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INTEGRATED WATERSHED MANAGEMENT USING REMOTE SENSING AND GIS TECHNIQUES

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ABSTRACT

Watershed is a geo-hydrological unit draining at a common point by a system of streams. Watershed management is the rational utilization of land and water resources for optimum production with minimum hazard to natural resources. Remote sensing (RS) and Geographical Information Systems (GIS) techniques can be utilized for effective management of land and water resources in a watershed. Even the Government of Andhra Pradesh is implementing watershed development programs on priority basis for sustainable development of land and water resources on holistic approach. The activities of watershed management mainly include rainwater harvesting structures, soil conservation measures and environmental protection measures.

The study area was Boothpur Mandal, which is one of the 64 mandals of Mahaboobnagar district. These areas have been identified as chronically drought affected areas in the State because of scanty and erratic rainfall. Collection of source data like satellite data of two seasons, SOI toposheets and village maps were carried out. Secondary data like ground water levels, agriculture, population and socioeconomic data were collected. Various thematic maps like base map, contour map, drainage map, soil map, geomorphology map, slope map and land use/land cover map were prepared by using SOI toposheets and satellite imageries. After analysing all maps, action plan map was generated for the soil and water conservation in the study area.

INTRODUCTION

Watershed is an ideal unit and accepted approach for planning, development and management of land and water resources. Watershed management requires the understanding of relationship among land use, soil and water. All life depends on water, which is one of the important natural resources available to mankind. It is a driving force for all developmental activities and of great importance for people and environment. Providing water in desired quantity and quality has been a constant endeavour of all the countries. With the growth of human civilization, man's requirement for water has increased many folds due to its multiple uses such as agriculture, power generation, industries, navigation and recreation etc. Intensive agriculture, changing life styles, rapid industrialization and urbanization have all created new demands, which are growing year after year. Indiscriminate exploitation of surface and subsurface waters has led to severe water scarcity and environmental degradation. The spatial-temporal variation in rainfall has further aggravated the problem.

WATERSHED MANAGEMENT

Watershed management is an iterative process of integrated decision-making regarding uses and modifications of lands and waters within a watershed. This process provides a chance for stakeholders to balance diverse goals and uses for environmental resources and to consider how their cumulative actions may affect long-term sustainability of these resources. The guiding principles of the process

are partnerships, geographic focus and sound management (strong science and data). Human modifications of land and water directly alter delivery of water, sediments and nutrients, and thus, fundamentally alter aquatic systems. People have varying goals and values relative to uses of local land and water resources. Watershed management provides a framework for integrated decision-making, where we strive to: (1) assess the nature and status of the watershed ecosystem, (2) define short-term and long-term goals for the system, (3) determine objectives and actions needed to achieve selected goals, (4) assess both benefits and costs of each action, (5) implement desired actions, (6) evaluate the effects of actions and progress toward goals and (7) re-evaluate goals and objectives as part of an interactive process.

Watershed management requires use of the social, ecological and economic sciences. Common goals for land and water resources must be developed among people of diverse social backgrounds and values. An understanding of the structure and function-historical and current of the watershed system is required, so that the ecological effects of various alternative actions can be considered. The decision process also must weigh the economic benefits and costs of alternative actions and blend current market dynamics with considerations of long-term sustainability of the ecosystem. Sustainable production depends on health, vitality and purity of production environment of which land and water are important constituents. Therefore, for scientific utilization of the natural resources base of land and water, the ideal geographical unit would be the product of interaction of rain with land i.e., the watershed. Watershed management practices are those changes in land use, vegetative cover and other nonstructural and structural actions that are taken on a watershed to achieve watershed development objectives.

