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Groundwater regime of the WRY-2 sub-watershed of Wardha River basin around Wardha Taluka, Wardha District, Maharashtra, India using an integrated approach of remote sensing and GIS techniques

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Abstract: The main component of the earth surface is the water, so that RS and GIS is effective utilization in ground water prospecting and watershed management. The rampant growth of population and advancements in life style have tremendously increased the demands for food, fuel, fodder, fiber, shelter, communication, etc. These growing demands are putting the resilience of the natural resource base under threat. To ensure food and water security, the vertical and horizontal expansion of production, has to be effective without degrading productivity. The development of ideas on sustainable livelihoods was witnessed during 1990s. These grew from awareness that rural development approaches based purely on agricultural production were insufficient to meet the livelihood needs of the rural and landless poor. Agricultural land and livestock frequently generate only a portion of rural livelihoods, which are not primarily agrarian or land-based. Other forms of income generation, perhaps derived from migration, part-time trade or handicraft production may make a large contribution to an individual's or a household's livelihood. Instead of considering land or water and its potential for development, attention was given instead to people's needs and their priorities for development, which is challenging for land based development projects, such as the watershed development program.

Development through watershed approach is one such developmental option. Watershed management is the study of the relevant characteristics of a watershed, aimed at the sustainable distribution of its resources and the process of creating and implementing plans, programmes and projects to sustain and enhance watershed functions that affect the plant, animal and human communities within a watershed boundary. A watershed is a logical, natural planning unit for sustainable agricultural research and development particularly when environmental considerations are emphasized. Hydro logically, watershed could be defined as an area from which the runoff drains through a particular point in the drainage system. The database is created using various techniques for the watershed management, i.e Morphometric analysis, Land Use and Land Cover. The most important use of water in agriculture is for irrigation, which is a key component to produce enough food.

In this present study, an attempt has been made to understand the groundwater regime of the WRY-2 subwaterhed of Wardha River basin around Wardha Taluka, Wardha District, Maharashtra using an integrated approach of remote sensing and GIS techniques with Arc GIS Desktop 9.3 and ERDAS Imagine 9.2 software for the sustainable watershed management.

Key Words: Morphometric analysis, Land Use, Land Cover, Geographical Information

Introduction

Water is the most important renewable and finite natural resources since it is required for agriculture, industry and domestic purposes. This rapid population increase causes not only increase of water demand but also affect largely the land use change, that is land degradation, soil erosion and change in hydrologic regimes. Managing water resources is a major challenge for the country. The crisis about water resources development and management thus arises because most of the water is not available for use and secondly it is characterized by its highly uneven spatial distribution (Wani, et al. 2002). The principal source of ground water recharge in the Wardha district is through rainfall. Water resources development is a continuous process which has to be resorted on account of ever-increasing demands (Arnold, et al.1990). Physical development will improve the economic situation significantly and lay a foundation for the support of improvement in living standards of the beneficiaries by the added income (Murthy, 1998). Whereas the physical impacts on the stream system can be lessened through application of currently available management techniques, political and social constraints may limit the possibility of developing and implementing an effective watershed management program. Specific stream pattern develops in response to the initial topography of an area and the distribution of the rock types of varying erosion resistance. The shape of the pattern depends on rock, soil, climate and the changes made to the

river. Drainage patterns are good indicator of the underlying rock types, structural features, nature of terrain and topography.

Study Area

The study area WRY-2 which is located in the survey of India toposheet Nos. 55L/6, 55L/6, 55L/9 and 55L/10 having latitude 78°46'54"E 20°56'40"N and longitude 78°58'50"E 20°56'34"N is present in the Wardha district of Maharashtra. The data require for watershed management includes drainage morphometry, and Satellite image of the study area, etc. The WRY-2 sub-watershed of Wardha river basin located in Wardha taluka of Wardha district of Maharashtra state. Nearly 38 villages are covered by the WRY-2 sub-watershed (Fig.1).

