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An Integrated Approach of Remote Sensing and GIS for Surface Water Conservation and Management Plan, Madhya Pradesh, India.

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Abstract. Land use/land cover mapping plays an important role for surface water conservation and management plan. The study of land use/land cover mapping prioritizes locations for suggesting appropriate recharge structures and effects of land use/land cover (LU/LC) changes on surface water storage. Main objective of the study is surface water conservation and management via multi-spectral information resulting from remotely sensed data to increase the irrigation. With the use of remote sensing/GIS data and techniques in current study, catchment area, gross command area, minimum draw down level, full reservoir level, length of dam and height of the dam have been delineated. These parameters are required for feasibility study and detailed project report preparation for dam construction. The land use/land cover statistics of submerged area help to identify the cultivated land, fallow land, open/waste land, forest, settlement and surface water bodies of study area. Identification of fracture/lineaments, creation of digital elevation model, digital terrain model and 1 meter interval contours are prerequisites for undertaking surface water conservation and management in basaltic terrain. Command area of the proposed scheme lies in Beda sub-basin, which is a tributary of the Narmada river. This study proves that implementation of Nimkheda scheme will increase the cultivated area under irrigation, facilitate the farmers for multi season cropping and help in improving their economic condition.

Introduction

The remote sensing technique has been used to measure the land cover from which land use can be inferred particularly with ancillary data. Land use is obviously constrained by environmental factors such as soil characteristics, climate, topography and vegetation. It also reflects the importance of land as a key and finite resource for most human activities including agriculture, industry, forestry, energy production, settlement, recreation, water catchment and storage. The satellite images play a vital role in identification of land use/land cover mapping.

The methods of classifying remotely sensed images are based on statistical classification of single pixel in a single digital image (Thomas *et al.*, 2004). Recent studies reveal that pixel based classification methods may be less than optimal since they do not consider the spatial relationships of landscape features (Schiewe *et al.*, 2001). The remote sensing techniques have been used to measure the land cover, from which land use can be inferred particularly with ancillary data of priority knowledge (Nobi *et al.*, 2009). Land cover mapping serves as a basic inventory of land resources for all levels of government environmental agencies and private industry throughout the world (Vijith, and Satheesh, 2007). GIS and remote sensing technology have emerged as valuable tools in natural resource management. Accordingly, geospatial information tools of GIS and remote sensing have already found widespread use in the areas of forestry, water management as well as resource planning during environmental crisis (Twumasi, 2005).

Relative to other forms of water harvesting, such as ground water and small dykes, dams reduce the fixed cost of accessing irrigation in the command area (Dhawan, 1989; Biswas and Cecilia, 2001). Unaffected land in the catchment area upstream to the reservoir is unlikely to benefit from dam irrigation, as lift irrigation is rarely practiced for dams (Thakkar, 2000). Infact, government agencies control the flow of water through the opening of gates and sluices. Finally, the control of water pumping sites typically maximizes water distribution through the canal network and maximum water storage in the reservoir, often restricts water use upstream from a dam.

For study, Nimkheda area has been selected which is situated 80 km from Khargone district of Madhya Pradesh, India, (longitude 75°29'23.92"E to 75°33'36.229"E and latitude 21°33'17.595"N to 21°36'42.813"N) covering an area about of 35.00 sq km. Entire area is covered by Deccan basalt (Fig.1).

Materials and Methods

For the present study, survey of India topographical map on the 1: 50,000 scale, LISS IV and high resolution GeoEye I (0.5 meter resolution) image have been used. To achieve the objective, integrated approach of remote sensing and GIS with convergence field data have been adopted in the present study. In order to carry out this study, following data were collected.

