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LAND USE PLANNING THROUGH LAND EVALUATION OF A WATERSHED USING REMOTE SENSING AND GIS TECHNIQUES

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ABSTRACT

Critical appraisal of existing land becomes significant for assessment of sustainable development of any resource, as the runoff moves and water resources on spatial-temporal dimension are indispensable. The process of planning at grass root level for optimal utilization of these resources further needs deeper evaluation. Timely as well as reliability on available data facilitates the planner to formulate a comprehensive plan with unambiguity. The present work envisages to assess natural resources for a part of Maheshwaram watershed area situated in Rangareddy District, A.P., and to identify the existing problems and potential of the area and to generate an action plan for the optimum development on a sustainable basis. The efficient and proper utilization of water resources is very essential in order to fulfil the water requirements for various purposes such as drinking, irrigation, industrial use, etc. It can be achieved by proper watershed management, which requires various characteristics of watershed such as land use information, geology of the area, soil type, drainage system, it's size and shape of streams. Conventional and manual techniques for the study of watershed characteristics are expensive and time consuming. Remote Sensing and GIS techniques can provide quick and accurate information about watershed characteristics for the efficient watershed management. IRS-1D (LISS-III+PAN) data have been used to generate different thematic maps. The action plan suggests necessary measures to be taken to convert the unproductive areas into profitable one without increasing environmental degradation.

INTRODUCTION

Land and water are two broad components on which the entire biotic community thrives. Because of increasing human pressure, the harmonization of interrelationship between the other living creatures and the mankind itself has arisen innumerable problems. The socio-economic development of our country is interlaced with our natural resources and the manner in which they are managed and exploited. Reliable and timely information on the available natural resources is very much essential to formulate a comprehensive land use planning for sustainable development. The land, water, minerals and biomass resources are currently under tremendous pressure in the context of highly competing and often conflicting demands of an ever-expanding population. Consequently over exploitation and mismanagement of resources are exerting detrimental impact on environment.

The striking manifestations of the phenomenon are various kinds of land degradation, water and air pollution, and biomass deterioration. The need of the hour is to reverse the process of degradation and to conserve and enhance the resource base for our country keeping pace with the accelerating technology. This is indispensable as apart from meeting the present needs of the people, the future generation has to co-exist with the nature without altering the basic entity of the latter. Watershed management has been accepted as an approach to the integrated area development programme, which signifies development of all sorts of resources for planning and implementation in unit area.

Conservation and harvesting of water resources on a watershed basis should receive top priority in the strategy for development of dry lands. Other components of increased crop production such as improved seeds, fertiliser, agricultural machinery, plant protection measures, etc. should be adopted in coordination with water availability. Information on land use/land cover is the basic prerequisite for land resource evaluation, environmental assessment, utilization and management. A considerable degree of land transformation is being witnessed as a result of growing population pressure on the finite land resources culminating in deterioration of the environment. As a precursor, it is necessary to understand the 'cause and effect' of the transformations through scientific studies.

OBJECTIVES OF THE STUDY

The present study was carried out with the following objectives:

- To identify the double crop areas and the degraded areas using remote sensing data.
- To assess the problems and potentiality of the area.
- To map certain thematic information by interpreting the satellite imageries and Survey of India toposheet and production of maps.
- To generate a resource based land use plan (Action Plan) for sustainable development.

Based on the technical guidelines given by Department of Agriculture, Govt. of India, various water resources development and management techniques, soil and water conservation measures and optimal land use patterns were suggested for the overall sustainable economic development of watershed.

From mid-eighties, development of dry land agriculture on watersheds has been a national strategy for sustained productivity and rational utilisation of natural resources. Thus, the deterioration of natural resources in an area can be contained. The total resource can be properly developed, only by adopting the watershed approach. The basic unit of development is a watershed, which is a manageable hydrological unit. In this approach, development is not confined just to agricultural lands alone, but covers all the areas, starting from the highest point of the area (ridge line) to the outlet of the natural stream. In terms of resource development, it covers development and management of resources like soil, water, vegetation and all associated components (Crusade 1995).

