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INTEGRATED LAND AND WATERSHED DEVELOPMENT OF DOMAKONDA WATERSHED, NIZAMABAD DISTRICT, ANDHRA PRADESH, INDIA - GIS APPROACH

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ABSTRACT

The current study was taken up to investigate the utility of GIS tools for evaluation of Integrated Wasteland Development Programme (IWDP) implements in Domakonda watershed, Nizamabad district, Andhra Pradesh, India. Having information about natural conditions, resources, limitations and problems of watersheds, planning based on problems severity, potentials and priorities to decrease economic and human losses, increase in efficiency of resources based on capabilities and finally defining the best alternatives according to health and sustainability of ecosystems in a watershed are main objectives of land use planning. Resources allocation process is vital task especially for resources with limitations. One of these resources all over the world is land to use for different purposes. Since land use planning process use combination of different spatial information sources, applying effective tools with analysis capability is necessary. The present study were classified into different land use/land cover, slope, digital elevation model (DEM), contour, drainage.

INTRODUCTION

Watershed management is perceived by many as a viable approach for increasing agricultural production in rain-fed marginal areas on sustainable basis. Many countries in the world including India are investing billions of rupees in treating several millions hectares of land on watershed approach (Shanwad *et al*., 2008). Watersheds are characterized by their high degree of cultural and ecological diversity and are considered as basic unit for sustainable development. The main goal of sustainable development is improving public welfare and preserving the environment for next generations. One of the most useful applications of GIS for planning and management is the landuse suitability mapping and analysis (McHarg, 1969; Hopkins, 1977; Brail and Klosterman, 2001; Collins *et al*., 2001). Broadly defined, land-use suitability analysis aims at identifying the most appropriate spatial pattern for future land uses according to specify requirements, preferences, or predictors of some activity (Hopkins, 1977; Collins *et al*., 2001). The GIS-based land-use suitability analysis has been applied in a wide variety of situations including ecological approaches for defining land suitability/habitant for animal and plant species geological favorability (Bonham-Carter, 1994), suitability of land for agricultural activities (Cambell *et al*., 1992; Kalogirou, 2002; Tamma Rao *et al*., 2012), landscape evaluation and planning (Miller *et al*., 1998), environmental impact assessment (Moreno and Seigel, 1988), selecting the best site for the public and private sector facilities (Church, 2002), and regional planning (Janssen and Rietveld, 1990). Land and water are essential resources for day to day activities. Knowledge of drainage, land use/land cover and hydro-geomorphology and other terrain attributes are important for planning and management activities. In these days importance of impact assessment in watershed development programme and capabilities of GIS technologie in watershed management, a study was carried out on impact assessment of Domakonda Watershed in Nizamabad District, Andhra Pradesh, India.

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MATERIALS AND METHODS

Topographical maps of 1:25,000 scale have been used for the preparation of base map and drainage map. Prior to analysis, the map has been projected on [WGS 84] [EPSG: 4326], digitized, edited and given annotations by Map Info 6.5 techniques. Digitisation of the base maps were carried out using Digitiser Drawing Board III (Calcomp). The digitized maps were edited. During editing segment checking like intersection, selfoverlap and dead-end corrections were carried out. Projection and polygonisation of units followed the editing. After polygonisation annotations were given for different polygons and the maps were ready for analysis. Geocoded imageries of IRS-IC LISS III FCCs (1997) of 1:50,000 scale, aerial photographs (of 1990) of 1:25,000 scale, Survey of India (SOI) toposheets 56 J/7 SE and 56 J/8 NE on 1: 25,000 scale were utilized for the preparation of all maps and preparation plan is given in Fig. 1.

