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ASSESSMENT OF LAND USE LAND COVER CHANGES IN MIDDLE GODAVARI (G-5) SUB BASIN OF RIVER GODAVARI USING RS AND GIS

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ABSTRACT

In the present study, Kaddam watershed of G-5 sub basin i.e. 'Middle Godavari' sub basin of Godavari River Basin has been considered for the evaluation of land use land cover changes. Eight rain gauge stations were identified in and around the study area and accordingly the sub basin has been divided into eight sub areas namely Khanapur, Kaddam, Neredigonda, Boath, Ichoda, Utnoor, Inderavelly, and Bazarhathnoor based on Thiessen polygon network. The land use/land cover classification was made based on Normalized Difference Vegetation Index (NDVI) using two IRS-P6 LISS-III satellite imageries each for Kharif and Rabi seasons. The areal extent of Water Bodies was computed as 25.408sq km for the year 2003 and 16.988 sq km for the year 2004 in the Rabi season .The areal extent of Cropland was computed as 613.803 sq km for the year 2003 and 597.701 sq km for the year 2004 in the Rabi season. The areal extent of bare soil was computed as 23.19 sq km for the year 2003 and 71.409 sq km for the year 2004 in the Rabi season. The areal extent of Fallow land was computed as 57.643 sq km for the year 2003 and 47.479 sq km for the year 2004 in the Rabi season. The areal extent of Forest was computed as 1897.52 sq km for the year 2003 and 1883.99 sq km for the year 2004 in the Rabi season .The areal extent of Water Bodies was computed as 13.818 Sq km for the year 2004 and 20.244 sq km for the year 2005 in the Kharif season The areal extent of Cropland was computed as 570.422 sq km for the year 2004 and 457.625 sq km for the year 2005 in the Kharif season. The areal extent of bare soil was computed as 63.993 sq km for the year 2004 and 49.931 sq km for the year 2005 in the Kharif season. The areal extent of Fallow land was computed as 91.675 sq km for the year 2004 and 143.337 sq km for the year 2005 in the Kharif season. The areal extent of Forest was computed as 1877.65 sq km for the year 2004 and 1946.43 sq km for the Year 2005 in the Kharif season. It could be concluded that for the considerably large areas comprising predominantly of vegetation, NDVI classification is better suited. NDVI classification is found to be especially suitable in such cases where the analysis was carried out using either past imageries or present imageries with no ground truth data.

Key words: Remote Sensing, GIS, NDVI, Land Use, Land Cover

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1 INTRODUCTION

Land use/land cover inventories are essential for the optimal utilization and management of resources in a given sub basin. Land cover refers to different features covering the earth's surface including vegetation cover, water bodies, open scrub etc. It integrates the sum of human activities having an influence on the environment. The USGS has devised a land use/land cover classification system for use with remote sensor data (Anderson et al., 1976). Land use and land cover information should be presented on separate maps and should not be intermixed (Lillesand et al., 1979). With the latest advancements and the wide range of applications in the field of remote sensing, Geographic Information System (GIS) facilitates the adoption of new methodologies which prove to be highly efficient. (Sahai et al., 1985) used multidate, multispectral Landsat imagery of pre and post monsoon studies. The overlay of the toposheet on the satellite image with appropriate ground truth provides the features of the land use/land cover of the selected area. ERDAS 8.7 has been used to study land use/ land cover features of the sub basin. The objective of the present study is to study and evaluate the land use and land cover changes in Kaddam watershed of G-5 sub basin i.e. 'Middle Godavari' sub basin of Godavari River Basin, Andhra Pradesh, India. Nayak and Jaiswal (2003) observed that the conventional hydrologic data are inadequate for the purpose of design and operation of water resources systems. In such cases, remote sensing data are of great use for the estimation of relevant hydrological data. RS data can serve as a model input for the determination of river catchment characteristics such as land use /land cover, geomorphology, slope, drainage etc. GIS offers the potential to increase the degree of definition of spatial sub units, both in number and descriptive detail.

Holben (1986) studied that Normalized Difference Vegetation Indices (NDVI) increased as one proceeds from water through ice, snow, opaque clouds, bare soil, to green vegetation. (Wiegand et al., 1991) have argued that, at a specific site, the cumulative evapotranspiration and cumulative vegetation index should be highly correlated because the same green plant tissue measured by NDVI is due to absorbed active photo synthetic radiation. Reddy (1997) described that satellite data provides integrated information on rock types, land forms, geological structures, weathering, soil types, erosion, land use/land cover, surface water bodies, distribution of ground water, slope details, soil type, rainfall, irrigated areas and their acreage etc., All these data, incorporated into the GIS package, it will form an excellent data base and becomes useful for judicious planning, proper development and effective management of water resources.