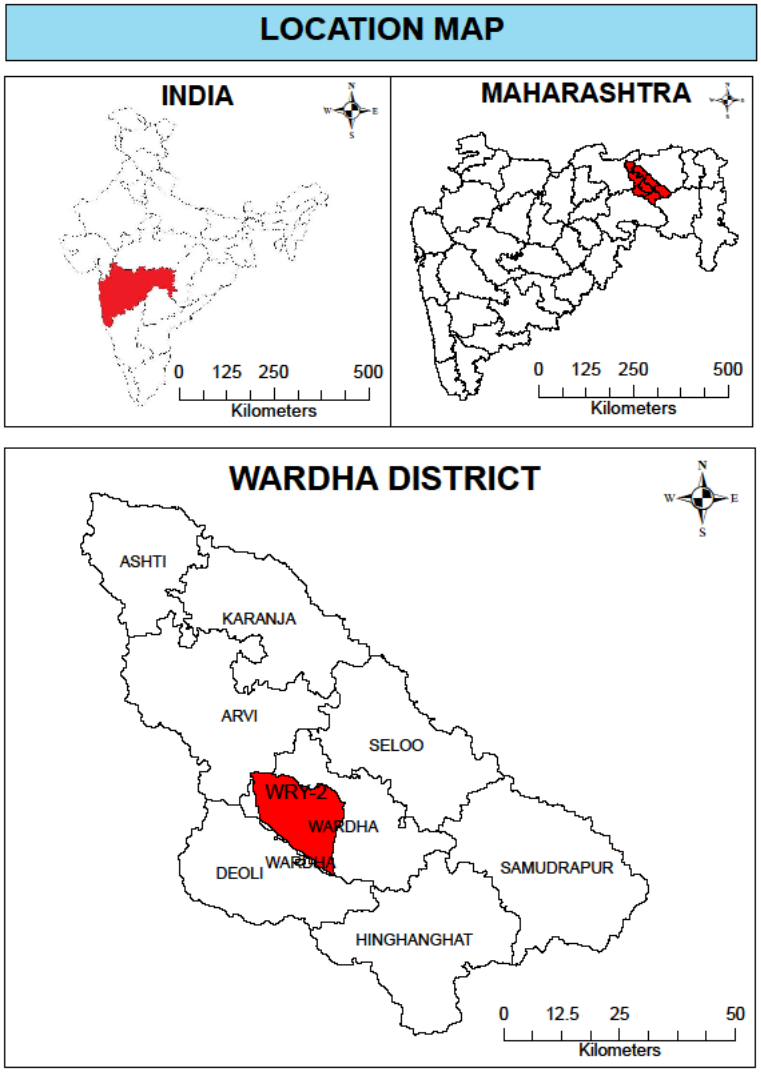

Fig.1 Location Map of Study Area

Methodology

The study area WRY-2 which is located in the survey of India toposheet Nos. 55L/13 and 55L/14 is present in the Wardha district of Maharashtra. The database is created using various techniques for the watershed management; the maps are prepared by georefrancing and digitization from SOI toposheet using Arc GIS 10. Attributes were assigned to create the digital database. The Survey of India Toposheets of scale 1:

50,000 are used for delineating the watershed boundary, drainage pattern for the preparation of base map and extracting different thematic layers for the various part of analysis namely drainage, road and water bodies etc. The order was assigned stream by following Strahler, (1964) stream ordering technique. Various morphometric parameters, such as linear aspects of the drainage network: stream order **(N_u)**, stream length **(L_u)**, and bifurcation ratio **(R_b)**, and areal aspects of the drainage basin: drainage density **(D_d)**, as presented in Table (2).

