local method of charcoal making wherein while opening the *Karimoottam* after incomplete combustion/partial combustion, some of the red hot charcoal came into contact with open air (oxygen) and hence such of those red hot charcoal started burning still further and brought more ash as residue. This situation is further aggravated by dousing with cold water to put off the combustion by the charcoal maker. This resulted in further increase in ash yield besides increase in broken charcoal recovery. This area needs indepth research for designing a better method of charcoal making. It should be remembered that charcoal is the residue of wood as a result of heating it to high temperature in a closed space and allowing it to cool on its own accord without entry of any air. Hence dousing cold water to put off the red hot charcoal is to be avoided.

From the present investigation, it is suggested that fuel wood billets/rootstocks of higher diameter class of *P.juliflora* (>10.5 cm) is suitable for charcoal making with higher charcoal recovery. The recovery of charcoal can be still increased by refining the local method, called *karimoottam*.

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APPLICATION OF REMOTE SENSING TO STUDY THE ENVIRONMENT AND ECOSYSTEM : A CASE STUDY FOR FOREST COVER MAPPING

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ABSTRACT

Remote sensing technique can be better utilised for identifying different types of forest cover in a tropical forest eco-system. Four major forest types and one type of grassland vegetation were identified on satellite imageries. By using aerial photographs, 11 forest types and 4 types of grasslands were identified from the same study area. By integrating the interpreted information of aerial photographs and satellite imageries, it was possible to identify different types of forest and their areal extent by converting the information into a two dimensional forest cover map.

KEY WORDS : Remote Sensing, Environment, Ecosystem, Forest Types, Vegetation Mapping, Satellite Imageries, Aerial Photographs

The vegetation cover over the planet Earth has been reducing at a faster rate, especially in tropical countries, which can not be compensated even at the present rate of afforestation work. The loss of forest cover may be attributed to both biotic and abiotic factors. The heavy demand for food, fodder, firewood, raw materials for industry etc., accelerates deforestation and hence degradation of denudation of vegetation affects our environment and ecosystem drastically. Obtaining a reliable information about our forest types, vegetation cover, wildlife habitat, energy flow etc., are of paramount interest to monitor our environment and eco-system. Obtaining of such information through conventional methods is not only time consuming but also costlier. In this context, the role of remote

appreciated very much. Nowadays, remote sensing is being employed in natural resources surveys (Roy, 1983, 1985). With the objective of identifying the forest cover types using remote sensing data products, a case study was undertaken at the Kanha National Park, Kanha, Madya Pradesh (80° 26' to 81° 30' E longitude and 22° 07' to 22° 27' N latitude).

MATERIALS AND METHODS

The remote sensing data products *viz.*, aerial photograph (B/W panchromatic 1:10,000 scale) and satellite imagery (Landsat TM-FCC 1:50,000 scale) obtained during summer season and the survey of India toposheets (1:50,000 scale) pertaining to the study area were used for the present study. The whole work was completed in three phases *viz.*, prefield work, field work and post field work as per modified Kuchler's (1967) comprehensive method. Since stereovision is not possible in satellite data (Landsat TM-FCC) only visual interpretation was done and a few broad physiognomic units alone were delineated based on the variations in photoelements (tone, texture, pattern, size, shape and location). Detailed information regarding different forest types under each physiognomic units as well as the understorey information were obtained by interpreting aerial photographs under mirror stereoscope for 3-D view of the objects. By integrating the interpreted data from both the aerial photographs and satellite imageries, detailed vegetation covers were identified.

Representative sample plots were made on satellite imageries and aerial photographs in each strata, proportional to the forest types, following stratified random sampling technique. Field checking for the correctness of interpreted data was done in the corresponding sample plots in the field (forest area). The revised survey of forest types in India by Champion and Seth (1968) was taken as guidelines for identification of different types of forest vegetation in the study area.

RESULTS AND DISCUSSION

Based on tonal variations, only four major types of forest vegetation *viz.*, moist sal forest, moist mixed forest, dry mixed forest and seral vegetation were identified. Besides these four forest types, one type of grassland was also identified on satellite imageries. However, with the help of aerial photographs more detailed information was obtained in each of the four major vegetation types.

