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Forest land use map of Chandaka wildlife sanctuary, Odisha using multidate data

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Abstract
The area statistics of Forest land use classes of Chandaka Wildlife Sanctuary obtained in the year 2006 using digital image processing technique and geographic Information System, we found among forest classes the dense mixed forest covers 3917.96 ha. in the sanctuary area where as open mixed forest covers 6024.56 ha., which is the maximum area cover in this sanctuary. Degraded mixed forest covers 3181.74 ha. Dense Sal forest covers 55.81 ha., open Sal forest covers 82.40 ha. and degraded Sal forest covers 23.38 ha. in the sanctuary area. Eupatorium/ Lantana comes 2131.29 ha which causes serious damage for the regeneration of other forest species. Teak is found to be 270.97 ha. and Bamboo covers 1501.91ha. The waste lands like land with/ without scrub covers 140.28 ha., mining/ queries area is 12.92 ha., Barren rocky/stony area covers 30.79 ha. The settlement area like town/ city covers 15.82 ha. and village covers 28.66 ha. in the sanctuary. The water body is found to be 140.85 ha. The agricultural land is about1623.16 ha. in the sanctuary area. From area statistics of change detection of forest land use between the year 2003 and 2006 of Chandaka- Dampara Wildlife division we found that town is increased by 0.57 ha. due to increase in population and village is decreased by 0.81 ha. Agricultural land is increased and it is 126.49 ha. due to requirement of crops and food of population. Among forest covers dense mixed forest is decreased by 2977.09 ha. open mixed forest increased by 2015.72 ha. and degraded mixed forest increased by 1639.84 ha. Among Sal forest dense Sal forest is decreased by 8.81 ha, open Sal forest is increased by 57.44 ha. and degraded Sal forest is decreased by 6.52 ha. In total Sal forest is increased. Eupatorium/ Lantana area is decreased by 1014.36 ha. Teak is increased which is 32.51 ha. Bamboo also increased and it is 39.65 ha. Land with/ without scrub area is increased by 60.08 ha. Mining/ quarries area decreased by 0.39 ha., barren rocky/ stony area is increased by 5.79 ha. The water body also increased which is 29.86 ha.

Keywords: Land use, Digital image, geographic Information system, Multi date data

Introduction
All over the world people have started thinking of future needs of the community and realized the necessity for improving the environment and concerning the same. Human civilization particularly in our town and cities are exposed to polluted atmosphere due to fossil fumes, dust, noise and over population. In everyday life the human beings are struggling for noise free, dust free, smoke free healthy environment, which prevails in forest conditions. Both human being and other animals are so much so dependent on plants that their existence would have been doubtful without the plants. The forests act as the lungs for the locality and provide O_2 and pure air to city dwellers, who seek the same for the maintenance of life. Now the planners have started laying stress on providing small wood lots and greenery in an around large towns and cities to cater the needs of urban population.

The timely information of renewable as well as non-renewable natural resources is necessary for planning and development of country. Among all renewable natural resources forest has taken a significant position because of its environmental, economic & aesthetic values. The present situation of over exploitation of forest resources have brought about irrevocable, deleterious like change in climatic conditions, soil erosion, desertification loss of genetic resources, pressure on wildlife and their habitats. Forest type mapping and monitoring on regular basis need for managing India's dwindling forest resources including the preservation and management of wildlife.

Remote sensing is a process of sensing identification and segregation of various earth features from a distance without being physically coming contact with target. Remotely sensed data may provide a better source for derivations of land cover due to consistency, reproducibility and coverage in locations where ground based knowledge is sparse (Roy and Joshi, 2002) [5]. Thus, remote sensing is one of the potential tools to carry out vegetation mapping. Remote sensing data represent a mixture of information pertaining to land surface features. Photographic image and multispectral scanner data are the two broad categories of Remote

sensing data products. Aerial photographs capable of providing stereoscopic view of the landscape have widely been used for mapping of natural resources. Satellite data could simply describe as spectral imprint of land surface features. It is well known fact that a given land cover feature is partly reflected and partly emitted. The land features, which can perceive would undoubtedly differ with respect to relative proportion of observation, transmitted and reflected/ emitted energy in different spectral bands. It is the reflected/ emitted energy component, which is measured through satellite. Thus since the pattern of reflectance/ emission of energy in different spectral regions is a property of earth surface features, Land cover features can be differentiated in satellite data if the relationship between a land cover feature and its spectral response commonly referred as spectral 'signature' presented as reflectance of different wave lengths graphically on statistically is precisely established.