Morphometric Analysis

Drainage Morphometry is found to be very important in evaluating drainage pattern and watershed management programms of the watershed area. The study area is dominated by erosional land forms like lava plateau, lava plains, linear ridges, conical hills, mesa, butte and escarpments, and depositional landforms such as alluvial cones, alluvial fans, and Bajada deposits. WRY-2 Watershed area, which is one of the tributary of the Wardha River, Remote Sensing (RS), Geographical Information System (GIS) has proved to be an effective tool in delineation of drainage pattern and it provides effective solutions to overcome most of the problems of land and water resources planning and management arising due to usage of conventional methods of data collection. The occurrence and movement of groundwater in an area is governed by several factors, such as topography, lithology, geomorphology, structure, land use and interrelationship between these factors Jaiswal, et.al.,(2003). Morphometry is the measurement and mathematical analysis of configuration of the earth surface and the shape and dimensions of its landforms (Thornbury, 1969). The drainage basin analysis of WRY-2 watershed in Wardha tributary has been carried out quantitatively including linear, aerial and relief aspects. In the linear aspects, the stream order, stream length, bifurcation ratio, mean lengths of streams, stream length ratio, and mean stream length ratio are analyzed (Fig.2).

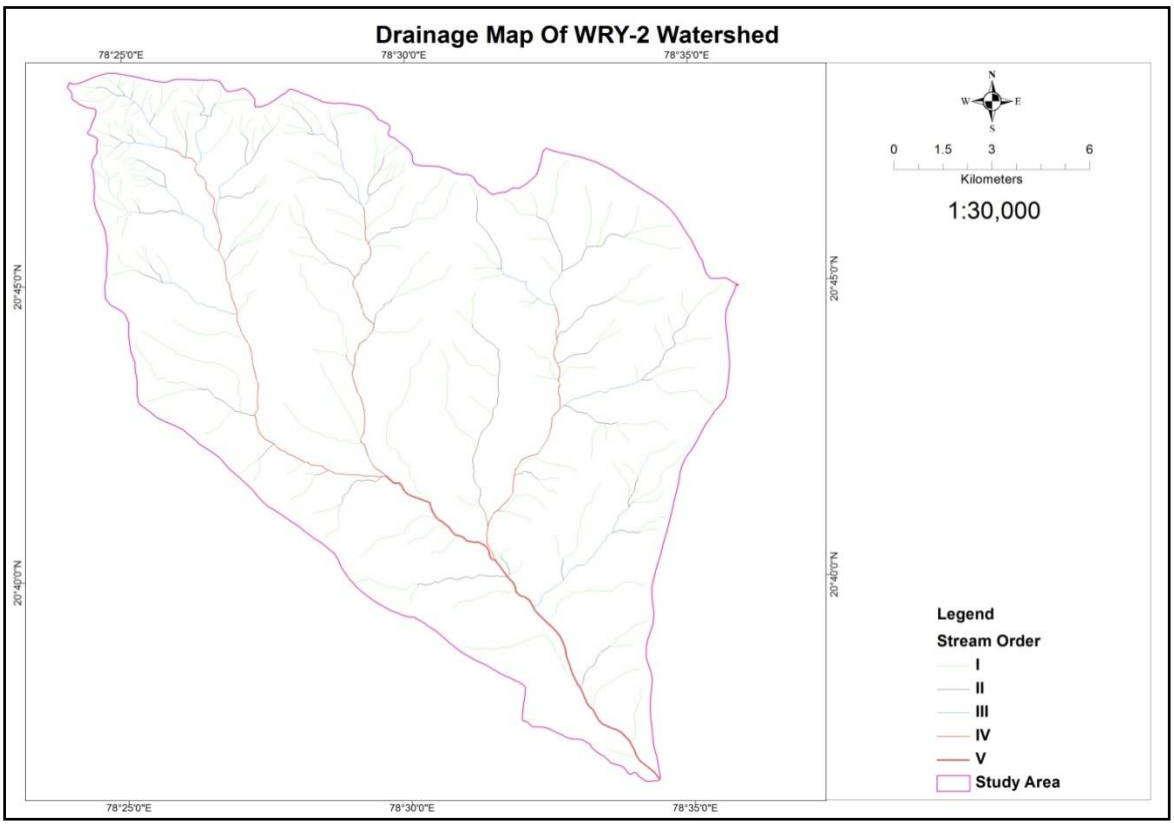

Fig.2 Drainage Map

Land Use / Land Cover

Land Cover, defined as the assemblage of biotic and a biotic components on the earth's surface is one of the most crucial properties of the earth system. Land use and land cover is an important component in understanding the interactions of the human activity with the environment and thus it is necessary to be able to simulate changes. Land use refers to man's activities and the varied uses which are carried on over land and land cover refers to natural vegetation, water bodies, rock/soil, artificial cover and others noticed on the land (NRSA, 1989).

