

Land Resources Expansion Monitoring and Management: A RS-GIS Approach

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Abstract- Land resource monitor use is necessary to prepare the land use plans because of rapidly land use changes/expansion around the Shivpuri city, India. For this purpose exploratory, semi-detail and detailed surveys are undertaken using remote sensing techniques and satellite imageries in order to acquire useful and variety of information at same scale and assist in monitoring valuable information. In this paper, study on land resource mapping through supervised classification has presented for better understand the land uses characteristics and expansion monitoring. On 1:15,000 scale, supervised classification image generated from supervised signature classes varies pixel to pixel (sample points using a random point generate or for each land cover class) land uses on satellite images and accuracy assessment designed and implemented on the IRS-1D satellite 2003 and 2006 images data. IRS-1D facilitated multi faceted applications in the fields of agriculture, forestry, land use etc. The accuracies varied according to the class and classified data verified on ground with the help of GPS. This approach encourage to govt. and local development agencies to use remote sensing and gis based land resource mapping and their management in respective areas.

Index Terms- Accuracy assessment, Change detection, Land resource map, Land resource management, Supervised classification.

I. INTRODUCTION

The Shivpuri city, after became Shivpuri district, has growth and developmental activities such as building, road construction, agricultural, forest, urban population growth, human encroachment and also expansion of touristic culture etc. These activities are resulting in unplanned land use and increased the land consumption and modification of land uses over built day-by-day. Land resource is a fundamental unit of production and finite resource for most human activities including forestry, industry, agriculture, settlement and water storage. For sustainable land utilization, it is essential to know the land characteristics, extent and location, In order to improve the economic condition of the area without further deteriorating the bioenvironmental; every bit of the available land has to be used and manage in the most rational way. This requires present and past land expansion monitoring data of the area. Land resource image classifications have been used alongwith multitemporal satellite data for features identification, analysis, and pattern recognition on the image. The classification process is based on object patterns of their DNs (Digital Numbers) with neighbouring pixels, reducing the range of DNs (Digital Numbers) in several spectral bands to a few classes in a single image data.

II. STUDY AREA AND DATA USED

The area under study lies between 25°20'-25°30' degrees latitude and 77°35'-77°45' degrees longitude and falls in SOI toposheet number 54G/11 covering total area of approximately- 309 sq. km and height from the mean sea level is 521.5m. It forms a part of Shivpuri district which is bounded on the north and south by Gwalior and Guna districts of M.P. respectively, on the east by Jhansi district (U.P.), and on the west by Kota district of Rajasthan Figure 2.1. NRSA (National Remote Sensing Agency, Hyderabad) collected the IRS-1D LISS-III data (22nd February, 2003 and 24th January, 2006) in digital form which have been used in the present study. The topographic map 54G/11 at scale 1:50,000 published by Survey of India (SOI) has been utilized for image interpretation and GCPs collection.

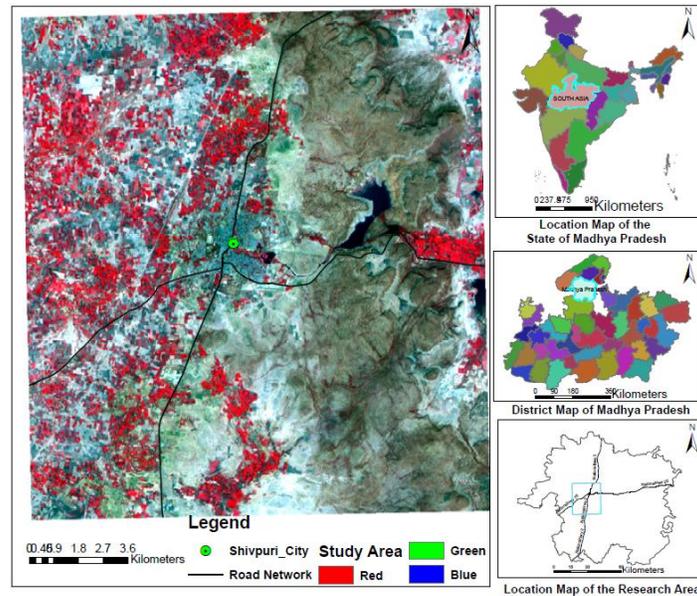


Figure 1: Location map of the study area (24th January, 2006)

III. RESULT AND DISCUSSION

A number of data processing steps are involved in land resource data classification. The steps divided into following two categories....

