TECHNICAL REPORT No. 2

PREINVESTMENT SURVEY OF FOREST RESOURCES

EAST GODAVARI (A. P.)

PHOTOINTERPRETATION AND MAPPING

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GOVT. OF INDIA
MINISTRY OF AGRICULTURE
NEW DELHI
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WHAT THE REPORT CONTAINS?

Technical Report No. 2 "Photo-Interpretation and Mapping" is a supplement to the main report "Pre-Investment Survey of Forest Resources, East Godavari (A. P.)" issued by the Organization. This technical report deals with the use of aerial photographs and photo-interpretation procedures as well as maps prepared for the East Godavari Catchment. In spite of small scale of photographs, aerial photo-interpretation reduced the ground inventory work and improved area accuracy considerably thereby improving precision of total volume estimates by strata. More important contribution of aerial photographs was the production of reliable Landuse and Forest Cover Type maps on 1" = 1 mile scale in a relatively short period and at a comparatively low cost.

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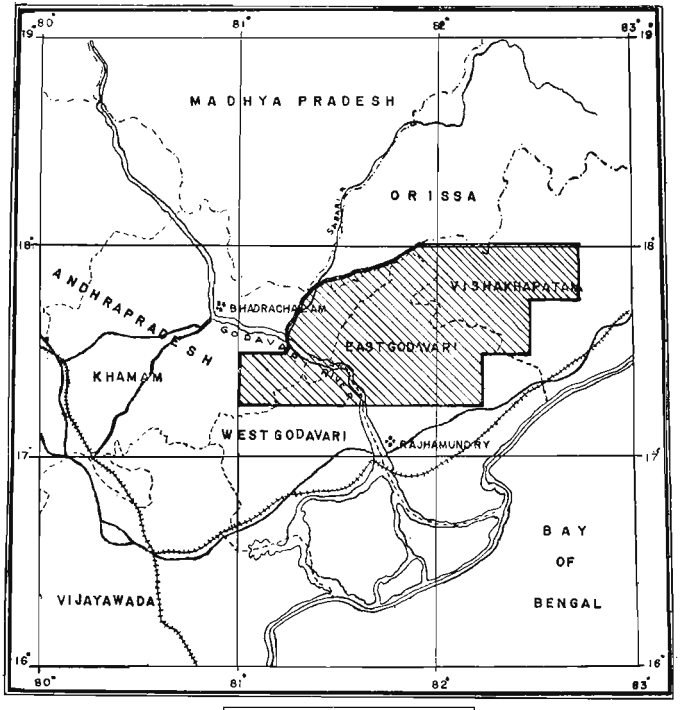
MAP SHOWING THE LOCATION OF SURVEYED AREA OF EAST GODAVARI. (A. P.)

SCALE : 1 INCH = 32 MILES



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SURVEYED AREA.

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1. INTRODUCTION

An area of 10,416 sq km. was selected in East Godavari catchment of Andhra Pradesh for Preinvestment Survey of Forest Resources, during the year 1969-70 The area is richly endowed with forest wealth, whose potential has not yet been fully harnessed for the economic development of the region Small scale aerial photographs have been used for assessing the forest resources and for preparation of forest maps

2 NAME, LOCATION & EXTENT OF SURVEY AREA

Though the area is known as East Godavari catchment, it lies both on the eastern as well as western side of Godavari river The area lies between latitude 17° 15' and 18° N and longitudes 81° and 82° 45' E, and is shown in Figure 1 Bastar district of Madhya Pradesh and Orissa State form the north-western boundary

The coast of the Bay of Bengal is hardly 25 km. as the crow flies from the nearest point of the survey area Rajahmundary and Visakhapatnam are the main market centres near the area of the total area of the project (10,416 sq km.) nearly 70% is estimated to be covered by forest growth

TOPOGRAPHY AND DRAINAGE

The tract lies on the Eastern Ghats and is mostly hilly except the periphery and small valleys inside The hills may be divided into two main groups; one west of Godavari river i e near Polavaram; and the other, east of Godavari The first group of

hills is formed by a part of Eastern Ghats and its buttresses most prominent feature in this group is the flat-topped crest of Papikonda rising to a height of 756 m. above m.s.l. The average elevation of the hills is 460 m. above m.s.l..

The group of hills on the eastern side of Godavari river constitutes Eastern Ghats and the ridges run north-east to south-west, more or less parallel to the coast. The elevation ranges from 150 m to 1526 m The upper slopes of hills are quite steep and the tops are generally flat with little tree growth.