The land use/ land cover is derived from the LISS IV satellite image using image classification techniques such as supervised and unsupervised. The most of the land is under agricultural crop land in the present study area and other area is covered by forest, built up, waste land, and Water body (Fig.3 and Table 1).

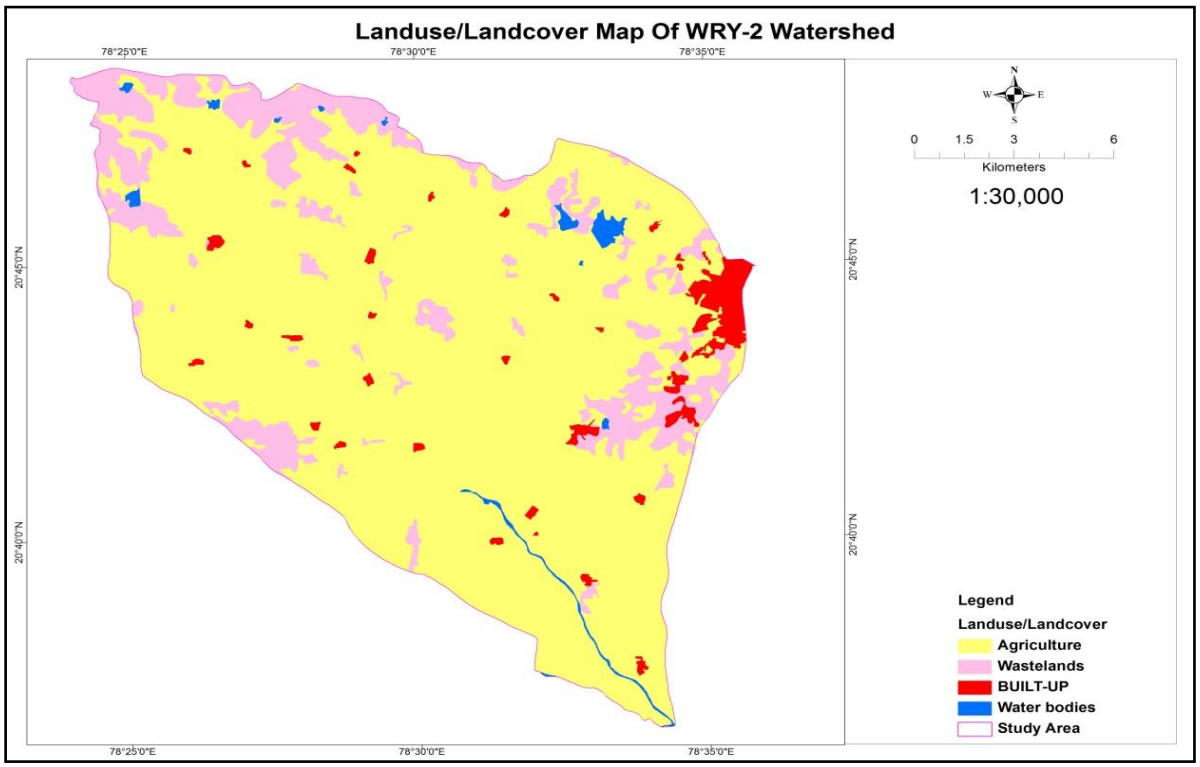

Fig. 3 Land Use/Land cover Map

Table 1 Area under Land Use and Land Cover

Land Use/ Land Cover	**Area in Km^2**
Agricultural Crop Land	211.57
Built up (Rural and Urban)	6.76
Waste Land	35.68
Water bodies(River, Canal,)	2.37
Total	256.38

Land use describes how a parcel of land is used such as for agriculture, settlements or industry, whereas land cover refers to the material such as vegetation, rocks or water bodies that are present on the earth surface. The water bodies include river, canal, tank, pond and reservoir etc.