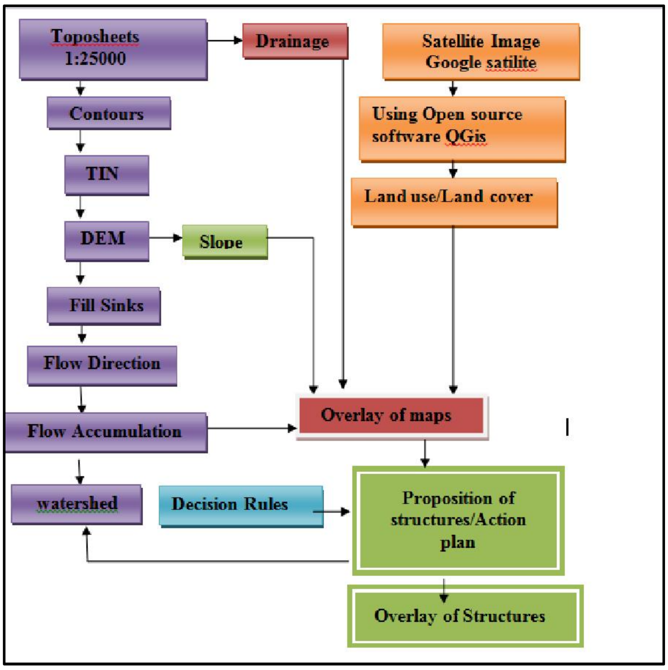

Fig. 1. Prepartion plan Diagram

Location and Extent

The study area falls in North latitude 18˚13' 30" and 18˚ 18' 0" and East longitudes 78˚ 24' 0" and 78˚ 28' 0" (Fig 2) and it falls in Survey of India Toposheets 56 J/7 SE and 56 J/8 NE. The present first hand ap proach was made to undertake the study with the objectives of landuse/landcover changes in the area

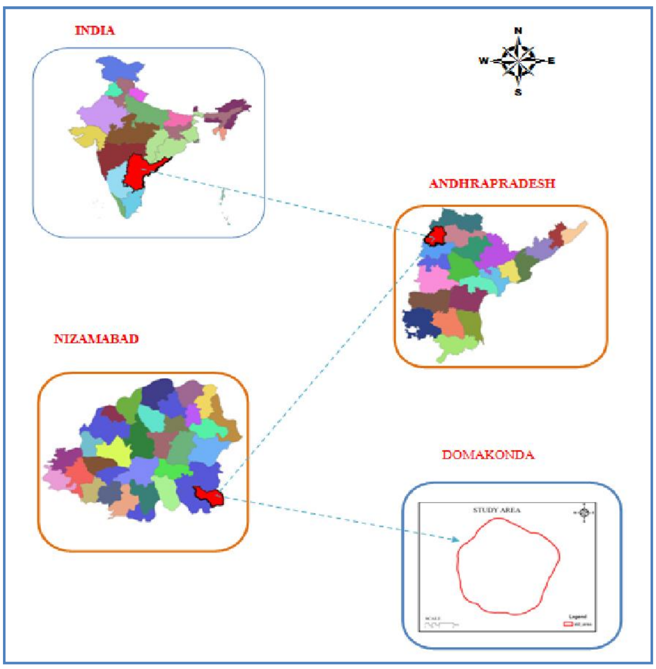

Fig. 2. Location map of the study area

and their contribution to the existing geomorphology using SOI toposheets and preparation of maps, which is includes map of contour, map of drainage, map of slope and map of digital elevation model (DEM).

Watershed as a System

Watersheds are usually defined in terms describing it as a single, inert physical entity. Watersheds can also be viewed as an active system based on its natural attributes, sometimes referred to as an ecosystem (Lotspeich, 1980). While a watershed and an ecosystem can be equivalent in area, they are not always identical. A single watershed may include multiple ecosystems, and a single, large ecosystem can encompass a number of smaller watersheds. While a watershed can be defined based on topography and water flow, an ecosystem is usually more difficult to define, because it does not necessarily have fixed physical boundaries. A watershed is an unusual type of ecosystem, because it does have well defined boundaries. The two controlling elements of a watershed system are its climate and geology (topography). Climate supplies the energy and water into the system. Once the energy and water enter the system, the geology of the watershed controls how they proceed through the system. Within the watershed, other elements, such as soil, vegetation, animals, and human activity react to the water and energy. Viewing the watershed as an integrated system leads to some interesting observations. Systems can be modeled, and GIS provides an ideal technology to assist in that modeling. A watershed, much like most other systems, has measurable inputs and outputs. While the water entering the watershed cannot be precisely measured, it can be accurately estimated. The water flowing past the point that defines the watershed can also be measured rather easily. By comparing the quantity and quality of the water entering the system, to the quantity and quality exiting the system, one can see the results of any actions that might be occurring within the system. This is one of the fundamental differences between watershed planning and most other planning processes.

Implement the watershed plan

When implementation of the plan begins, the dynamics of the planning group will change. The stakeholders assembled for the plan are no longer thinking about what should be done, but being asked to follow through with the strategies outlined in the plan. Sometimes, this means a significant change in the planning group's participants.

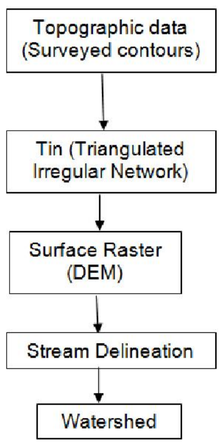

Fig. 3. Plan of watershed

It is critical that any new group members brought onboard are committed to the goals of the plan, and invest themselves in implementing the plan. In order to ensure the strategies in the plan are properly applied, a work plan can be used, which describes the implementation measures that are to take place within certain time-frames. The GIS becomes more static at this point (Fig 3).