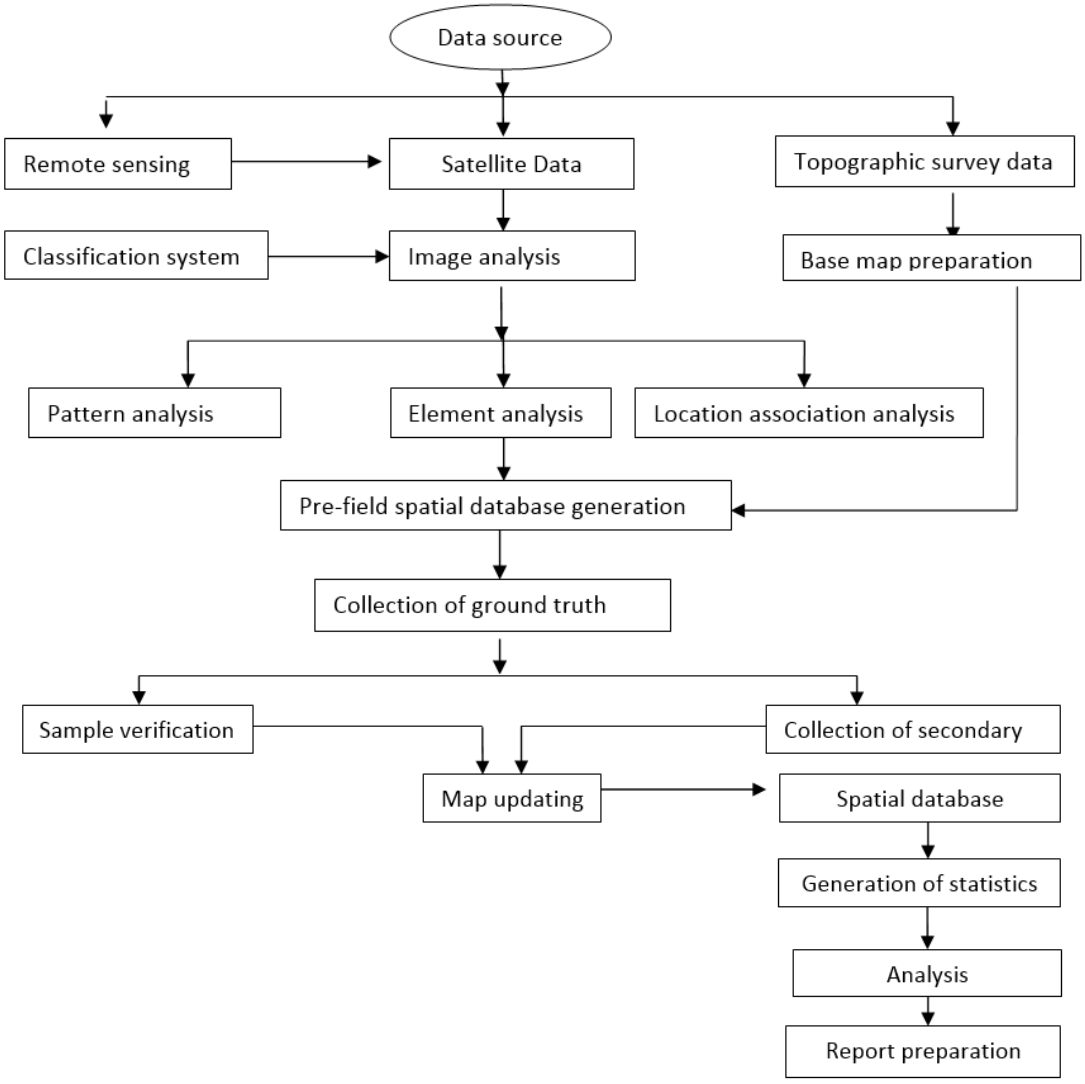
The present study deals with the analysis of land use/ land cover pattern of the Chandaka- Dampara Wildlife Division using Digital image processing technique and geographic Information System has been attempted in addition. In addition Forest administration map, and wildlife infrastructure map and drainage map has been prepared from the multispectral Indian Remote sensing Satellite data as well as the Survey of India topo-sheets.