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Drainage Analysis

The drainage is digitized from the SOI toposheet using GIS technique and stream ordered using Strahler method (1964). The WRY-2 Sub-watershed having stream order up to 5th order. The bifurcation ratio can also show which parts of a drainage basin is more likely to flood. The bifurcation ratio is not same from one to another due to irregularities in the topographic feature of the drainage basin. The average bifurcation ratio of WRY-2 sub-watershed is 1.94.Drainage density is the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. Drainage density depends upon both climate and physical characteristics of the drainage basin. High drainage densities also mean a high bifurcation ratio. The drainage density of WRY-2 sub-watershed is 1.36 km/km$^{2.}$ (Table 2).

Drainage Density:-

Drainage Density is the ratio of total length of all order to the total area of the basin.

Drainage Density = Total Length of steams of all orders / Area

= 349.47/256.38

=1.36 km/km^2

Table 2 Stream order and number of streams

Stream Order	Number of Stream	Bifurcation Ratio
1	187	3.4
2	55	4.58
3	12	4
4	3	3
5	1	
Total	590	1.94

Geomorphology

On the basis of interpretation of satellite image, SOI Toposheets, and field visits it is clear that geomorphology of the area comprises of plateau, denudation hills, alluvial pain. Plateau is the table like land. It is broad, elevated, and almost level. It covers southern part of the watershed along the watershed divide. This landform is easily identifiable in the satellite data due to flat top, occupying the higher altitude. The geomorphology of the watershed is having landforms features area moderate dissected plateau, denudational hill and alluvial pain in the lower part of the WRY-2 sub-watershed of Wardha River Fig. 4).