Land Use-Land Cover (LU-LC)

Wise land-use planning involves making knowledgeable decisions about land use and the environment. Holistic planning involves input from multiple, interrelated data sources and types. In order to accomplish this feat a great deal of information must be considered simultaneously. Today, advances have been made towards extraordinary digital systems for utilization in land-use planning. Computer programs including decision support systems (models), Geographic Information Systems (GIS), spreadsheets, databases, and color desktop publishing programs contribute to the speed and efficiency of the overall planning process. Also available are inexpensive, sometimes free, digital photos and images, digital maps, and digital file distribution options (GeoComm, 2000; Radford Univ., 2000; USGS, 2000).

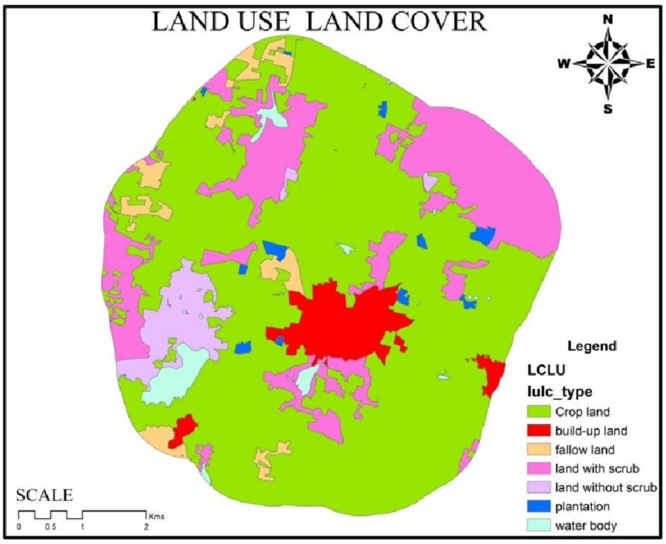

Fig. 4. Land use/land cover map of the study area

During the past few decades, most of environmental data were arranged in a map form that makes GIS one of the best analytical tools to analyse environmental information (Weerakoon 2002). Land suitability analysis advanced by McHarg (1969) has, over the past 40 years, become accepted as one of the most comprehensive approaches in land use planning. Its basic purpose is to determine the suitability of a given area for a particular use (Murphy 2005). Multi-criteria Decision Making (MCDM) methods were introduced to extend GIS analyzing capabilities since MCDM methods are capable of dealing with heterogeneous criteria that are both qualitative and quantitative in nature (Malczewski 1999, 2004). MCDM integrated with GIS is widely used for land suitability analysis (Siddiqui *et al*., 1996; Weerakoon 2002; Kontos *et al*., 2005; Simsek *et al*., 2006; Sener *et al*., 2006, 2010; Lamelas *et al*., 2007; Delgado *et al*., 2008). The LU-LC of the area provides important indications of the extent of groundwater requirement and utilization. The synoptic viewing through GIS has provided the multi-spectral data, which has been utilized for classifying LU-LC. The land use/land cover map (Fig. 4) of the entire Domakonda Watershed was generated. The major land use/land cover classes such as crop land, built-up land, fallow land, land with scrub, land without scrub, plantation and water body were identified in the study area. From the point of view of land use, crop land with vegetation is an excellent site for groundwater exploration (Todd and Mays, 2005).

A contour line is a line on a map or chart connecting all points of the same elevation. Any point on a contour line is the same elevation as all the other points on the same line. In other words, contour lines connect points of equal elevation and contour map of the Domakonda watershed is given in Fig 5.