DETAILS OF THE STUDY AREA

The Boothpur Mandal lies geographically between latitudes 16°43'19" and longitudes 77°59'24" and is covered in the Survey of India toposheet numbers 56 K/14 and 56 L/2. It is one of the 64 Mandals of Mahaboobnagar district in Andhra Pradesh. Mahaboobnagar district occupies an area of 17415.23 km^2 with various agricultural, mining and quarrying, manufacturing, and household industries. As per the census of 2001, forests occupied 267ha and irrigated area occupied 997ha. The district has a total road length of 1116.317 km and a railway route of 196km. The total population of the district as per 2001 census is 35.14 lakhs, which is comprised of 3.71 lakhs of urban population and 31.43 lakhs of rural population. The decadal growth rate of the district from 1991 to 2001 i s 14.20 %.The major crops grown in the study area are rice, jowar, cotton, bajra, bengalgram, ragi, red gram, groundnut, castor, maize, chillies and sunflower. Because of long span of dry periods and less number of rainy days, the area suffers from poor soil moisture condition, resulting in frequent droughts and famines. Due to erratic nature of rainfall and impermeable nature of rocks, the stream channels are formed into shallow and wider valley floors. The drainage pattern is dendrite as a whole. Most of the stream courses are controlled by geological structures.

NEED FOR THE STUDY

The upland areas of Mahaboobnagar district in A.P. form part of semi-arid zone in peninsular India with scanty and erratic rainfall. These areas have been identified as chronically drought affected areas in the State. Famines have affected the area frequently in the past and their frequency of occurrence has increased during the last five decades. It is universally recognized that the most

effective way to eliminate drought and famine and to reverse the desertification process in an area is by augmenting water supplies to the area to optimally cater the basic needs of drinking and sustaining the agriculture on which the majority of the population depends.

With the advent of satellite remote sensing technology and computer based Geographic Information System (GIS), it has become possible for environmental planners to have correct overall perspective with least investment of time and money. Keeping these in view, the present study employs GIS combined with remote sensing technologies for augmenting and optimal utilization of water resources and watershed management programmes, which will culminate in the overall socio-economic development and poverty alleviation in the study area.

DETAILS OF THE DATA USED

To study the natural resources, the data used for the preparation of different maps are:

1. SOI Toposheets No: 56 K/14 and 56 L/2
2. LISS-III Imageries data from NRSA on November 14, 2005 and February 24, 2006 representing Kharif and Rabi seasons respectively.

OBJECTIVES OF THE STUDY

1. Creation of data base for the study area consisting of thematic layers like land use/ land cover, geomorphology, slope, soil, geology, base and drainage etc. using SOI toposheets and satellite imageries on Arc GIS platform. This constitutes the spatial database.
2. Delineation of watershed map.
3. Integration of thematic layers.
4. Generation of action plan through suggestion of watershed treatments like rainwater harvesting structures and erosion prevention methods etc.
5. Socioeconomic analysis of study area.

METHODOLOGY

The broad methodology adopted and followed to achieve the objectives of the present study involves the following steps:

1. Collection of source data like satellite data of two seasons, SOI toposheets, village maps and tentative soil erosion maps. These are the main inputs for the preparation of thematic layers.
2. Two seasons satellite data of PAN and LISS III were geometrically corrected and enhanced. Then both PAN and LISS III data were merged using principal component method and cubic convolution resampling technique. Finally, after map composition satellite imagery was printed in FCC in 1:50,000 scale.
3. Preparation of basic themes like base map, contour map and drainage map from the source data. Then updating of base map and drainage map from the satellite image by visual interpretation.
4. Watershed map and slope map were prepared from the drainage map and contour map respectively.
5. Thematic maps (related to natural resources) like land use/land cover map and geomorphology map were prepared by visual interpretation of the satellite imagery. Visual interpretation is carried out based on the image characteristics like tone, size, shape, pattern, texture, location, association and background etc. in conjunction with existing maps/literature.