- Pre-field Work
- Post-field Work

Pre-field work carried out include that satellite data, 54G/11 toposheet, geo-referencing the image (well-distributed points on prominent features such as- (intersection of streams, permanent waterbody .etc) and subset of the area (AOI), image enhancement techniques (spectral and spatial), image interpretation as well as, preparation of base maps at 1:50,000 scale of the study area (Gupta et al, 2004). Post-field work carried out include that land resource expansion classified maps based on supervised techniques, accuracy assessment, modification according to pre-field work and ground truth surveys. The GPS points were collected to prepare GPS map, analyzed and validated through ground truth survey to finalizing the classified image (GPS points overlap on image) and SOI topographic sheets. All the processing has been done on ERDAS Imagine, ArcGIS software.

A. Supervised Classification

The land resource classification operations were performed to produce land resource use and cover map from LISS III images figure 4 and 5. The process of resource classification involve such as:- Selection of a land resource classification scheme-in this study, six land resource use and cover classes were defined, the detail description of these classes along with their interpretative characteristics on the False Colour Composite (FCC) of LISS-III image given in Table 1. Sample of training signature-The number of training samples for each class have been collected from relatively homogeneous areas consisting of those classes as respective classes on the ground (D. Lu et al, 2007). Maximum likelihood classification-This classifier is based on the decision rule that the pixels of unknown class membership are allocated to those classes with which they have the highest likelihood of membership (Foody et al., 1992). In supervised classification assigned each cell in a study area to a class or category which corresponds to a meaningful grouping of locations such as- forests, water body, fields and residential areas (Peihuang et al, 2008) and algorithm examines the pixels or aggregates of each location into one of the specified number of groups or clusters present in the image. The methodology adopted for supervised classification has been shown in Figure 2.

The land use/land cover study has been carried out on 1:50,000 scale images with 23.3 meters resolution depending on rate, pattern and trend in the study area (X. H. Liu et al, 2002). The land use/land cover supervised classified images are shown in Figure 6 and 7. The methodology adopted for temporal comparison has been shown in Figure 3. Multitemporal satellite data have been used to generate land use/land cover classes such as- forest, agriculture, waterbody, fallow land, settlement and waste land alongwith visual interpretation techniques which are verified during the field work. The temporal comparison of and use/ land cover (22nd February, 2003 image and 24th January, 2006 image) are shown in Table 2 and Figure 8.

Table 1: Characteristics of land use/land cover classes

Land Cover Class	Description	Characteristics on LISS-III FCC
Agriculture	Regular shape, size pattern	Dull red and smooth appearance
Forest	Tall dense trees	Light brownish to red to dark brownish with rough texture
Fallow Land	Agricultural fields without crops	Bluish/greenish grey with smooth texture
Settlement	Towns and villages; block appearance	Bluish
Waste Land	Degraded land, slopes in foot hills, eroded soils,	Light brown to greenish blue, varying in size and dispersed pattern
Water Bodies	Reservoir and lakes	Cyanish blue to blue according to the depth of water and sediment content