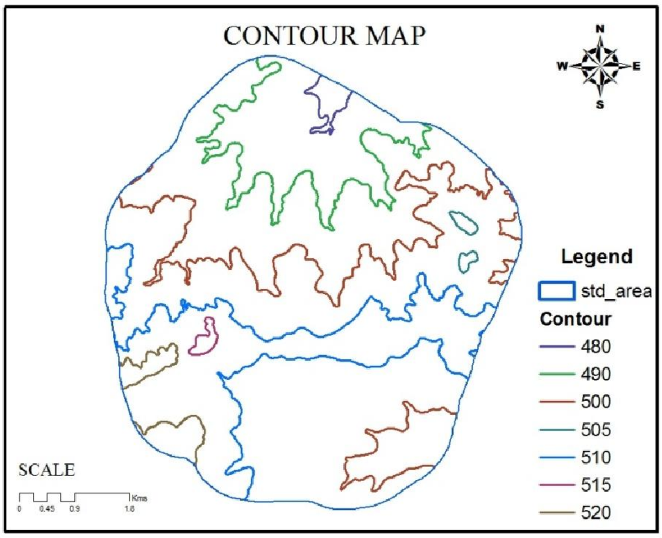

Fig. 5. Contour map of the study area

Contour Characteristic Terminology

Depression: A low place in the ground having no outlet for surface drainage.
Hill: A naturally occurring mass of earth whose crest or summit is at a lower elevation than a mountain.
Mesa: A flat-topped mountain bounded on all sides by steep terrain.
Ridge: Long narrow elevation of land, often located on a mountainside.
Saddle: Ridge between two hills or summits.
Valley: Stretch of low land lying between hills or mountains and sometimes occupied by a stream.

Digital Elevation Model (DEM) using ASTER satellite data (http://www.glcf.umd.edu/data/aster/) of the area was generated with ArcGIS software. This was used to generate contours and thereby slope analysis of the area. Relevant morphometric parameters for the basin area were calculated based on various standard techniques and methods. The application of digital elevation models (DEM) in the study of landscape to evaluate the landscape processes is not a very new concept now. Most DEMs have the generalization of land surface built into them. If these generalizations are within the spatial range of the process that are operating in the landscape of interest, there is no problem. With the rapid increase of sources of DEMs extraction of land surface parameters is becoming more and more attractive to numerous fields ranging from precision agriculture, soil-landscape modelling, climatic and hydrological applications to urban planning, education and space research. Recently, high resolution Cartosat data are available with resolution of one meter, but still this resolution is coarser than the landscape process scale operating in such areas. Hence an attempt has been made in the present study to investigate the detailed geomorphometry of a Domakonda Watershed (Fig. 6) from the DEM of a ground surveyed data which is at a finest possible resolution.

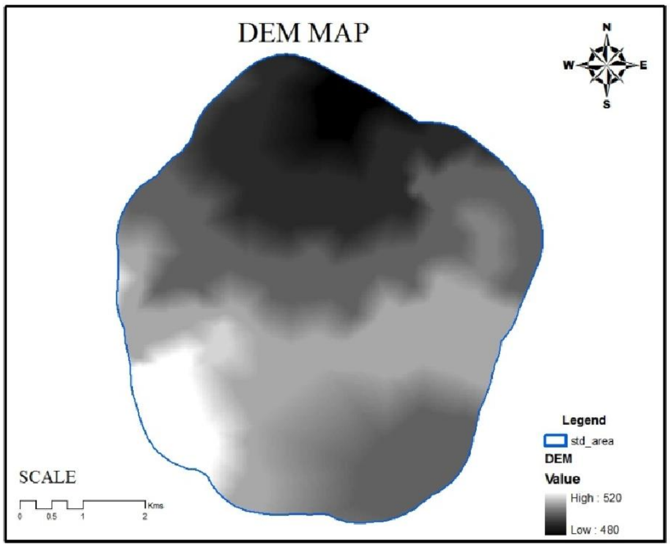

Fig. 6. DEM map of the study area

Slope and Aspect

Slope analysis is an important parameter in geomorphic studies. The slope elements, in turn are controlled by the climatomorphogenic processes in the area having the rock of varying resistance. An understanding of slope distribution is essential as a slope map provides data for planning, settlement, mechanization of agriculture, deforestation, planning of engineering structures, morphoconservation practices etc. (Sreedevi *et al*. 2005). A slope is an inclined ground surface that forms an angle with the horizontal plane (flat ground). The degree of inclination, steepness, is also called slope (Fig 7). Aspect is the compass direction that the slope is facing (Fig 8).