Detailed description of the occurrence of each of the forest types and their association with other forest types in the study area are furnished hereunder.

MOIST SAL FOREST

Sal forests are the major forest constituting nearly 50 per cent of the total forest area of the whole Kanha National Park. Based on the geographical distribution (or location), sal forests are classified into three types *viz.*, valley sal, slope sal, and regeneration sal. Generally, sal occurs approximately at an altitude of 500 to 600 m. Beyond this elevation, they are sporodically occurring in few scattered patches not as pure stand but as a mixture with terminalia.

Valley sal

Valley sal occurs along the river banks, *nala* or stream beds on soil type ranging from alluvial to loamy soils (loam, clay loam, fine loam etc). For the purpose of the present study, valley sal has been defined as those sal occurring on a flat terrain or stony or gently sloppy or undulating terrain having a slope angle of 10° and below, irrespective of soil type on which they occur. The height of the trees varies between 20 and 30 m, the stand density (crown density) ranges from 70 to 80 per cent and the ground cover between 80 and 90 per cent. Generally the following are the type of vegetation occurring as groundstorey (or understorey) depending on the soil type and moisture availability.

In alluvial soils near stream or river or *nala* beds flamengia (*Flamingia bracteata*), Banraha (*Flamingia semialata*) Sindhi (*Phoenix acualis* and seedlings of sal and its associates *viz.* *Terminalia.*, Diospyros, Jamun, *Mallotu phillippensis* etc., occur as understorey. In soil with gravel or stoniness occurring just above the *nala* beds bamboo (*Dendrocalamus strictus*) occurs as understorey.

Slope sal

Slope sal occurs on the slopes of small hillocks and slightly away from the water source. The type of soil varies from sandy loam to clay loam with stoniness ranging from 30 to 50 percent and rock outcrops 1 to 5 per cent. The height of the stand varies from 20 to 30 m. For the purpose of the present study, the slope sal has been defined as those type of sals occurring on a sloppy terrain having more than 10^{o} slope and extending upto 30^{o} approximately. As the elevation increases, the tree height slightly decreases. The crown density ranges between 80 and 90 per cent and the ground cover varies from 85 to 90 per cent. Bomboo, *Phoenix acualis*, seedlings of sal etc., occur as understorey vegetation.

Regeneration sal

There are mostly young crop of sal ranging from the size of pole crops to moderately matured sal. They occur both in valley sal area and slope sal area in patches. The height is more than 25 m, the crown density between 80 and 90 per cent and the ground cover is about 90 per cent. They occur on alluvial to loamy soils. Flamengia, *Phoenix acualis*, Bomboo, seedlings of *Diospyros, Terminalia, Lagerstroemia, Cassia fistula*, etc.. occur as ground storey.

MOIST MIXED FOREST

Terminalia

It is a close associate of sal. *Terminalia* occurs in loamy, sandy loamy, and clay loamy soils in an approximate elevation ranging from 500 to 600 m in pure patch as well as a mixture with sal and its distribution extends upto 800 m along hill slopes and ridge tops. As the elevation increases the height and crown size decreases. For the purpose of the present study, *Terminalia* forest has been defined as a forest having more than 50 per cent of *Terminalia* in a forest stand. The stand height varies from 25 to 30 m, the crown density is about 60 to 80 per cent. Seedlings of *Diospyros, Ougenia, Sterospermum suavelens, Embelica robusta, Desmodium latifolium*, bomboo etc., occur as ground storey. At higher elevations (> 600m) *Terminalia* is not occurring in pure stand but as a mixed stand with *Bosewellia, Lagerstroemia, Ougenia, Buchanania* etc.

Terminalia-sal

For the present study, this type of association has been defined as follows: The population of *Terminalia* is more than 70 per cent and that of sal is less than 30 per cent. The general stand height of this group varies from 20 to 25 m, the crown density from 60 to 80 per cent and the ground cover is between 85 to 90 per cent. This type of association occurs near the *nala* or stream beds on sandy or alluvial or loamy soils approximately at an elevation ranging from 500 to 700 m.