Identification and delineation of Land use/Land cover, location, extent and their spatial distribution patterns are possible because of the synoptic view provided by the Satellites and their ability to resolve both macro and micro details on a single imagery. It provides periodic coverage of the same area thus enabling to obtain Multi-temporal data useful for monitoring the dynamic aspects of Land use/Land cover. It provides data both in analog and digital form. Such data is amenable for both visual interpretation and digital analysis for extracting thematic information. It is relatively fast, cost effective and economical for inventorying several details of LU/LC than the most of the other methods of surveying. The different Multi-spectral and Spatial data can be merged with other satellite data for optimizing the LU/LC identification and discrimination.

2 STUDY AREA

The area selected for present study is Kaddam watershed of G-5 sub basin i.e. Middle Godavari sub basin of Godavari River Basin. The Godavari basin is situated between East longitudes 73^0 21' to 81^0 09' and North latitudes 16^0 07' to $22^0$50' in the Deccan plateau covering large areas in the States of Maharashtra, Madhya Pradesh, Chattisgarh, Orissa, Karnataka and Andhra Pradesh. The Godavari basin extends over an area of 3, 13, 812 sq.km which is nearly 10% of the total geographical area of the country. Godavari catchment was divided in to eight sub basins. The study area is a part of G-5 sub basin i.e. Middle Godavari sub basin of River Godavari which lies between latitudes $17^0$04' and $18^0$30' North and longitudes $77^0$43' and $79^0$53 East. The Middle Godavari sub basin has a catchment area of 35723 km^2, which constitutes 11.38% of the total basin area and entirely lies in the State of Andhra Pradesh. In the present study, Middle Godavari sub basin has been considered up to Kaddam reservoir only which lies between latitudes $19^0$05' and $19^0$35' North and longitudes $78^0$10' and $78^0$55' East. The areal extent of the study area is 2651km^2, which constitutes 7.4% of the sub basin area. The climate in the study area is semi arid with an average annual rainfall of 765mm, approximately 50% of which occurs during June. The minimum and maximum temperatures range from 1.8 to 31.5°C and 7.4 to 43.6°C respectively. Daily mean relative humidity ranges from 10 to 100%. The highest wind speed 136 km/hr.

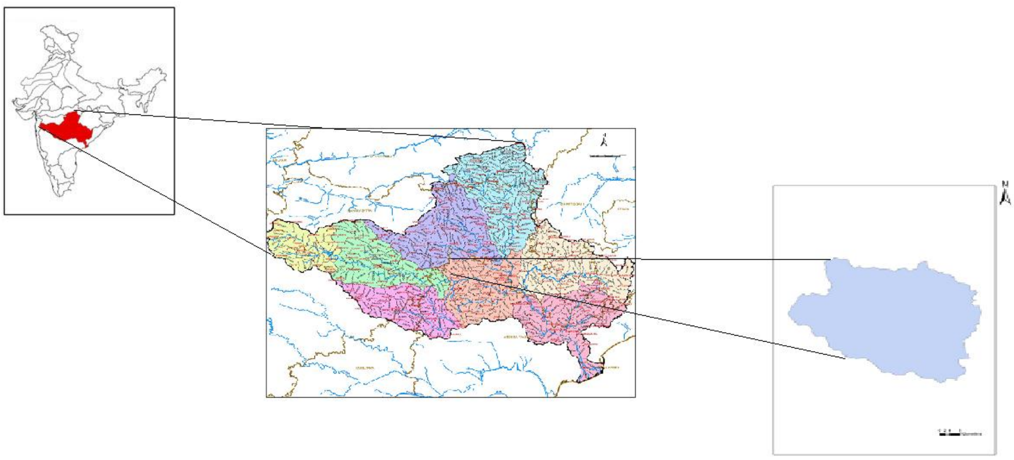

Fig 1: Location plan of Middle Godavari sub basin (G-5)

3 DATA USED

Spatial data in the form of satellite imageries for the preparation of Land use/Land cover details at sub basin level were procured from National Remote Sensing Agency (NRSA), the details being listed in Table 1. These satellite imageries for both Kharif and Rabi seasons for two years pertain to Indian Remote Sensing Satellite (IRS) P-6, Linear Imaging and Self Scanning Sensor (LISS –III) with a resolution of 23.5m. The topographic maps used namely 56 I3, I6, I7, I8, I10, I11, I12, I14, I15 and I16 on a scale of 1:50,000 were collected from Survey of India (SOI), Uppal, Hyderabad for the delineation of watershed boundary.