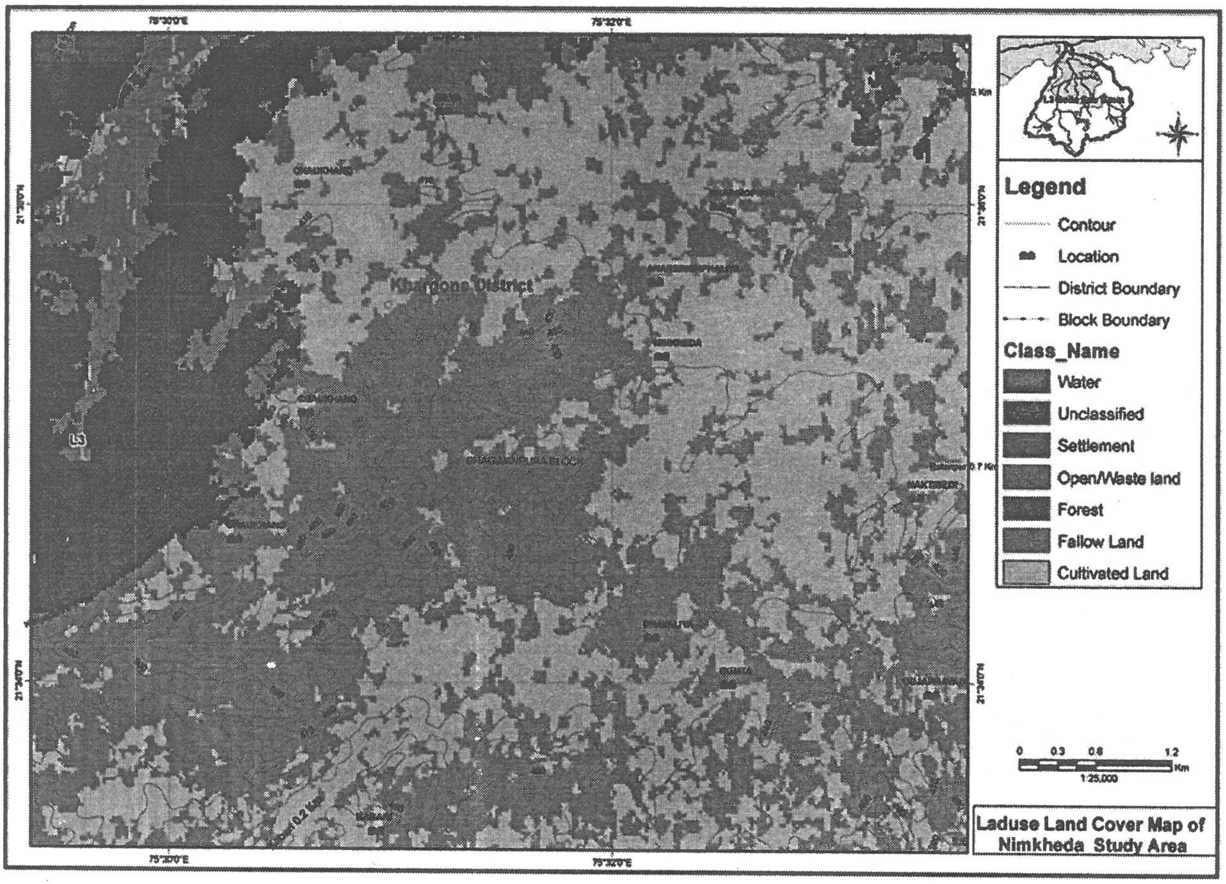

Fig.1. Land use/land cover map of the study area

Collection of rainfall data, procurement of GeoEye images, preparation of base map and land use/land cover on 1:4000, preparation of DTM and contour map of 1 meter interval, aspect and relief map from DTM, pre-field interpretation of hydro-geomorphology using satellite data, integration of all Remote sensing and GIS data, identification of feasible scheme and limited field checks have been carried out for ground truth verification.

The proposed Nimkheda scheme is based on feasibility reconnaissance surveys which have been carried out at site with input from SOI toposheets, satellite imageries and GPS instruments. The overlap of the proposed command area with any nearby irrigation scheme was avoided. For the present study the interpolated contours of 1.0 m were generated using GIS technique based database of images. The interpolated contour map was used to work out the details of the proposed scheme.