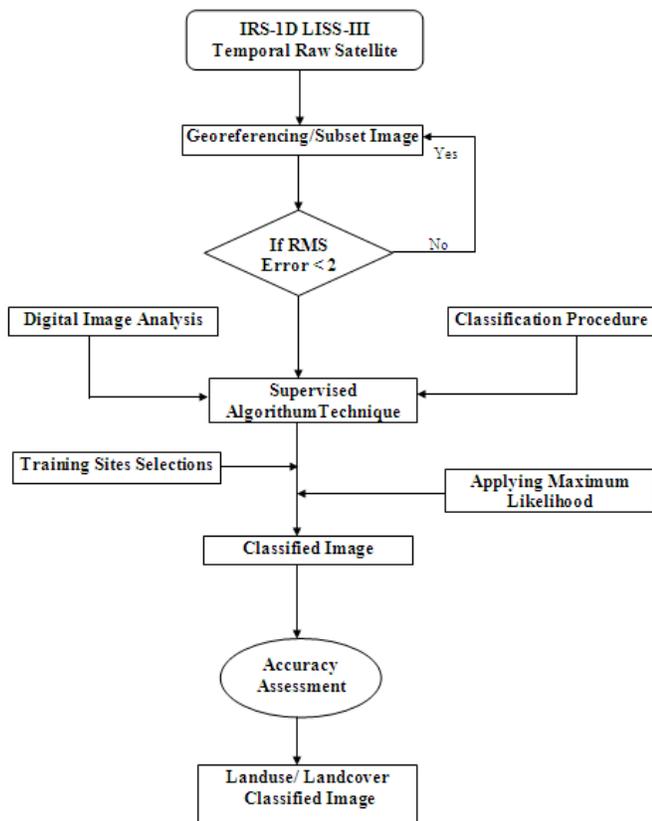


Figure 2: Methodology of Supervised Classification

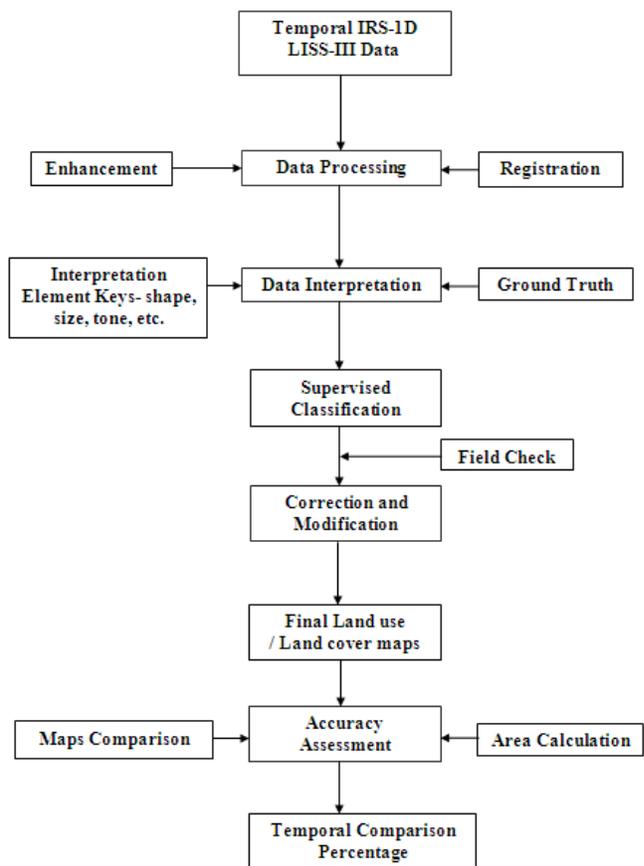


Figure 3: Methodology of Temporal Comparison

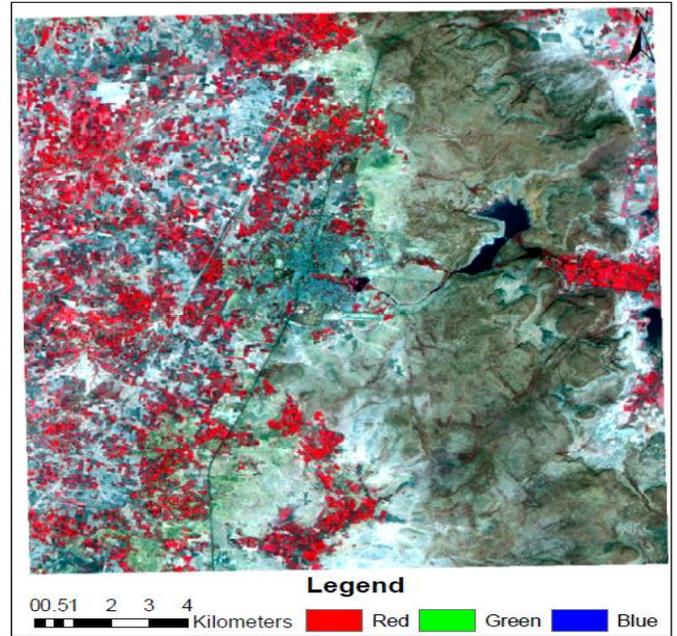
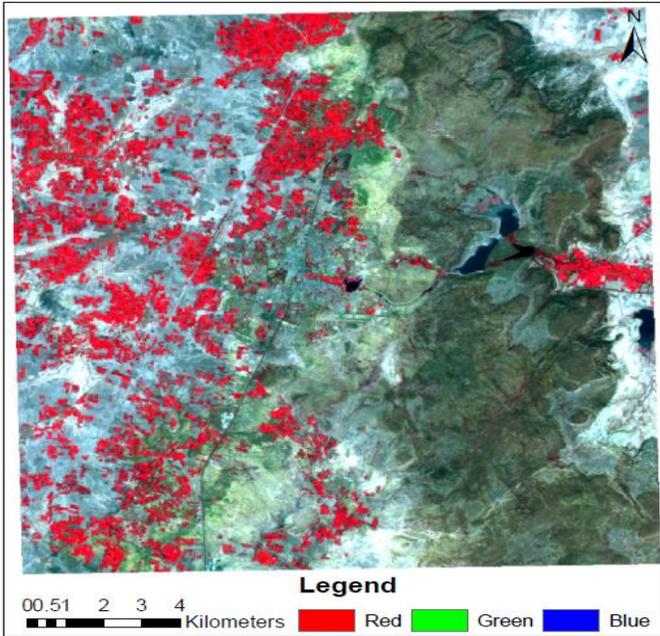