Table 1 Details of Satellite Imageries

Sl.No	Date of pass	Path, Row, Shift and Scanner	IRS	Season
1	04-12-2003	99, 58, 50% SHIFT, LISS-III	P6	Rabi
2	02-04-2004	99, 58, 50% SHIFT, LISS-III	P6	Kharif
3	22-12-2004	99, 58, 50% SHIFT, LISS-III	P6	Rabi
4	28-03-2005	99, 58, 50% SHIFT, LISS-III	P6	Kharif

4 METHODOLOGY

4.1 Spectral Response of Vegetation: The visible and near infrared bands on the satellite multi spectral sensors allow monitoring of the greenness or vigor of vegetation. Green vegetation is highly absorptive in the visible part of the spectrum, mostly owing to the presence of chlorophyll. Beyond a wavelength of about 700nanometers, the absence of absorbing pigments and leaf structure results in high reflectivity for green vegetation. In contrast, other features such as bare ground, water, snow and clouds have similar reflectance in visible channel compared to near infrared channel. Stressed vegetation is less reflective in the near infrared channel than non-stressed vegetation and also absorbs less energy in the visible band. Stratification of the Normalized Difference Vegetation Index (NDVI) response to broad scene components was shown in Table 2. Vegetation indices were found to increase as one proceeds from water through ice, snow, opaque clouds, bare soil, to green vegetation Holben (1986). Out of the various vegetation indices available, NDVI is very widely used as it minimizes the effect of change in illumination condition and surface topography (Holben, 1986). The NDVI is defined as the ratio of difference between the near infrared and red reflectance to their sum.

where

$$NDVI = \frac{CH2 - CH1}{CH2 + CH1} \quad \textbf{(1)}$$

CH1 = Spectral reflectance from red band / channel
CH2 = Spectral reflectance from near infrared band / channel

Table 2 Albedo Values for Different Cover Types.

Sl. No	Cover Type	Planetary Albedo		
		CH1	CH2	NDVI
1	Dense green leaf vegetation	0.050	0.150	0.500
2	Medium green leaf vegetation	0.080	0.110	0.140
3	Light green leaf vegetation	0.100	0.120	0.090
4	Bare soil	0.269	0.283	0.025
5	Clouds	0.227	0.228	0.002
6	Snow and Ice	0.375	0.342	-0.046
7	Water	0.022	0.013	-0.257

The thematic map of Land Use / Land Cover has been prepared using ERDAS 8.7. The classification of land Use / Land Cover classes were evaluated using NDVI. Of all the available methods of image classification with regard to vegetation and its sub classification, NDVI forms the basis for a better classification and hence adopted for the present study. And also, as the study area is considerably large comprising predominantly of vegetation, NDVI classification is better suited and hence employed for the classification of Land Use / Land Cover. This data is used as an input for direct runoff estimation.

5 PREPARATION OF LAND USE / LAND COVER THEMATIC MAP

Spatial data in the form of satellite imageries for the preparation of Land Use/Land Cover details at sub basin level were procured from National Remote Sensing Agency (NRSA) the details are listed in Table 1. These satellite imageries for both Kharif and Rabi seasons for two years pertain to Indian Remote Sensing Satellite (IRS) -1C & 1D, Linear Imaging and Self Scanning Sensor (LISS –III) with a resolution of 23.5m. The collected satellite images were georeferenced in ERDAS 8.7 then rectified and finally projected. The delineated watershed in vector form was overlaid on projected satellite imagery to get sub set of the study area. Thiessen polygon coverage which was prepared in GIS in vector form was overlaid on sub set image of the study area in ERDAS 8.7 to get delineation for all ten sub areas namely Khanapur, Kaddam, Neredigonda, Jainoor, Boath, Ichchora, Narnoor, Utnoor, Inderavelli, Bazarhatnoor and Sirpur. Normalized Difference Vegetation Index (NDVI) was employed as the basis for Land Use / Land Cover classification. This method of classification has been found to be suitable for the study area i.e., Middle Godavari sub basin as the data used was pertaining to the past period i.e., years 2003,2004 and 2005 and also the study area is considerably large comprising predominantly of vegetation. Study area has been classified for Land Use / Land Cover into five classes viz., Water bodies, Crop land, Bare soil, Fallow land and Forest in each sub area based on NDVI values generated in ERDAS 8.7. Area under each class has been calculated from the attribute table in Arc.GIS9.2. The classified thematic map was converted from raster to vector format for further analysis. The Land Use / Land Cover thematic map and soil map were intersected in command tools of ARC/INFO.