6. Preliminary quality check and necessary corrections were carried out for all the maps prepared.
7. Field visits were carried out to check the delineated units of the maps prepared by visual interpretation of satellite imageries. Wherever necessary field photographs were taken. Primary data of land use, soil, well inventory and secondary data related to irrigation, agriculture, land use and ground water were collected.
8. Field observations were incorporated into the related thematic layers. Well status map was prepared by plotting the well inventory data on the village maps.
9. Final quality check and necessary corrections were carried out for all the maps prepared.
10. All the maps prepared were converted into soft copy by digitization. In that process editing, labelling, mosaicking, quality checking and data integration etc. were carried out.
11. Land use/land cover map, drainage map, ground water prospects map, slope map and command area map were integrated with village map and analysed to get villagewise statistical findings.
12. Villages were categorized by irrigation utilization and natural resources utilization based on the villagewise statistical findings.
13. Ranking criteria is prepared for the prioritization of villages for the developmental activities based on the available natural resources, and accordingly villages are ranked and categorized.
14. Report was prepared with report generation, graphics preparation, A4 size layout preparation, editing, composition and annexure preparation.
15. Preparation of arc GIS/arc view project file with hotlink to all thematic maps.
16. Preparation and plotting of maps.
17. Preparation of final deliverables in soft copy format for submission.

PREPARATION AND ANALYSIS OF VARIOUS THEMATIC MAPS

Base map: Base map of Boothpur was prepared by using Survey of India topographic maps on 1:50,000 scale. All the settlements, road network, rail network, water bodies and forest areas were taken into consideration. By comparing the Survey of India topographic maps with that of the satellite image, the size of all the settlements was increased and updated.

Drainage map: Drainage map was prepared by using Survey of India topographic maps on 1:50,000. All the streams and tanks existing in the study area were marked on this map. These streams were further classified based on stream ordering. Up to fourth order streams exist in the study area.

Slope map: Slope map of this area has been prepared from the SOI top sheet with 20m contour intervals; the local relief cannot be detected. In the study area three types of soil horizons were identified.

Soil map: Soil map was prepared from GIS maps. In the study area three types of soil horizons were identified.

Geomorphology map: Geomorphology is defined as part of geology dealing with the description of earth's surface features/landforms. The Encyclopedia of Science and Technology defines the term geomorphology as the study of landforms including the description, classification, origin, development and history of planetary surface features. Geomorphology map was prepared.

Land use/Land cover map: Land use refers to man's activities and various uses, which are carried out on land. Land cover refers to natural vegetation, water bodies, rock or soil, artificial cover and others resulting due to land transformation. The land use/land cover map of the present area was prepared. Four broad categories of land use were identified and mapped in the investigated area.

They are: 1. builtup land or settlements, 2. agricultural land, 3. forest, 4. waste lands.

The various thematic maps like location map, base map, drainage map, slope map, soil map, geomorphology map and land use/land cover map were prepared using RS and GIS techniques and are shown in Figs. 1 to 6.

INTEGRATION OF THEMATIC LAYERS

As discussed earlier six thematic layers have been prepared for the study area. All these layers were integrated for the watershed characterization. Such integration aids in the generation of an action plan for the area, which is optimally suitable to the terrain and to the productive potential of the local resources so that the level of production is sustained without decline over time.

Socioeconomic conditions: All the data pertaining to 17 villages in Boothpur mandal were collected and analysed. Population data, literacy data, livestock data, transportation facilities, medical facilities, crops grown and industries details were collected to assess the socioeconomic conditions of people all the 17 villages in the mandal.

Action plan generation: The action plan for soil and water conservation works was prepared for the study area. Action plan map is shown in Fig 7. The contour and cadastral map was used for preparing a design plan showing layout of proposed soil and water conservation works. Based on the slope, soil type and current land use, conservation structures like contour bunds/vegetative barriers, continuous contour trenches, mini percolation tanks, sunken gully pits and sub-surface dams were designed duly considering the existing holding boundaries.

Other studies: Several other studies have also been made on the use of remote sensing and GIS to study the land use, natural resources and to develop an action plan for management. Kerala Remote Sensing and Environmental Centre and Kerala Landuse Board executed a project on integrated study for sustainable development of Kasargod district, Kerala in which they have generated an action plan package by taking into consideration of socioeconomic data and existing natural resources information (NRSA 1995).