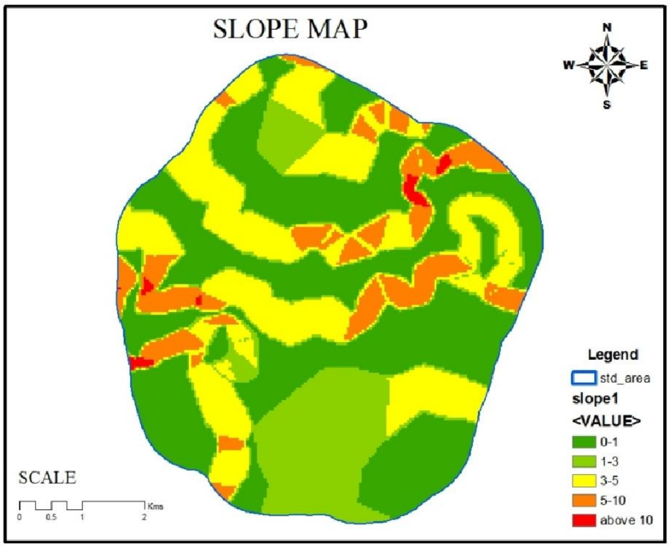

Fig. 7. Slope map of the study area

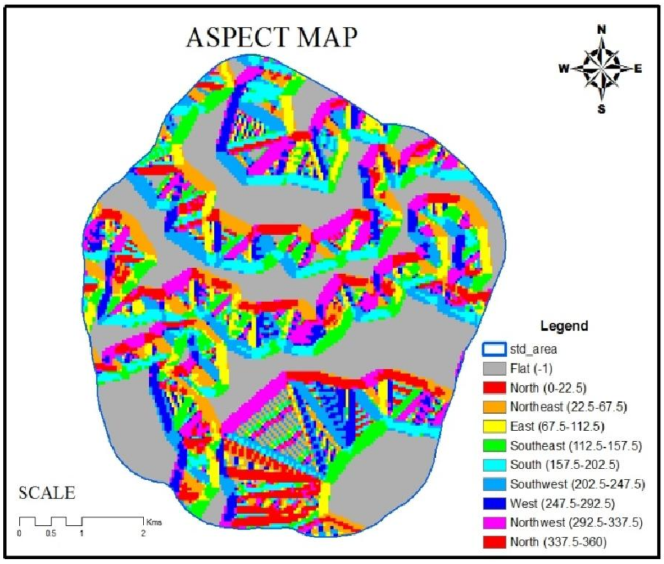

Fig. 8. Aspect map of the study area

Percent Slope

Slope is usually expressed in percent. It is useful in estimating the amount of time it takes to construct a piece of fireline. The estimation of percent slope can help determine whether or not a dozer, engine, or hand crew can work the topographic area. It is also used as an input for making fire behavior calculations. A one percent slope indicates a rise or drop of one unit over a distance of 100 horizontal units. Usually the mapper will be working with feet; therefore, a one percent slope rise would indicate a one foot rise over a 100 foot horizontal distance.

Estimating slope is a simple mathematical process. The formula is:

PERCENT SLOPE= VD x 100/HD or RISE x 100/RUN
VD or RISE = Vertical Distance (difference in elevation between two points; subtract one point in elevation from the other point).
HD or RUN = Horizontal Distance measured with ruler on a map, from one point to the other).

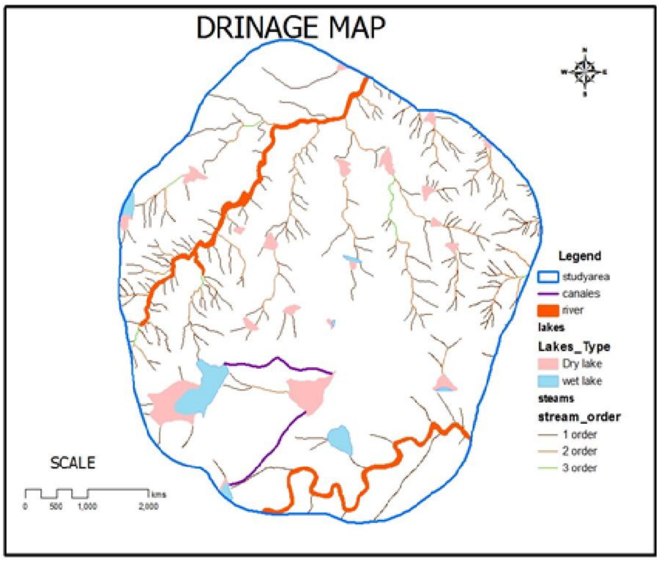

Fig. 9. Drinage map of the study area

Drainage and Surface Water Bodies

The study areas are drained by numerous first, second and third streams mostly originating in the northern part and flowing towards south. Only three tanks have been noticed across the drainage in the sub-watershed (Fig 9). The drainage in the sub-watershed represents sub-dendritic pattern.

Conclusions

Watershed prioritization is considered as one of the most important aspects of planning and development for natural resources for water conservation measures. The present study recapitulates the integrated approach for developing a preliminary prioritization of sub-watersheds in Domakonda Watershed. The sub-watersheds which are falling under very high priority may be taken up for implementation of soil and water conservation measures. The study demonstrates the utility of remote sensing and GIS techniques in prioritization of watersheds which may be helpful for planners and decision makers for planning at sub-watershed level.

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