Materials and methods

On screen interpretation technique has been adopted for preparation of forest land-use map of the study area through Arc info software package has been used for the study. This classification is mainly based on different forest types according to Champion and Seth (1968) [1] and other broad non-forest class. The forest densities have been classified into three different classes- i. More than 40% crown cover represent the dense forest, ii. 10- 40% crown cover represent the open forest, iii. less than 10% crown cover represent the degraded/ scrub forest

Standard false colour composite (FCC) image OF IRS LISS III has been used by combining band 1, 2, 3 in 1:50000 scale. In addition Survey of India topo-sheets have been used to prepare base maps and other maps described earlier. The LISS III images are corrected form atmospheric path radiance by using dark object subtraction method (Chavez, 1988) [2].

Methodology for database generation



Development of classification system

The classification system is a mean of grouping of land use activity in pursuit of a predetermined purpose. The minimum delineation unit for the division has been taken as 3mm x 3mm in the image scales. The nomenclature and the definitions have the compatibilities with existing terminologies adapted by various departments. Selection of classification terminologies has been done in such a manner

that certain land use classes can be generalized and aggregation of similar or multiple land use classes can be possible at different levels of requirements. The classification system adopted for the land use/ land cover mapping of the Chandaka Wildlife Division is given below-

i) Built-up land (i. town/City ii. Village)
ii) Agricultural land (i. Crop land ii. Plantation)
iii) Forest is classified (i. Dense mixed forest ii. Open mixed forest iii. Degraded mixed forest iv. Dense Sal forest v. Open Sal forest vi. Degraded Sal forest vii. Teak viii. Bamboo ix. Eupatorium / Lantana)
iv) Waste land (i. Land with / without scrub ii. Water logged and marshy land iii. Mining/quarries iv. Barren rocky / stone area v. Sand)
v) Wetland (i. River / canal/ reservoir / tank/ pond)

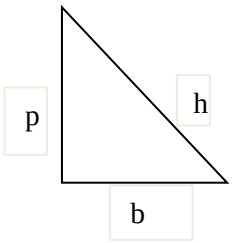
Image interpretation key

Image interpretation key is a valuable aid to identify various factures on the satellite image. It is mainly on the basis of element and pattern analysis where tone, texture, shape and spatial resolution of the image play an important role in the identification and discrimination of the objects (Jessica P Caria *et al.* 2001) [3]. The interpretation key has been developed and accordingly the image interpretation has been carried out.