Watershed management may be defined as the process of formulating and carrying out a course of action involving manipulation of natural, agricultural and human resources of a watershed to provide resources which are desired by and suitable to the watershed community, but under the condition that soil and water resources are not adversely affected. Watershed management must consider the social, economic and institutional factors operating within and outside the watershed. Watershed management practices are those changes in land use, vegetative cover and other non-structural and structural actions which are taken on a watershed to achieve watershed development objectives (Chakrabarthi 1993).

STUDY AREA

The study area is Maheshwaram watershed of Ranga Reddy district, Andhra Pradesh and covers an extent of 53 km^2 located to the south of Hyderabad between 78°24'30" to 78°29'00" east longitude and 17°06'20" to 17°11'00" north latitude.

DATA COLLECTION

The basic satellite data selected corresponds to IRS-1D multi-spectral data of November 2002

Table 1: Characteristics of IRS satellite data.

Satellite & Sensor	Path/Row	Date of Pass	No. of Bands	Band width (Microns)	Spatial Resolution (meters)	Product Type/ Format	Scale
IRS-1D LISS-III IRS- 1D (LISS-III+PAN)	1100/61	5th Nov. 2002 25th Dec. 2002 13th Feb. 2003	3	G: 0.52-0.59 R: 0.62-0.68 NIR: 0.77-0.86	23.5 5.8	Digital (BIL) & rectified hard copy	1:50,000

(LISS-III), December 2002 and February 2003 (PAN+LISS–III) period (Table 1). Survey of India (SOI) topographical maps on 1:50,000 scale viz., 56K/8 was used for base map preparation. Village map of Maheshwaram, compiled by Joint Director of Agriculture, Govt. of A.P., Hyderabad, has been obtained. Ground truth verification of doubtful areas and ground measurements form important components of satellite-based remote sensing studies, which will enhance the interpretation accuracy (Lillesand & Kiefer 1978).

Software Used for Analysis

- ERDAS IMAGINE 8.5 for vectorization and map composition.
- ARCGIS 8.3.1 for rectification of errors and assigning attributes

The work was comprised of the following major steps:

1. Data conversion
2. Assigning attributes to coverage features
3. Statistics
4. Preparation of maps like base map, drainage map, soil map, land use/land cover map
5. Action plan

Application to Study Area

Base map: Base map shows the settlements, major and minor roads, railway lines, major water bodies, telephone lines, etc. The Base map prepared for the study area is shown in the Fig. 1.

Land use/Land cover map: Land use/Land cover map shows different land use/land covers categories derived from remotely sensed satellite data. Agricultural land use study has acquired a special significance in the present day problem oriented to studies of the growth and resource utilization (National Remote Sensing Agency 1991, 1993).

Table 2: Land use/Land cover statistics level-I of Maheshwaram watershed.

Sl.no	Category	Area in sq. km
1	Built-up	1.38
2	Cropland (paddy)	6.80
3	Cropland (other crop)	27.90
4	Double crop	2.07
5	Fallow	0.17
6	Plantation	4.59
7	Forest	3.73
8	Scrub land	3.59
9	Barren rocky	1.77
10	Tank	0.82

The major land use/land cover categories which are identified in the Maheshwaram watershed include built-up land, agricultural land, forest land, waste land, water bodies and others.

The agricultural lands in the study area have been classified as:

1. Double crop (paddy area)
2. Kharif (paddy)
3. Kharif (other crop)
4. Mixed plantation
5. Current fallow

Fig.1: Base map of Maheshwaram watershed.

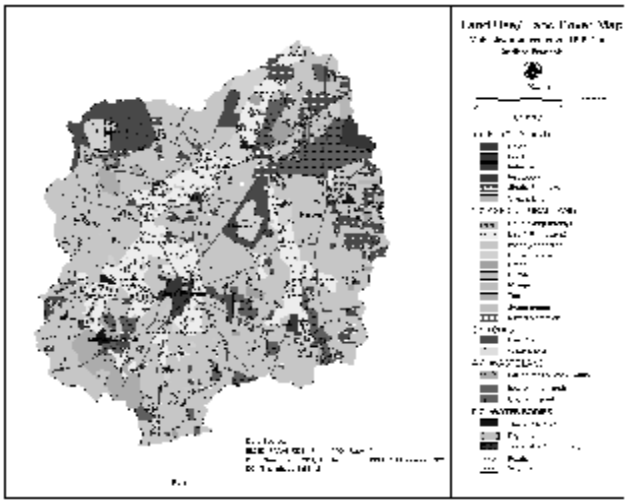

Fig . 2: Landuse/Landcover map of the study area.