Results and Discussion

On the basis of satellite data examination six classes of land use have been classified on the basis of level I classification, considering RUIS standards. These demarcated classes are water body, settlements, open/waste land, forest, fallow land, cultivated land and unclassified class (Fig.1). The satellite image has good indicators like tone, texture colour, and pattern to establish land use / land cover mapping.

The land use/land cover details show cultivated land of 41.82%, fallow land of 11.89%, and forest area of 12.02%, open/waste land of 34.17% and settlement of 3.37% in entire area. These values are good indicators and play the significant role for dam construction. The land use/land cover statistics of entire area has been given in Table.1.

Table 1. Land use/land cover statistic of the study area.

S.No.	Class Name	Lu/Lc statistic (Ha)	Area (%)
1	Cultivated Land	1443.5625	41.82807155
2	Fallow Land	409.75	11.87274699
3	Forest	414.9936	12.02468338
4	Open/waste Land	1179.5	34.17670548
5	Settlement	3.375	0.097792608
6	Water	0	0
Total		3451.1811	100

In the study area, for the conservation and management of surface water, a dam site has been selected. Dam site has been divided into four parts such as submergence area, command area, dam axis and catchment area (Fig.2).

Land use/land cover statistics of submergence area in Nimkheda tank scheme identifies cultivated land 3.4375 ha, fallow land 1.6875 ha, open/waste land 2.125 ha. Such information gives an idea for the selection of site for surface water conservation and management plan because settlement and forest areas do not fall in particular submergence zone.