Figure 4: FCC Image of the study area (22nd February, 2003)

Figure 5: FCC Image of the study area (24th January, 2006)

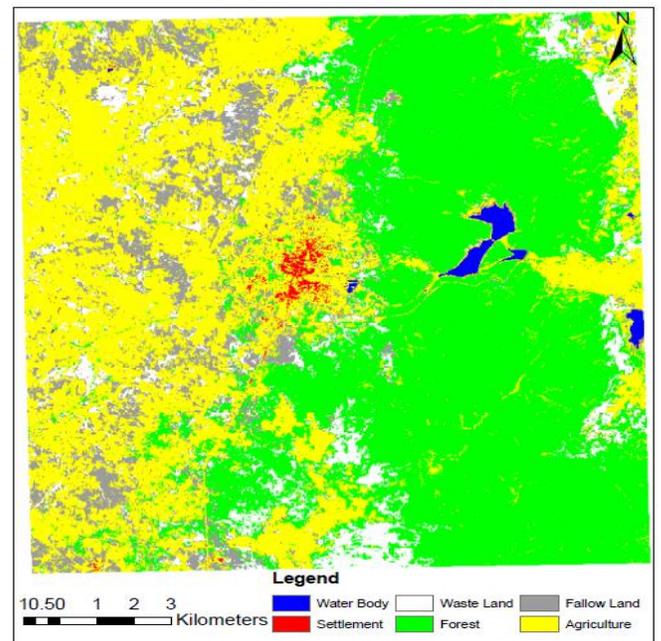
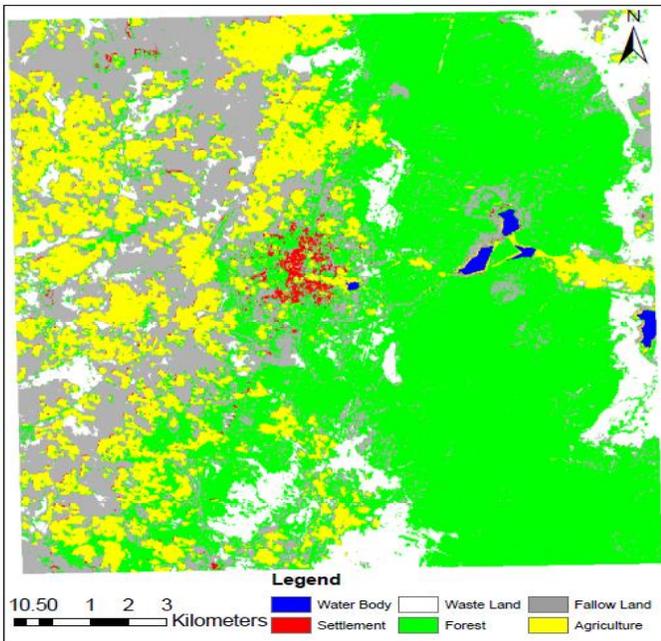


Figure 6: Supervised Image (22nd February, 2003)

Figure 7: Supervised Image (24th January, 2006)

1 Agricultural Land

The Kharif and Rabi are two main crops cultivated in the area. The Kharif crops are Soyabeen, Ground nut etc. while the major Rabi crops are Wheat, Gram etc. Mostly agricultural area occurs in the western portion and the eastern margin of the study area. The agriculture area covers approximately 65.415sq.km and 115.165sq.km on classified images of 2003 and 2006 respectively (Figure 6 and 7). In the study area, the temporal comparison is +12.756% (Table 2). The agricultural activities are distinct by geometric arrangements of the field. Agricultural land appears in bright red to red in color and is easily separated from surrounding forest area with the regular shape, size in contiguous to non-contiguous pattern on satellite images (Anderson et al., 1976).