NRSA (1995) has carried out another project on IMSD in Madnur area, Nizamabad district. A.P. describing the problem of soil erosion in the study area. Keeping in view of the above said problem they have generated an action plan. Similarly, NRSA has also undertaken another project on integrated study using space technology for sustainable development of Daring Barhi block, Phulbani district, Orissa in 1995. The space-borne techniques, especially the satellite remote sensing and GIS, are being used widely for natural resources mapping, development, management and monitoring.

Rao (1996) gave an account of the concepts and methodology for sustainable development on watershed approach dwelling upon the use of remote sensing and GIS techniques. He has brought out clearly the use of remote sensing and GIS techniques to natural resources mapping for micro level planning on watershed basis and described a case history of a watershed in Anantapur district.

Gowtam et al. (1996) reported that how remote sensing and GIS techniques compliment conventional surveys particularly in survey land and water resources and to evaluate watershed characteristics.

RECOMMENDATIONS

The following recommendations are proposed:

- Non-arable lands are to be developed for silvi-pasture by the construction of soil conservation

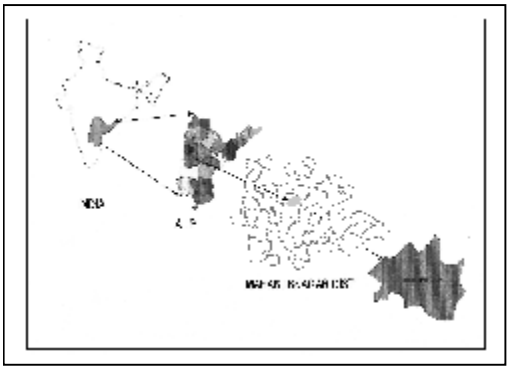

Fig. 1: Location map.

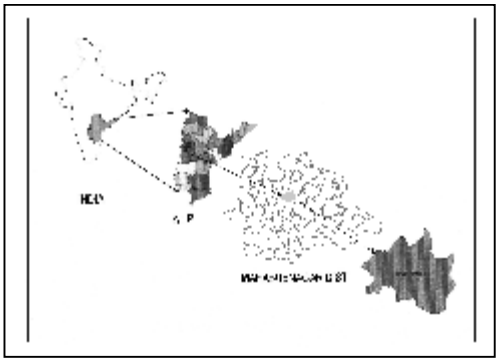

Fig. 2: Base map.

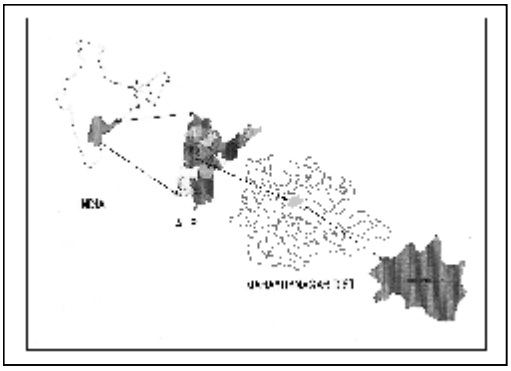

Fig. 3: Drainage map.

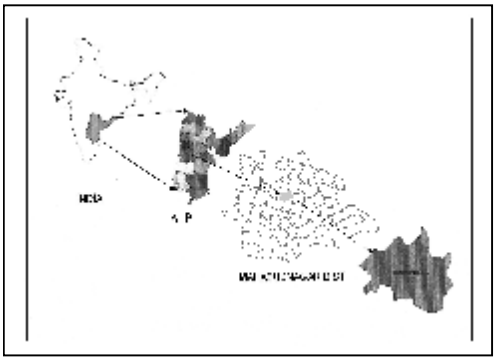

Fig. 4: Geomorphology map.

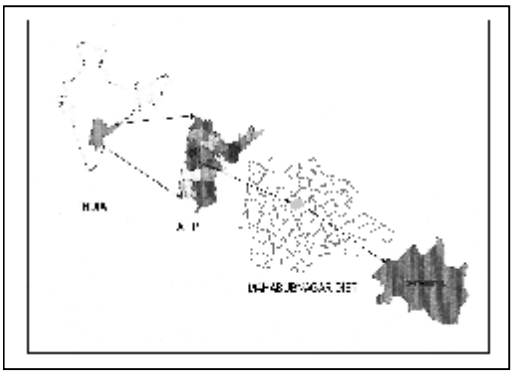

Fig. 5: Soil map.