The following classes of wasteland classes have been identified in the study area.

1. Land with or without scrub

2. Barren rocky/Stony waste

Land use/Land cover map is shown in the Fig. 2. The Land use/Land cover statistics level-1 Maheshwaram watershed are given in Table 2.

Drainage map: The stream order in the Maheshwaram watershed area has been categorized. The number of streams in the first order are 99 and in the fourth order is only 1 in the main stream. Bifurcation Ratio (R_b) is the ratio between total number of streams of one order to that of next higher order.

The bifurcation ratio "R_b" is calculated by the equation:

$R_b = N_u/N_u + 1$

Where N_u represents the stream order and Nu + 1 streams of next higher order. The 'R_b' value in the catchment area ranges from 3.00 to 4.55. Higher bifurcation of 4.55 indicates a well developed drainage network of the catchment. The bifurcation ratio in the second and the third order is less when compared to the mean bifurcation ratio of the catchment area, which is 3.66. This indicates that there are few lower order streams in the catchment, thus, restricting the surface water flow. The fourth order stream forms the main stream in the catchment and it flows over an undulating terrain. Bifurcation ratios ranging between 3 and 5 are characteristics of natural stream systems (Hortan 1932).

Mean length of streams also decreases with the decrease in stream order. It is also noticed in the length ratio (LR) whose value decreases from 2.34 in fourth order to 0.48 in the first order. The mean length ratio is 2.38 kms and comparing this with the length ratio between first and second order streams, it is observed to be low indicating that the water flow in the source region is limited due to semi-arid environment and low rainfall. Higher length ratio of fourth and third order stream indicates a higher surface flow.

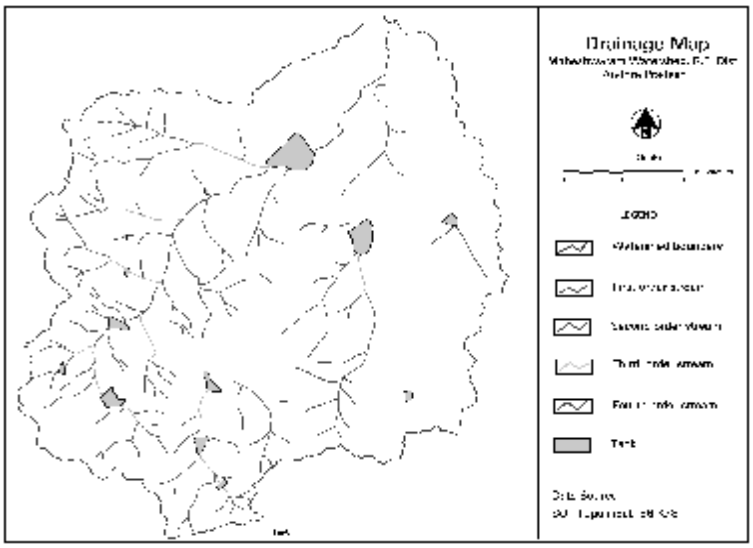

Fig. 3: Drainage map of the study area.