2 Fallow Land

The fallow land is clearly separated from crop land with dark greenish tone, smaller size, and regular/irregular shape, contiguous to non-contiguous pattern on satellite images (Anderson et al., 1976). These lands are used for cultivation but temporally allowed to uncultivation for one or more seasons. It is under dry land farming, paddy and other dry crops. Mostly fallow lands are found in most of the western portion of the study area. The area under fallow land covers 68.594sq.km and 29.610sq.km approx on classified images of 2003 and 2006 respectively (Figure 6 and 7). The temporal comparison is -9.996% in the study area (Table 2).

3 Forest Land

Forests of the study area are largely tropical to sub tropical type from which the timbers, fuel wood, fodder and food products are extracted as well as encroachment in nature. Most of the forest area is covered by the reserved forest such as- Madhav National Park, Chironji Park with dense canopy of tall trees, occupying the eastern half of the study area with characteristic light brownish to red to dark brownish, smooth texture and irregular shape on satellite images. The forest area covers about of 148.607sq.km and 126.351sq.km on classified images of 2003 and 2006 respectively (Figure 6 and 7). The temporal comparison is -5.707% (Table 2) in the study area.

4 Settlement

Settlement covers buildings, transportation, communication utilities etc. in association with waterbody, agricultural and forest lands. Settlement is widely spread in central part of the study area. Roads and Railway lines are distinguished by characteristic linear features. It covers an area of 1.338sq.km 2.596sq.km on classified images of 2003 and 2006 respectively (Figure 6 and 7) along with the temporal comparison +0.323% (Table 2). Settlement appears scattered in bluish green tone in varying shape and size, located close to water and agricultural sources (Anderson et al., 1976).

5 Waste Land

Waste lands are covering significant portion of available land resources. It is generally degraded land in hilly topographic locations. Waste lands are associated with moderate slopes in foot hills, eroded soils, rocks and are surrounded by agricultural plain land. Mostly waste lands are distributed haphazardly in the study area with characteristic light brown to greenish blue, varying in size and dispersed pattern on satellite images (Anderson et al., 1976). It covers approximately an area of 23.784sq.km and 33.338sq.km on classified images of 2003 and 2006 respectively (Figure 6 and 7). The temporal comparison in the study area is +2.450% (Table 2).

6 Water Body

A number of reservoirs, lakes are found in study area such as- Bhagora Tal, Chand Pata Tal, Madhav Lake, Signiwas Tal, Raichand Kheri Tal etc. These water bodies are occupying low land, plain lands, surrounded by hills and are generally used for domestic water supply, hydel power generation and irrigation purposes. It is depending on the availability of seasonal water in the nature. These are seen clearly on satellite images in blue or cyan colour depending on the depth of water (Anderson et al., 1976). It covers an area of 1.325sq.km and 2.028sq.km NE-SE on classified images of 2003 and 2006 respectively (Figure 6 and 7) along with the temporal comparison +0.180% (Table 2).

Table 2: Supervised Comparison (generated from 22nd February, 2003 & 24th January, 2006 images)

Supervised LU/LC	LISS-III (2003)		LISS-III (2006)		Differences	
	Area (sq.km)	%	Area (sq.km)	%	Area (sq.km)	%
Agriculture	65.415	21.170	115.165	37.270	+49.750	+12.756
Forest	148.607	48.093	126.351	40.890	-22.257	-5.707
Fallow Land	68.594	22.199	29.610	9.583	-38.983	-9.996
Settlement	1.338	0.433	2.596	0.840	+1.258	+0.323
Waste Land	23.784	7.697	33.338	10.789	+9.554	+2.450
Water Bodies	1.325	0.429	2.028	0.656	+0.702	+0.180