6 RESULTS AND DISCUSSION

Four satellite imageries were analyzed using ERDAS 8.7, two of them pertaining to Rabi season and another two related to summer season in the years 2003, 2004 and 2005 respectively. The thematic map of Land Use / Land Cover has been prepared using ERDAS 8.7 for all imageries. The land Use / Land Cover classes were evaluated using Normalized Difference Vegetation Index (NDVI). Study area has been classified into five classes viz., Water bodies, Crop land, Bare soil , Fallow land and Forest in each sub area based on NDVI values for Land Use / Land Cover classification. Areal extent under each class has been calculated from the attribute table of ERDAS 8.7. The areal extent of Water bodies, Crop land, Bare soil, Fallow land and Forest classes has been calculated for each sub area. From these details, Land use class wise Statistics have been generated..

The areal extent of water bodies in Rabi season was estimated as 25.408 sq km and 16.988 sq km for the years 2003 and 2004 respectively. The decrease in water spread area from the year 2003 to 2004 was due to corresponding decrease in rainfall in the study area from 920 mm to 756 mm. Similarly, the areal extent of water bodies in Kharif season was estimated as 13.818sq km and 20.244 sq km for the years 2004 and 2005 respectively.

The areal extent of Cropland was computed as 613.803 sq km and 597.701sq km for the years 2003 and 2004 respectively in the Rabi season and 570.422and 457.625sq km for the years 2004and 2005 respectively in the Kharif season. The areal extent of Cropland has decreased by 16.102 sq km and 112.797 sq km in Rabi and Kharif seasons respectively. While the decrease in Rabi is not considerable, the decrease in Kharif season can be attributed to delayed monsoon and corresponding delay in growing period coinciding with summer.

The areal extent of bare soil was computed as 23.19sq km and 71.409 sq km for the years 2003 and 2004 respectively in the Rabi season and 63.993and 49.931sq km for the years 2004 and 2005 respectively in the summer season. Bare soil increased by 48.219 sq km and decreased by 14.062sq km in Rabi and Kharif seasons respectively. The areal extent of Fallow Land was computed as 57.643 sq km and 47.479 sq km for the years 2003 and 2004 respectively in the Rabi season and 91.675 and 147.337 sq km for the years 2004 and 2005 respectively in the Kharif season. Fallow Land decreased by 10.164 sq km and increased by 55.662 sq km in Rabi and Kharif seasons respectively.

The areal extent of Forest Land was computed as 1897.52 sq km and 1883.99 sq km for the years 2003 and 2004 respectively in the Rabi season and 1877.65 and 1946.43 sq km for the years 2004 and 2005 respectively in the summer season. Forest Land decreased by 13.53 sq km and increased by 68.78 sq km in Rabi and Kharif seasons respectively indicating that the forest area did not register much difference. The variation of areal extent of water bodies, Crop land, Bare soil, Fallow land and forest classes of land use and land cover in each sub area has shown in Figs. 2 to 6.

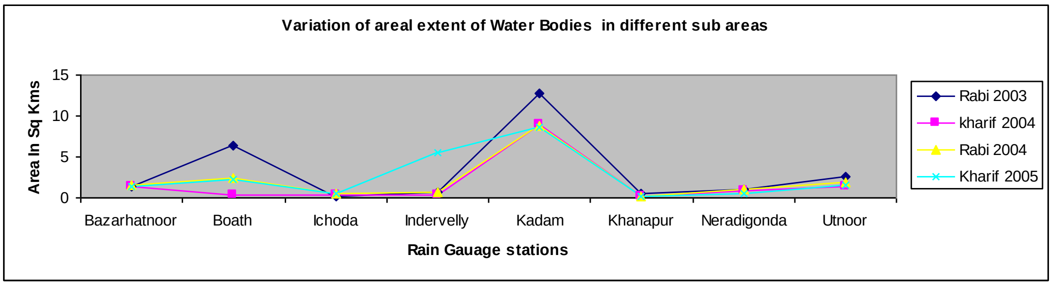

Fig. 2 Variation of areal extent of Water bodies in different sub areas.