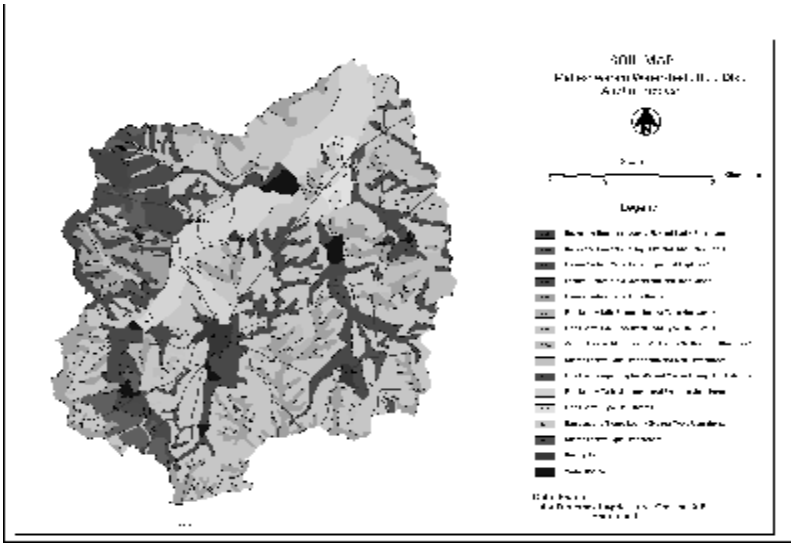

Fig. 4: Soil map of the study area.

The drainage intensity in the hill area and upper slopes is high, and moderate in lower slope. The drainage pattern is dendritic to sub-dendritic. The drainage map is shown in Fig. 3.

Soil map: In order to plan the efficient utilization of land resources without affecting the environment, mapping on soils based on a systematic study is very important. Utilizing the soil resources based on their productivity and capability, lead to good economic and agricultural development of the region. Mapping of soils by satellite remote sensing technique is well established by virtue of its

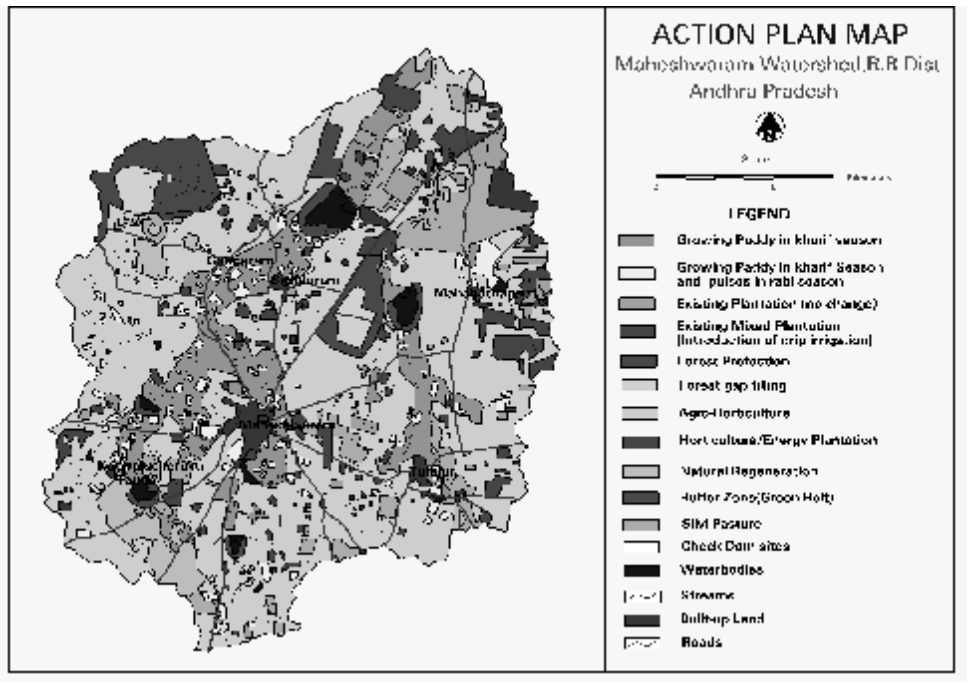

Fig. 5: Action plan map of the study area.

accuracy in boundary delineation and cost effectiveness besides being time saving (Moutappa 1968, Saxena 1996). In this study land resources were evaluated for agricultural and non-agricultural uses. Soil map is shown in Fig. 4.