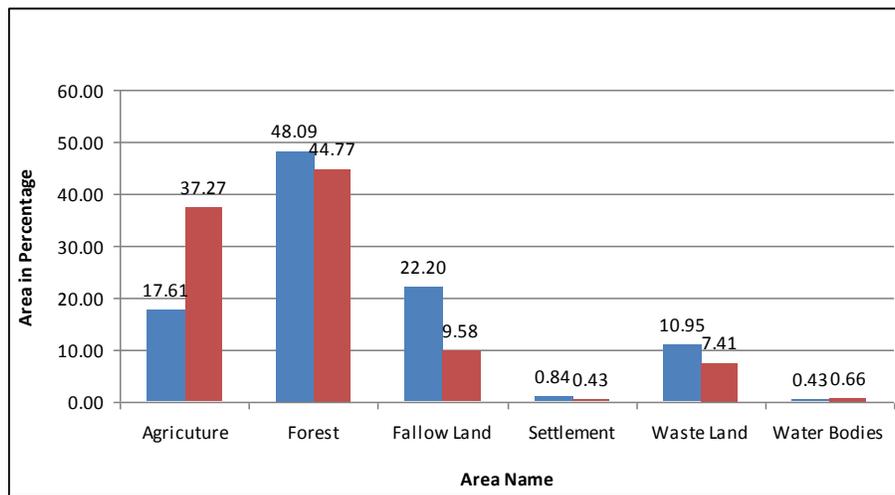


Figure 8: Supervised Comparison Chart (generated from 22nd February, 2003 & 24th January, 2006 images)

B. Thematic Accuracy Assessment:

Thematic maps produced with remote sensing and geographical information systems (GIS) technologies have provided detailed information to the users of the land use/land cover maps (J. E. Mendoza et al, 2002). Key to the usefulness of a map for any user is the degree of quality, or accuracy of the map. Accuracy assessment of the classified images has been carried out based on the land use/land cover ground truth data collected. Random sampling points have been implemented based on the land cover classes (D. P. Roy et al, 2002). The results of the accuracy assessment are presented in Table 3. The overall accuracy of the land use/land cover calculated are 83.63% and 0.8238 respectively for 2003 image, while accuracy measures and kappa statistics of 87.60% and 0.8814 were obtained for 2006 image.

Table 3: Thematic Accuracy Assessment (22nd February, 2003 & 24th January, 2006)

S. No.	Supervised LU/LC	LISS-III (2003)		LISS-III (2006)	
		Area (sq.km)	Accuracy (%)	Area (sq.km)	Accuracy (%)
1	Agriculture	65.415	84.48	115.165	88.96
2	Forest	148.607	78.95	126.351	92.65
3	Fallow Land	68.594	80.95	29.610	84.76
4	Settlement	1.338	94.24	2.596	95.87
5	Waste Land	23.784	70.43	33.338	82.92
6	Water Bodies	1.325	92.78	2.028	80.45
Overall Accuracy (%)		83.63		87.60	
Overall Kappa Statistics		0.8238		0.8814	

C. Land use/Land cover management:

To determine the land use/land cover management factors, the application of Remote Sensing and GIS techniques is needed. Each land resource management factor does not have same effect but it is interlinked with agriculture, watershed, soil condition, environment, topography, forest etc. (Xian-Jun Shi et al, 2008). The land use/land cover management views are given below.

5.1 Agricultural Management

In the western portion of the study area, most of the area is occupied by agricultural land. They produce wheat, groundnut, mustered, gram, sugarcane, and soyabean etc. Agricultural lands are increasing due to peoples cutting valuable tree that are surrounding the agricultural land for increasing the agricultural fields and settlement. Management point of view, Set up the agricultural land priorities based on farming systems, valley area utilized, crop types, the area under green cover, black soil type with

good ground water potential etc. the agricultural land having gentle slope should be properly fenced with adequate irrigation facilities. Steep hill slopes should be developed as grass lands, strip cropping, stream frequency and drainage density should use in the agricultural land development and management.

5.2 Forest Management

In the northern to southern portion of the study area, hilly undulating terrain land and dry deciduous forest are in the study area. They based on statistics, forest lands are being converted into degraded and open forest which is due to soil erosion, high run-off, cutting of thick forest cover for fibre and timber, improper drainage system contribute to the degradation phenomena of the forest and agricultural, settlement expansion in the northern and southern portions of the study area. Degraded and open forest covers are needed to be converted into thick forest cover in areas having black soil through systematic and rich plantation, protection by forest boundary, proper drainage system (Mundia et al, 2005) and control over the agricultural and settlement expansion towards the forest area for protection and management.