Preparation of different layers of information in Chandaka wild life sanctuary

i) Road and settlement map: The road network showing national High way, state high way, metal road and forest road have been prepared from survey of India topo sheets no. 73H/11, 73H/12, 73H/15 & 73H/16 on scale of 1:50000. The layer was modified on the satellite image and demarcated in the road and settlement map. Similarly settlements have been interpreted from the satellite data and drawn in this map.
ii) River, drainage and water body map: The river, drainage and water bodies were interpreted from the satellite data. According to colour combination the blue coloured features are demarked as river, drainage and water bodies from the FCC satellite data of band combination 1,2,3 (1= blue, 2= green, 3= red).
iii) Forest administrative boundary: The boundaries of Wildlife division, Range, Section, Beat Reserved forest, Protected forest and Ekamra kanan area had been scanned from the map supplied by forest department. Then the scanned boundaries were digitized in arc info and the layers prepared. The division was divided into four ranges, boundary of all the ranges, sections and beats, Ekamra kanan area, forest roads as well as metal roads have been demarcated.
iv) Forest management map: The wildlife sanctuary boundary, Ekamra kanan area, National high way, major roads, other roads, division, range, section, beat, monitoring tower, fire watch tower had been scanned from the map supplied by wildlife authority. Then it was digitized in arc info and the map is prepared. The Division was divided into four ranges with headquarters at Chandaka, Bhubaneswar, Dampara and Haladia at Minisipatana. Three monitoring towers have been marked inside the sanctuary area at Ambilo, Kanhilaberna, Pitagadia and Kamakhunti. There was only one fire watch tower at the hill top road under Damapara range. The names of the reservoirs have been written in the map for better understanding of water availability and management planning.
v) Eco-Tourism Zone Map: Eco-tourism map showed the core zone and eco-tourism zone of the wildlife sanctuary. This map also contained wildlife sanctuary boundary, Ekamra kanan area, national highway, major roads, other roads, division head quarter, range head quarter, section, beat, monitoring tower and fire watch tower for convenient and betterment of the tourist. This information had been scanned from the map supplied by the Chandaka wildlife sanctuary authority. Then the scanned boundaries are digitized in Arc info and the layers were prepared.
vi) Slope Map Chandaka Wildlife Division: This map was prepared on the basis of lands with slope above 20º as hilly area marked in brown colour and land with slope below 20º as plane land. A base map is prepared from the IRS topo sheets 73 H/11, 73 H/12, 73 H/15 and 73 H/16 on the basis of counter lines. The counter lines were drawn in the topo sheets of 20 mt. height difference from mean sea level. When the distance between two counter lines was less than 2.2 mm then the slope was above 20º it is hilly area on the basis of tan formula.

$$\text{Tan } \theta = \quad p/b$$



If the distance between two counter lines is more than 2.2 mm then the slope is below 20º. it is plane area. These layers are scanned. Then the scanned layers are digitized in Arc info and the layers were then prepared.
vii) Forest land use map: The forest land use map of 2003 had been prepared by using IRS-ID LISS III Digital data of period 2003. It was prepared by digitizing the satellite image in Arc info according to the texture, tone, distance, size, shape and structure etc. similarly forest land use map 2006 of Chandaka- Dampara Wildlife Division has been prepared.

Ground verification

It is essential to collect information on the actual situation for which data cannot be obtained from remote sensing because of time lag between the period of data acquisition and field work. Thus it is necessary to correct the map in the field. Data on forest cover type, density, plant association, cropping pattern, plantation, nature of mining activities etc. had been collected from the area.

Map finalization

The forest land use/ land cover map was updated by incorporating the necessary information and finalization as per the knowledge gained during the field tour. Cultural features like road, railways, name of the villages, different administrative boundaries, different management features along with latitude and longitude details were transferred to the final forest land use map. Slope map showing lands below 20º slope (plane) and more than 20º slope (hilly) areas prepared separately.

Generation of area statistics for forest land use

Estimation of aerial extent of different spatial information is an important task in thematic mapping and survey because it helps in decision making and planning for the area. The extent of area under each of land use/ land cover category has been

estimated using the statistic to generate the area in sq. kms/ hectares.

Results

Supervised classification system had been adopted using maximum likelihood classification to classify the study area into 19 number of forest and non-forest classes. The forest classes mainly include miscellaneous, Sal, scrub classes where as the non-forest classes include settlement, agricultural land, wastelands and water body. The main species like Bamboo, Teak, Eupatorium and Lantana had been identified in the study area. The Bamboo breaks were generally grown in open lands and along the drainage, which are mainly used as food for elephants. Teak coppices were grown along the road sides intermixed with other miscellaneous species. Very few pure patches of Teak coppices were grown luxuriantly in the area. The Eupatorium and Lantana spp. were grown in massive way mainly in the north-eastern side of the sanctuary. These species were mainly responsible for checking of regeneration growth of Sal and Teak. Besides the forest plantations were found in the southern side of the sanctuary.