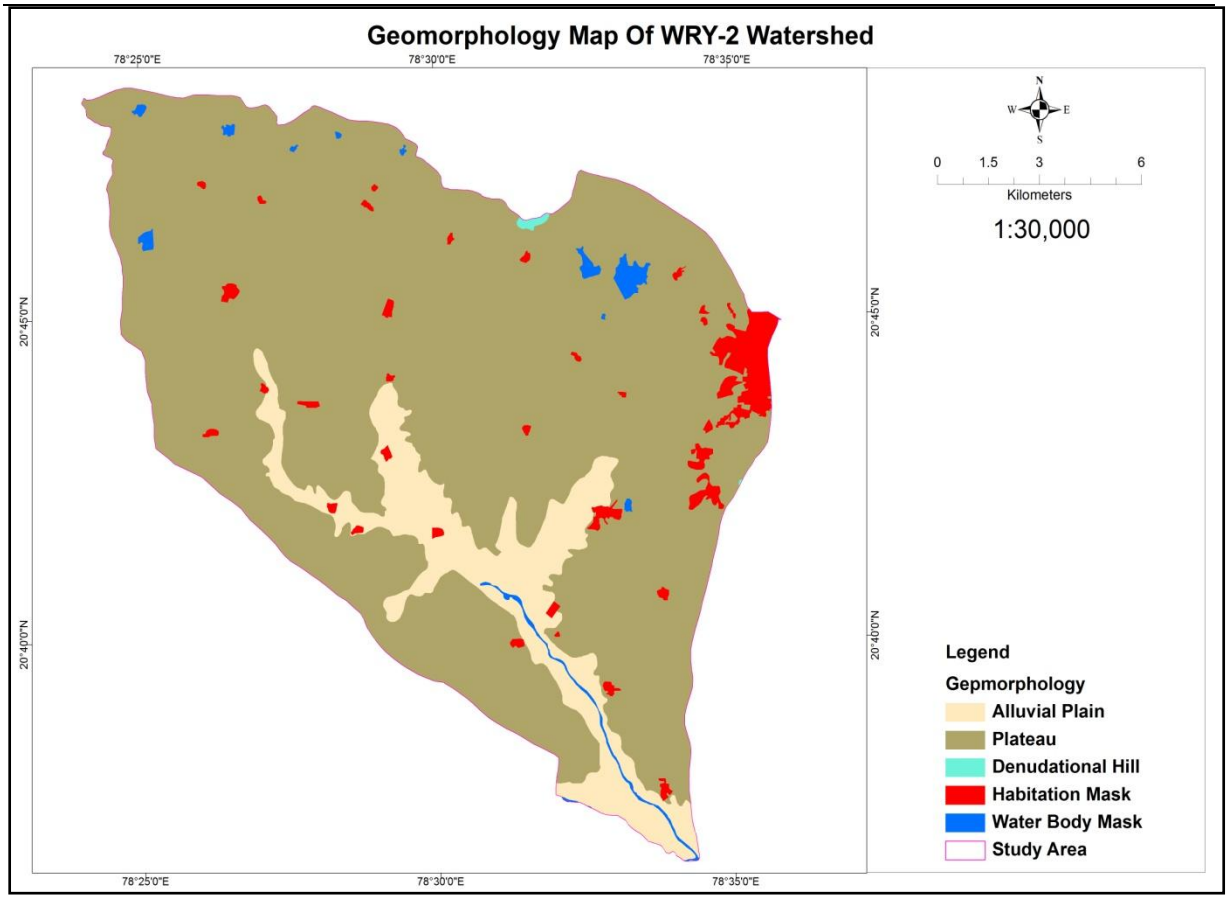

Fig. 4 Geomorphological Map

Triangular Irregular Network

Triangulated irregular network (TIN) is a digital data structure used in a geographic information system (GIS) for the representation of a surface. A TIN is a vector based representation of the physical land surface or sea bottom, made up of irregularly distributed nodes and lines with three dimensional coordinates (x, y, and z) that are arranged in a network of non-overlapping triangles. TINs are often derived from the elevation data of a rasterized digital elevation model (DEM). The TIN Map is prepared using the SRTM Data of 90 m resolution with the help of Arc GIS 10.0 Software (Fig. 5)..