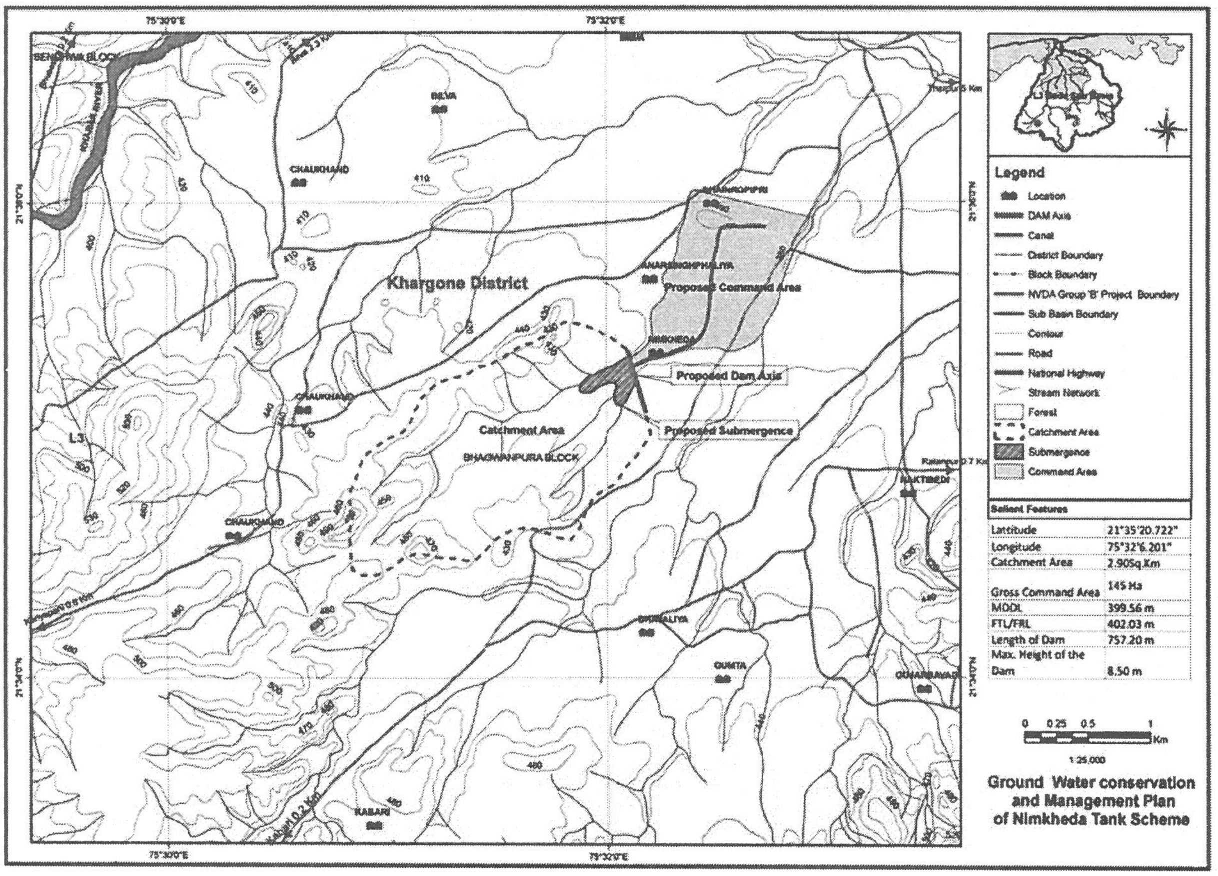

Fig. 2. Map showing surface water conservation and management plan

The salient features of Nimkheda tank scheme are latitude- 21°35'20.722" longitude- 75°32'6.201", catchment area- 2.90 sq.km gross command area- 145 ha, minimum draw down level (MDDL)- 399.56 m, full reservoir level (FTL/FRL) - 402.03 m, length of dam- 757.20 m, max. height of the dam -8.50 m.

The rainfall stations have been adopted for computation of runoff of the project site. The available 51 year annual rainfall data of Nimkheda area have been analyzed. Based on data series, the rainfall at 75% dependability has been ascertained as 572.5 mm. The maximum, minimum and mean rainfall are 1330.2 mm; 113 mm and 753.53 mm respectively. The yield calculated using Binnie's yield table corresponding to the maximum, mean and 75% dependable rainfall are 1.767 MCM; 753.53 MCM and 0.325 MCM respectively. Storage reservoir is proposed on stream falling in the drainage area, which will be feeding the main canal off taking from the Nimkheda storage scheme.

Area of available contours and DEM has been computed using GIS module. Areas at intermediate levels and corresponding gross capacity have been calculated by the usual method.

As this tank is required to cover the deficit irrigation requirement during non-filling period and all the available 75% dependable storage from the site is contemplated to be stored. Gross capacity for the proposed storage scheme is 0.38 MCM. The corresponding capacity at LSL is 0.052 MCM, MDDL is 0.079 MCM and FRL is 0.38 MCM respectively. Total area under submergence is 18.85 Ha and total cultivated area under submergence with respect to the designed FRL is 8.6 Ha. The main canal which is contour or ridge is designed to carry a maximum discharge of 0.025 cumecs at head is 1.83 km long.

At present, in Nimkheda area, the crop cultivations are totally dependent on rainfall and it is subject to vagaries of monsoon. Providing irrigation will improve the economic condition of the farmers and result in efficient utilization of soil and water resources of the region. Water distribution in the command area of Nimkheda dam is proposed via artificially constructed canal. The command area lies downstream from the reservoir, with the canal extending in the downstream direction along the main stream and covering parts of villages. The effects of dam on agricultural production in the neighboring downstream village have also been positive.

Land use/land cover mapping of Nimkheda and surroundings areas shows that the physical condition of soil and terrain are positive for multiseason crops.

Conclusion

Present study reveals that Nimkheda is an excellent location for surface water conservation and management. The gross command area is of 145 ha, so this scheme is effective for irrigation purpose for the surrounding villages.

It has been found that remote sensing coupled with GIS can be effectively used for real time and long term systems. The land use/ land cover pattern mapping of the area would be a good facility for development and management plan. This study proves that implementation of Nimkheda scheme will increase irrigation by 52 % of existing irrigation and facilitate farmers for multi season cropping.

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