Area statistics of Forest land use classes of Chandaka Wildlife Sanctuary

i) Area statistics of Forest land use classes - 2003

From the interpretation the area statistics of forest land use classes of the Chandaka Wildlife Sanctuary in the year 2003(Table-1). It showed that the main land use cover of this sanctuary is dense mixed forest which was about 6895.05 ha. In second place open mixed forest was present which covers 1541.90 ha. Degraded mixed forest covered 4008.84 ha. of the sanctuary. Among Sal forest dense Sal forest covered 64.62 ha. open Sal forest covers 24.96 ha. and degraded Sal forest covered 29.90 ha. in the sanctuary area. Eupatorium/ Lantana covered 3145.65 ha in this sanctuary. Teak covers 238.43 ha. which was mainly Teak coppice forest. The main source of food for elephants was Bamboo, which covered 1462.26 ha. in the sanctuary. Waste lands like land with/ without scrub was 80.20 ha., mining/ queries 13.31 ha., Barren rocky/stony area covered 25.00 ha. The more essential thing was water body, which was about 110.99 ha. in the total sanctuary. Agricultural land was found to be 1496.67 ha. in the sanctuary. Town/ city was 15.25 ha. and village was about 29.47 ha. in the sanctuary.

ii) Area statistics of Forest land use classes - 2006

From the area statistics of Forest land use classes of Chandaka Wildlife Sanctuary in the year 2006 (Table-1) we found that among forest classes the dense mixed forest covers 3917.96 ha. in the sanctuary area where as open mixed forest covers 6024.56 ha. which was the maximum area cover in this sanctuary. Degraded mixed forest covered 3181.74 ha. Dense Sal forest covered 55.81 ha., open Sal forest covers 82.40 ha. and degraded Sal forest covered 23.38 ha. in the sanctuary area. Eupatorium/ Lantana covered 2131.29 ha which caused serious damage for the regeneration of other forest species. Teak was found to cover 270.97 ha. and Bamboo covered 1501.91ha. covers 238.43 ha. The waste lands like land with/ without scrub covered 140.28 ha., mining/ queries area was 12.92 ha., Barren rocky/stony area covered 30.79 ha. The settlement area like town/ city covered 15.82 ha. and village covered 28.66 ha. in the sanctuary. The water body was found to be 140.85 ha. The agricultural land was about1623.16 ha. in the sanctuary area. The broad land cover classification accuracy has been found to be 91.5%, in the higher forest density classes the classification accuracy ranged between 93 and 95%, whereas in the lower density classes it was found to be between 82 and 85% by using the standard FCC (band 3,2,1) (Roy *et al.* 1996).

iii) Area statistics of Change detection of Forest land use classes

From area statistics of change detection of forest land use between the year 2003 and 2006 of Chandaka- Dampara Wildlife division (Table-1) we found that town is increased by 0.57 ha. due to increase in population and village is decreased by 0.81 ha. Agricultural land was increased and it is 126.49 ha. due to requirement of crops and food of population. Among forest cover, dense mixed forest was decreased by 2977.09 ha., open mixed forest increased by 2015.72 ha. and degraded mixed forest increased by 1639.84 ha. Among Sal forest, dense Sal forest was decreased by 8.81 ha, open Sal forest was increased by 57.44 ha. and degraded Sal forest was decreased by 6.52 ha. In total Sal forest was increased. Eupatorium/ Lantana area was decreased by 1014.36 ha. Teak was increased by 32.54 ha. and Bamboo increased by 39.65 ha. Land with/ without scrub area was increased by 60.08 ha. Mining/ quarries area decreased by 0.39 ha., barren rocky/ stony area was increased by 29.86ha. The water body also increased which was 29.86 ha.