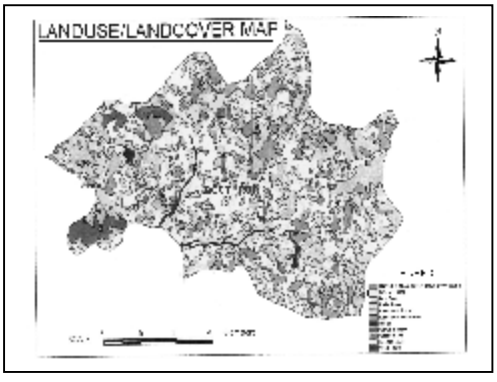

Fig. 6: Land use /Land cover map.

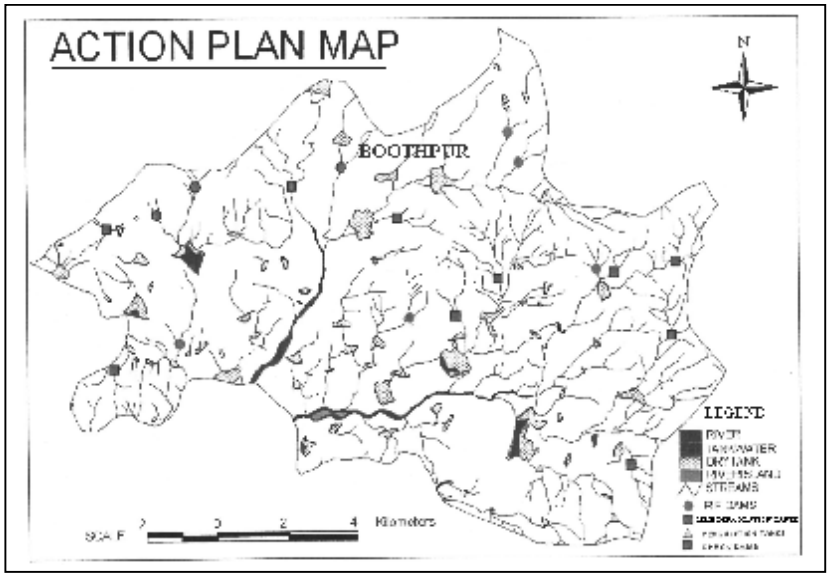

Fig 7: Action plan map.

and water harvesting structures like continuous contour trenches and sunken gully pits for sustainability.

- Degraded forests are to be afforested with trees, which produce raw material for rural industries, like leaf plates, bamboo products and carpentry etc.
- Unused arable lands to be reclaimed through agro-horticulture/horticulture by proper construction of soil conservation and water harvesting structures like contour bunding and mini percolation tanks.
- Kalabanda to be planted on the contour bunds for sustainability.
- Desiltation of tanks to be carried out to increase the water storage capacity and recharge.
- Systematic and scientific approach to be followed for cropping patterns, crop rotation and intensity of cropping, etc.
- Crop diversification by increasing area under fruits and vegetables, and adoption of crops requiring less water.
- Cultivate the sloping grounds by lift irrigation method from where the water is available in the lower level of the same land holder.
- Tapping the water potential for enhancing production through higher productivity in crops, livestock and fisheries.
- Further exploitation of ground water to be done through scientific approach like geo-physical surveys.
- Adoption of sprinkler and drip irrigation system for proper utilization of water.
- Strengthening of marketing and food processing facilities for the sustainability of agri-horticulture/horticulture development.
- Poultry farming, dairying, aquaculture and other industries to be developed by utilizing available natural resources for increasing livelihood of the people.

- Strengthening of transport and communication network for maintaining a supply system and marketing the products grown in the area.

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