUSIONS

A GIS database containing data pertaining to watershed land use/land cover, soil texture and drainage characteristics with different types of hydrological stimulation studies with the help of GIS database containing watershed boundary base map, drainage network and contour information, the various thematic maps such as land use/land cover, soil texture, etc. were prepared and also the various measures were computed to represent the linear aerial and relief aspects of the basin of watershed.

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