Development of Action Plan

The action plan is proposed for necessary measures to be taken to convert the unproductive areas into profitable one without increasing environmental degradation. Action plan for land resources is made from the thematic maps. In the study area, marginal lands could be profitably put to alternate land use systems like tree farming. Trees and scrubs contribute substantially for maintenance of a healthy balance in the ecosystem, besides meeting the basic human and livestock requirements. The basic Objectives for alternate land use system are:

1. To increase the biomass production per unit of land.
2. To utilize and conserve natural resources which otherwise will be subjected to degradation.
3. To improve the overall ecosystem of the region.

The decision rules for action plan are given in Table 3. The action plan map is shown in Fig 5.

CONCLUSIONS

Based on the analysis of the results following conclusions are made:

1. Soil erosion appears to be a major problem in the study area.
2. Most of the dry land agriculture is carried in monsoon season with only one crop per annum, while the well-irrigated land is used for two crops per annum in fertile regions.

Table 3: Decision rules for action plan.

Existing landuse/ Land cover	Soil	Recommended
Kharif crop (others)	Fine loamy/loamy skeletal, mixed Typic Rhodustalfs	Agro horticultural
Double crop	Fine loamy skeletal, mixed typic ustorthents	Growing paddy in kharif season and pulses in rabi season
Mixed plantation	Fine loamy, mixed fluventic typic ustorpepts	Mixed plantation (drip irrigation)
Current fallow	Loamy skeletal/coarse mixed, lithic/ typic ustorthents	Horticulture/energy plantations
Barren rocky/stony Waste	Fine loamy/loamy skeletal, mixed typic ustorpets/rhodustalfs	Natural regeneration
Land with/without scrub	Loamy skeletal, typic ustorpets	Silvi-pasture
Outer boundary of waterbody	Fine loamy aquic haplustalfs and coarse loamy udic ustorpets	Buffer zone for green belt
Forest area	Fine loamy typic ustorpets, typic haplustalfs.	Protection in reserve forest and gap filling

3. Marginal farmers for the sake of livelihood go for the water intensive paddy crop, to bail out the food requirement in year around, thus, pressurizing the ground water content and land holding which decreases its fertility.
4. Due to year round irrigation by tube wells there has been a large impact in ground water aquifer, which is decreasing steadily. Because of lack of awareness and scientific approach farmers are prone to hardships and debt trap, thus, leaving land fallow in consecutive season.
5. During ground truth visit, it was observed that fertile land near Tumlur to Mohabhatnagar road has some brick kiln units. This activity turned the area into a degraded land as the fertile topsoil is used to manufacture bricks and the area is presently not useful for agriculture. Abounded mud quarry or brick kiln was also noticed in Kalwakurty-Maheshwaram road and around Sirigiripuram and Gangaram villages.
6. Action plan for land resources was made from the thematic maps and suitable crops have been recommended.
7. Vegetative cover appears to be minimum within this area.

RECOMMENDATIONS

The following recommendations are made for the agricultural development of the study area:

- Silted sand can be applied on topsoil thereby reducing infiltration rate and increasing the water holding capacity of surface soils.
- By following good crop rotation the fertility level of the soil can be maintained.
- Instead of paddy cultivation, short duration crops like pulses, greengram, black gram and coarse serials like jowar, maize, etc. to be cultivated.
- The size of the fields should be reduced and the bunds should be strengthened with grasses and suitable tree species. Trees like Glyresedia, subabul, stylo and curry leaf are suitable.
- Most of the non-forest area is under undulating pediment, with slopes ranging from 1-8% causing slight to moderate erosion instead of severe erosion.
- Vegetative cover appears to be minimum. It is advised to grow trees such as custard apple, subabul, etc. along roads and field bunds, thereby increasing the study area with vegetative cover.

- Farmers should be encouraged to take up social forestry in the community lands.
- Water harvesting should be given importance so as to avoid the wastage of water from watershed. This will increase the ground water recharge besides providing supplementary irrigation during Rabi season.
- It was also observed that farmers are growing paddy in loamy skeletal soils, which is not suitable as it leads to wastage of water. The farmers are advised to irrigate dry crops.
- To catch on development program in Maheshwaram watershed area the brick kiln activity has to be banned. Any kind of human intervention that affects the soil fertility or damages the soil layer shall not be entertained as the basic soul of watershed management program get back seated.

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