Table 1: Area statistics of change detection of Chandaka Wildlife Sanctuary

Sl. No.	Category	LU-code	Area in 2003 (ha)	Area in2006 (ha)	Change(ha)
1	Town	11	15.25	15.82	0.57
2	Village	12	29.47	28.66	-0.81
3	Agriculture land	21	1496.67	1623.16	126.49
4	Dense mixed forest	31	6895.05	3917.96	-2977.09
5	Open mixed forest	32	4008.84	6024.56	2015.72
6	Degraded mixed forest	33	1541.9	3181.74	1639.84
7	Dense Sal forest	34	64.62	55.81	-8.81
8	Open Sal forest	35	24.96	82.4	57.44
9	Degraded Sal forest	36	29.9	23.38	-6.52
10	Eupatorium/ Lantana	37	3145.65	2131.29	-1014.36
11	Teak	38	238.43	270.94	32.51
12	Bamboo	39	1462.26	1501.91	39.65
13	Land with/ without scrub	41	80.2	140.28	60.08
14	Mining/ Quarries	43	13.31	12.92	-0.39
15	Barren Rocky/ Stony	44	25	30.79	5.79
16	Water body	61	110.99	140.85	29.86
	Total area		19182.5	19182.5	0

Discussion

In order to prepare the forest wildlife management plan the forest organization layers are very much essential. The forest organization layers consist of forest administrative and forest management boundaries. The forest administrative boundaries enclose division, range, section and beat. Whereas the forest management boundaries consists of reserved forest, protected forest and components. In Chandaka wildlife sanctuary division, sanctuary range and beat boundaries were already superimposed in classified map. The forest management locations, watch towers, anti poaching camps, monitoring tower, check gates which were vital parameters for preparation of forest management plan have been superimposed in the map.

There was marginal expansion of agriculture and township in wildlife sanctuary owing to the encroachment of forest land by the local inhabitants and expansion of township as the sanctuary is located near Bhubaneswar town. There was substantial decrease in the dense mixed forest leading to increase in open mixed forest and degraded mixed forest. There was decrease in dense Sal forest and degraded Sal forest and increase in open Sal forest might be due to exploitation of rich Sal stand by local population. Steps had been taken up to replace the perennial weeds Lantana/ Eupartorium indicated by reduced area coverage. There was marginal increase in the area under Teak, Bamboo, and Land with/ without scrub. Barren rock/ stony patches and water body area increment was due to creation of artificial water body for the wildlife as well as renovation of existing water harvesting structures inside the sanctuary.

Chandaka wildlife sanctuary was once identified as suitable habitat for wild elephant. It had well connectivity of the elephant corridors to Satkoshia and Baisipali sanctuary areas in the north and Nayagarh forest in the south. But due to shrinkage of the habitats and corridors became of natural as well as anthropogenic pressure the elephants and the other wildlife remained confined within the Chandaka wildlife sanctuary only. Excessive deforestation and agricultural encroachments in and around the Chandaka wildlife sanctuary have reduced the natural habitat of the elephants. Changes brought in habitat conditions due to increasing human influences on natural areas have posed serious threat to wildlife (Roy *et al.* 1992) [6]. The migration of elephants from one habitat to another habitat was mainly because of shrinkage of habitats, non availability of food & water, human-elephant conflict and exchange of gene with other elephant communities. Besides elephant there had been substantial population growth in spotted deer in Chandaka wildlife sanctuary, it was because of enough food material, availability of water and non-availability of carnivorous animals like tiger, lion etc. below 20^0 slope. The deer choose scrubs, forests and grass lands along the forest edges below 1000 mt altitude as their habitats (Manjupriya and Manjupriya, 2006) [4].