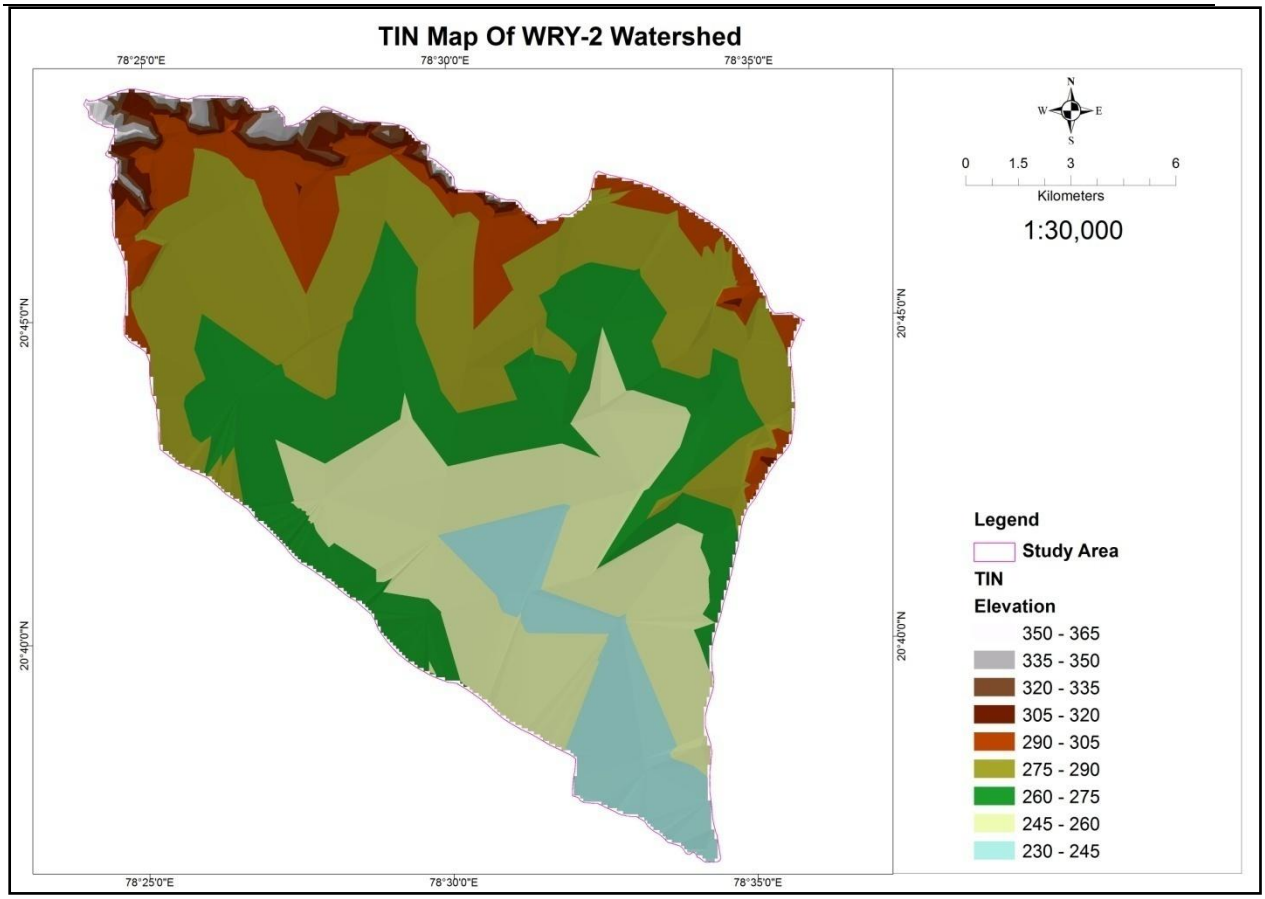

Fig. 5 Triangular Irregular Network (TIN) Map

Conclusions

Optimal utilization of land and water resources is essential for sustainable development. Resource management using watersheds as an organizing unit has proven to be an effective scale for natural resource management. It presents a common reference point for the many different activities and actors that affect the system, and promotes greater integration and collaboration among those actions. Remote sensing and its image processing technology provide access to spatial and temporal information on watershed, regional, continental and global scales (Yassir Arafat 2010). Further, new sensors and imaging technology are increasing the capability of remote sensing to acquire information at a variety of spatial and temporal scales. The scope of hydrological applications has broadened dramatically, although the problems of flood protection and water resources management continue to be of importance and relevance for the security of communities and for human, social and economic development (Rokade, et al. 2004).GIS and remote sensing applications have proved to be indispensable tools in decision making in the case of problem involving watershed conservation because of the enormity of spatial data involved. In this present study, illustration of how we can benefit from remote sensing and GIS technologies in watershed management and planning. Watershed management is the process of creating and implementing plans, programs, and projects to sustain and enhance watershed functions that affect the plant, animal, and human communities within a watershed boundary. The remote sensing data combined with field survey data can provide a unique and hybrid database for optimal planning and management of watershed. Space borne remote sensing technology is a unique tool to provide spatial, multi-spectral and repetitive information for effective planning. The land forms along with slope gradient and relief intensity are other parameters to determine the type of water harvesting and water conservation structures. This study has provided information regarding the soil map, land use land cover, slope map, Geomophological parameters, drainage density map, drainage pattern, Morphometric analysis and watershed Management response in WRY-2 Watershed in Wardha District Maharashtra, India. The detailed morphometric analysis of the study area shows that the presences of dendritic drainage pattern with the occurrence of fifth order stream.

At some places local radial drainage pattern is also seen. On the basis of stream channel systems to horizontal plain, various morphometric parameters such as length, area and arrangement etc are computed. In this study an attempt has been made to understanding the complexities of the landforms by using multivariate statistical analysis.

The result of morphometric analysis indicates negative correlation of stream order with the total number of streams present in the drainage Basin. The study reveals that remotely sensed data and GIS based approach is more appropriate than the conventional methods for the evaluation of drainage morphometric parameters and their influence on landforms, soils and eroded land characteristics at watershed level. Regional and local trends of geological setup are reflected in the variable orientation of channels of different rank in the catchment.

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