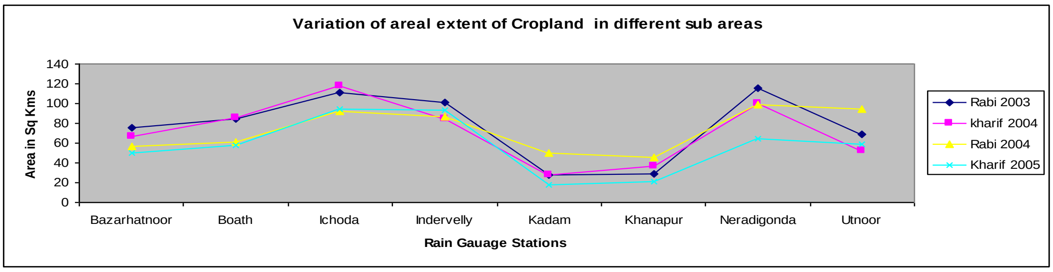

Fig. 3 Variation of areal extent of Crop land in different sub areas

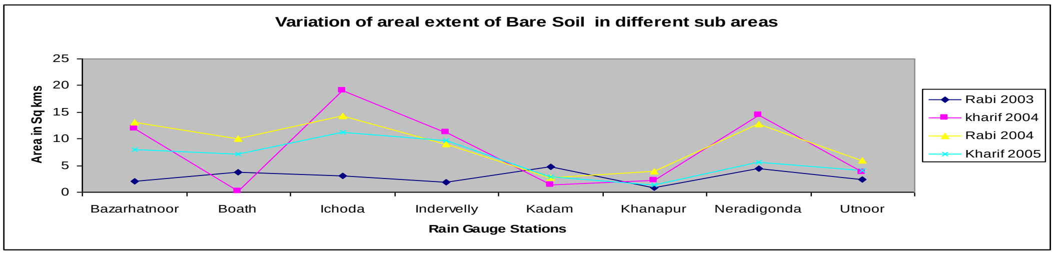

Fig. 4 Variation of areal extent of Bare soil in different sub areas.

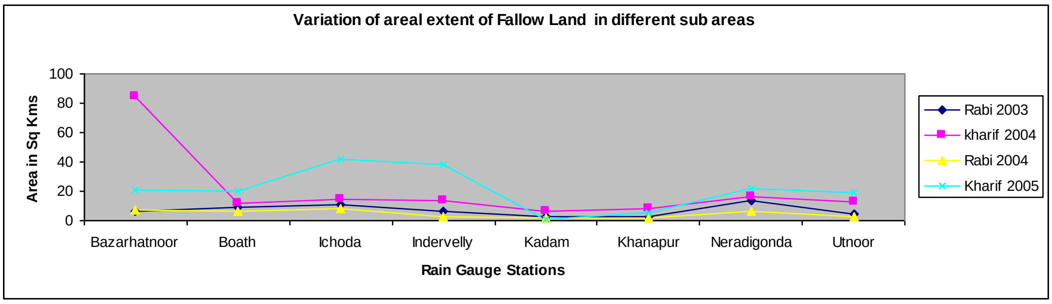

Fig. 5 Variation of areal extent of Fallow Land in different sub areas.

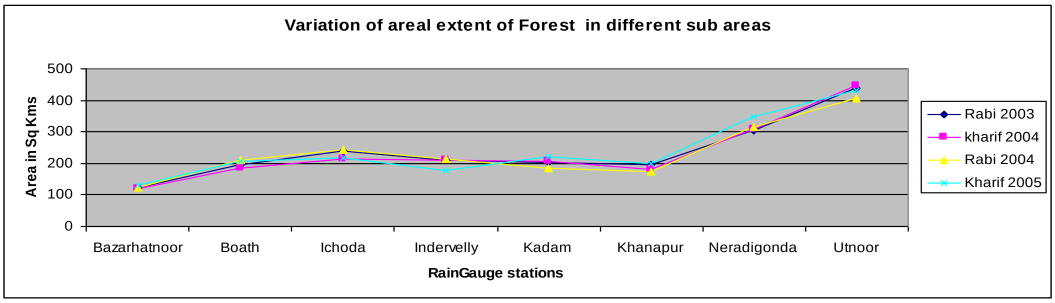

Fig. 6 Variation of areal extent of Forest land in different sub areas.

7 CONCLUSIONS

The classification of land Use / Land Cover classes were evaluated using NDVI. Of all the available methods of image classification with regard to vegetation and its sub classification, NDVI formed the basis for a better classification. It can also be safely concluded that for the considerably large areas comprising predominantly of vegetation, NDVI classification is better suited. NDVI classification is found to be especially suitable in such cases where the analysis was carried out using either past imageries or present imageries with no ground truth data.

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