Terminalia-Lagerstroemia-Ougenia

This association occurs at the ridge top on dadars and hill slopes just below ridge line. The height varies from 15 to 25 m depending on location. The crown density varies from 60 to 80 per cent and the ground cover is about 80 per cent. This association occurs mainly on clay loam soils and sometimes in loamy and alluvial soils on an approximate altitude ranging from 500 to 700 m. Bamboo, grasses, chippa (*Desmodium latifolium*) and seedling of *Terminalia, Ougenia* and *Lagerstroemia* occur as ground storey.

DRY MIXED FOREST

Terminalia-Bosewellia-Lagerstroemia

This type occurs on ridge top as well as on the hill slopes just below ridge line. The stand height varies from 12 to 20 m, the crown density from 40 to 60 per cent, and the ground cover is about 80 per cent. Bamboo and grass forms the understorey. This type of vegetation is observed at an approximate altitude ranging from 600 to 850 m on loamy and clay loamy soil.

Terminalia-Lagerstromeia-Buchnania

This is another type of vegetation observed on the ridge top of residual hills as well as on hill slopes just below the ridge line. The *Buchnania* is evergreen with compact crown. The stand height varies from 10 to 20 m, the crown cover from 40 to 75 per cent and the ground cover is about 75 per cent. Bamboo and grass occur as ground storey. This type of vegetation occurs at an approximate elevation betweehn 600-700 m.

Ougenia-Lagerstroemia

This type of vegetation occurs on uplands called dadars (vast plateau). Mostly the soil type is clay or clay loam with flat or slightly undulating terrain with gentle slope. The stand height varies from 8 to 10 m, the crown density is 50 to 60 per cent. The ground cover is about 80 per cent. The grass is the only dominant ground storey. During summer, the grass becomes dry and most of the grass areas were found burned by accidental fire. Sometimes intentional firing has also been reported. This type of vegetation occurs approximately beyond an elevation of 650 m on dadar lands (plateaus).

Seral Vegetation

Butea monosperma

This occurs generally as pure patches of seral vegetation invading grasslands in the meadows (plain area). The height of the stand varies from 5 to 5.5 m, the crown density from 65 to 70 per cent and the ground cover is about 80 per cent. It occurs on an approximate altitude ranging from 500 to 600 m.

Lagerstroemia

It occurs in pure patches as seral vegetation mostly on dadars invading grasslands. The stand height varies from 12 to 13 m, the crown density is 35 to 40 per cent and the ground cover 100 per cent. Grasses as understorey had been observed to cover the ground fully.

Grasslands

Meadow low grass

The height of the grass is less than one m. They occur on loamy, alluvial or sandy soils on the plains (either flat terrain or gently undulating valley).

Meadow high grass

The height of the grass is more than one m. They also occur on plains. The following are the main grass species occuring in meadows: *Apluda mutica, Arundo donax, Bothriochloa intermida, Capillipedium parviflora, Cymbopogon martinii, Dicanthium caricosum, Eragrostiella brachyphylla, Eragrostis tenella etc.* The meadow grasslands are distributed approximately in an elevation of 500-600 m. Slow intrusion of *Sal, Terminatia, Ougenia* etc., besides *Butea* has been observed.

Dadar low grass

They occur on clay or clay loamy soils on uplands called dadars or plateaus. The height of the grass is less than one m.

Dadar high grass

The occurrence of this grass is similar to the above but their height is more than one m. The following are the main grass species observed on dadars. *Cymbopogon martinii, Heterpogon contortus, Iseilema anthephoroides, Iseilema laxum, Themida trianra, Themida laxa etc.* The above mentioned 11 types of forest and 4 types of grasslands identified on integrating the satellite imageries and aerial photographs were finally transformed in to a two dimensional forest cover map for better visual appreciation as well as for estimation of the area under each type of forest cover. For forest ecological studies remote sensing may be considered an efficient tool as we were able to get more than 90 per cent accurancy of information in a short span of time.

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