5.3 Fallow Land Management

Fallow land is being converted into other uses. The variations in area covered under agriculture and fallow land attributed to changes in crop rotation, harvesting time and conversion of these lands into plantation. The areas indicated (southern to western) as fallow do not represent the true potential area available as land currently under pasture maybe suitable for cultivation and would add to the estimation of fallow area. Identifying pastoral lands as distinct from field crops is the next phase in providing a more accurate assessment of the extent of fallow land during this period.

5.4 Settlement Management

Rapid and unplanned urbanization not only results in adverse economic development but also causes unguided expansion of the city and creates problems of infrastructure planning and management. The urban area is creating pressure on the city surrounded rural systems and other resources. Most of the urban and industrial development occurs in the around the city and central part of the study area. Urban area can be managed through minimization of unplanned expansion towards agricultural and forest area. Urban environmental issues, change detection and trend analysis, area estimation, site selection, digital elevation model studies have provided information regarding the presence of open land, sparsely vegetated land and unfertile land for agriculture (waste land) which are needed to be managed and developed in the study area (Defreis et al, 1999). Remote Sensing has helped in analyzing these problems at their very root and suggest remedial measures.

5.5 Waste Land Management

The north-western portion of the study area, all lands are not equally resourceful, some are good and some are waste. Waste lands are found at many places in the study area and waste land increasing because of improper drainage frequency, settlement garbage, water level down and some palace soil not having porosity, permeability, and soil mix with rocks. Management points of view, after proper treatment, are suitable for settlement and afforestation purposes. In the public awareness and drainage systems, recharge of the ground water, vegetation density be increased while the siltation rate in water bodies and over grazing by animals be checked.

5.6 Water Body Management

The water body occurs in the eastern portion of the study area. A number of water harvesting structures for the artificial recharge surface and sub-surface water bodies such as check dams, percolation tanks etc. should be constructed over natural streams where suitable geologic and hydrologic conditions prevail. Existing ponds and lakes should be renovated, their embankments be restrengthened and desiltified and the rate of siltation in lakes and reservoirs be checked. The quality and quantity of water in these water bodies be periodically determined and adequate mitigation measurements be adopted for monitoring and control of pollution in the water regime.

IV. RESULTS AND DISCUSSIONS:

Land resource mapping and management serves as a basic inventory of land resources for all levels of government, private industry. Rapid developments in Shivpuri city, there is a need for real time monitoring of the land based changes. This study implemented a multi-temporal data classification approach to produce an accurate land use/land cover map and analysis and identify the temporal change detection in last few years. Basically, two approaches are used for the classification of land use/land cover maps. The first is the visual discrimination and second approach supervised classification carried out for some of the classes, accuracy assessments were examined on various land use/land cover classes through the multi-temporal satellite images.

The methodologies described above have been shown in Figure 2 and 3. The various land use and land cover classes delineated include settlement, agriculture, forest, water body, waste land and fallow land. Comparison of land use/land cover maps indicate temporal changes between land use/land cover features. The observation detected that the forest (-5.707%) and fallow land (-9.996%) are decreasing while agricultural land (+12.756%), settlement areas (+0.323%), waste land (+2.450%) and water bodies (+0.180%) are increasing. The area of each class for LISS-III (year 2003) and LISS-III (year 2006) data has been compiled in Table 2 and also shows

the change pattern in the land utilization from year 2003 to 2006 for the Shivpuri city. Accuracy assessment of the classified images has been carried out based on the land use/land cover ground truth data collected. The overall accuracy and kappa statistics of the land use/land cover calculated are 83.63% and 0.8238 respectively for 2003 image, while accuracy measures of 87.60% and 0.8814 were obtained for 2006 image and compiled in Table 3.

V. CONCLUSION:

The study has shown that it is possible to land resource classification of satellite images (agricultural land, forest land, fallow land, settlement, waste land and water body), accuracy assessment and their management carried out successfully through IRS-1D satellite. IRS-1D satellite carried a LISS-III camera providing a resolution of 23.5 m. This resolution has been used for land resource expansion mapping and monitoring of the study area. For ensuring planned development and monitoring the land utilization pattern, preparation of land resource mapping map is necessary. The usefulness of satellite data for the preparation of land resource expansion maps depicting existing land classes for analyzing their change pattern for Shivpuri city by utilizing supervised classification. It is expected to be useful for formulating meaningful plans and policies so as to achieve a balanced and sustainable development in the region.

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