The continuous forest belt, which was used to provide connection to Athgarh forest, has suffered and the natural corridors are lost. Therefore the creation of buffer zone around the sanctuary may result in reduction of forest degradation and damage to crop by the elephants. Removal of *Eupatorium sp.* and conservation of Chandaka forest require immediate attention. Since the production of food from human consumption and the maintenance of natural ecosystem are competitive in nature, there was an urgent need for the assignment of priorities. Eco-development programmers may help to restore its original form. Now most of the forest areas were connected with jeepable roads. Enough infrastructures had been created for the division during last few years. The urgent need was the conservation of these forest areas and removal of *Eupatorium spp.* which neither provided food nor cover for wildlife. Mining activities could be regulated inside the sanctuary area used for the transportation of fire-clay.

The slope map of the area showing less than 20^o and more than 20^0 had been prepared. Major forest land use classes mainly *Eupatorium, Lantana,* scrub cover, mixed shrubs are found within the 20^o slope. Besides dense, open mixed degraded forest, bamboo and teak forests were also found within this class. Chandaka provides enough food bearing plants for this spotted deer.

The degraded forest was highly dominated by the growth of *Eupatorium sp., Combretum decandrum, Aegel marmelos, Cassia fistula, Strychnos nux-vomica, Grewia tilioefolia, Terminalia chebula, Saccopentalum tomentosum and Pterospermum heyneaana*. Regeneration of various species were excellent with regular distribution. Dense *Dendrocalamus strictus* patches occurring in the openings, gentle slopes and adjoining the streams and water course acted as the main food source for the elephants. *Aegle marmelos,* have got converted to teak coppice which are also under serious threats. Many deciduous species were thriving in these forest areas eg. *Xylia xylocarpa, Careya arborea* and *Diosspyros sylvatica* were more frequently seen in teak coppice forest. Scrub forests were the degraded formations of moist miscellaneous forest. Pressure for fuel wood had made these areas completely devastated for which Eupatorium entered and dominated the total area. The species like *Cambretum decandrum, Careya arborea, Pterospermum hyeneanum, Grewia tiliaefolia, Aegle marmelas, Cipadersa fructicara* besides *Eupatorium adoratum* were found frequently in these areas.

Remote sensing and GIS are of vital importance for resource planning and management in wildlife division because of its ability to provide large amount of data in quickest possible time. The regular monitoring and proper protection of the natural forest cover and good regeneration at the cost of the Eupatorium may make Chandaka suitable habitat for elephants and spotted deer. Therefore remote sensing data and GIS can help the wildlife manager to monitor the forest in the protected area and help in restoring the ecosystem.

Conclusion

The preparation of forest land use map is a basic prerequisite for preparing a management plan for national parks and sanctuary. The present study was designed keeping view the above factors for wildlife habitat analysis in Chandaka wildlife sanctuary.

The standard FCC (band 3, 2, 1) can be used for mapping broad forest land use type still then by applying arc info techniques the perception of vegetation stratification becomes more informative. The principal component analysis colour composite holds good for vegetation stratification. The supervised classification with maximum likely-hood classifier gives comparative good results with highest order of accuracy. IRS ID digital data is fairly enough capable of providing information about forest cover types and land use classes although it covers narrow spectral range.

The carrying capacity of a national park on wildlife sanctuary depends on numbers of parameters from which food, cover, water, terrain conditions are the main factors. The variables and components which can be accessed through remote

sensing techniques are land use (other than forest land) like human habitations roads, canals & dams, built up lands, agricultural lands, plantation, wasteland, water sources, drainage, elevation classes and slope, forest cover density barren land, mining and quarries, water resources like groundwater recharge and discharge areas streams and water whole, wet lands etc. All the above factors should be considered for determining the carrying capacity of wild life sanctuary.

Thus remote sensing is of vital importance for resources planning and management in wildlife sanctuary because its ability to provide large amount of data in quickest possible times. With reference to the present study Chandaka with elephant population, and spotted deer population need to be monitored and protected. The regular monitoring and proper protection of the natural and forest cover and regeneration will make Chandaka wildlife sanctuary tourists paradise. Remote sensing from space platform can form an ideal data base towards achieving this goal.

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