Godavari river passes through the south-western portion of the area from north-west to south-east. The Sileru river, which is an important tributary of Godavari, forms the north-western boundary of the project Pamleru stream passes through the heart of the rich forest and drains the north-western parts into Godavari The other important streams draining the area are Eluru, Tandava, Varaha, Pedda Eru, etc On the whole, the general drainage is from north to south

The area is thinly populated. The tribals living in the area are Hill Reddis and Kovas. There are only few roads in the area, which have been constructed during the last few years The tract is mostly inaccessible and inhospitable

4 GEOLOGY, ROCK AND SOIL

The predominant rocks of this area are Gneisses, Kamthi, Barakar, and Rajahmundary sandstones

The soils are from dry shallow stony soils to red lateritic soils The occurrence of light loams is not uncommon around Polavaram and Gokavaram ranges Flat and gently sloping lands of Gokavaram and Sudhikonda ranges distinctly show the red lateritic soils

The soils are fairly deep in the valleys and lower hill slopes On upper slopes, the soils are shallow On the flat hill tops, the soils are very shallow with rocky out-crops.

5 CLIMATE

The climate is tropical monsoon type with average annual rainfall of 1500 mm. Most of the rain is received during the south-west monsoon from June to September About 15% of the rain is received from October to January during the north-east monsoon Moisture is available for major portion of the year except from January to May Early in the dry period, heavy dew keeps the soil moist but later on moisture scarcity is felt

6 COMPOSITION AND CONDITION OF THE FOREST

The forests are generally of the Southern Tropical Deciduous type There are various types found in this region depending on geographical location, altitude, rainfall, soil development and other biotic factors According to Champion and Seth (A Preliminary Survey of the Forest Types of India) the following forest types are

met with in this region:-

6.1. Southern Tropical Dry Deciduous forests.
6.2. Southern Tropical Moist Deciduous forests.
6.3. Savannah Type of forests.
6.4. Dry Thorn and Scrub forests.

The distribution and composition of the above types are given in the Working Plan of Kakinada Division and these are described briefly in the following paragraphs:

6.1. Southern Tropical Dry Deciduous Forests

The bulk of the forest falls in this category. The height of the trees is 15-20 m. and the forest is deciduous (leafless) in hot season from January end to May. The canopy is irregular and generally open to medium dense. Many trees in this type are in flower when leafless. The undergrowth consists of open thorny bushes, shrubs and grasses with few climbers.

The top canopy in this type consists mainly of Anogeissus latifolia, Terminalia tomentosa, Pterocarpus marsupium, Lagerstroemia parviflora, Adina cordifolia, Terminalia belerica, Soymida febrifuga, Sterculia urens and Garuga pinnata.

Teak (Tectona grandis) is conspicuous by its absence in this type.

Emblica officinalis, Aegle marmelos, Bauhinia racemosa, Buchanania lanzan, Erythroxylon monogynum, Gardenia Gummifera, Stephegyne parvifolia, Cassia fistula and Bridelia retusa are

some of the common trees found in the understorey

Bamboo (Dendrocalamus strictus) is found scattered but in some places it is seen in pure and dense patches

This forest type occurs upto an elevation of about 1000 m on the hills Rainfall varies from 75 - 120 cm with dry and prolonged hot summer and long period of drought The dry deciduous type of forests are commonly found in Sudikonda, Yeleswaram and hill slopes of Addathigala range

Heavy grazing and frequent fires in the hot season are common features in this type

6 2 Southern Tropical Moist Deciduous Forests

This type is confined to valley bottoms and sheltered localities as commonly seen in Addathigala range It is composed of high forests with a height of 20-30 m and characterised by closed canopy The forest is leafless only for a short period and new flush of foliage comes again by end of May. The top canopy consists of deciduous trees, underwood of semi-deciduous species and ground flora is evergreen In moist places cane brakes are common and in shady areas Epiphytes are present on trees The number of climbers and lianes is comparatively more

The top canopy commonly consists of Xylia xylocarpa, Terminalia tomentosa, Pterocarpus marsupium, Bursera serrata, Garuga pinnata, Dillinea indica, Salmalia malabarica, Anogeissus latifolia and Lagerstroemia parviflora. Valuable

species like Dalbergia latifolia and Tectona grandis are very rare or absent

The underwood consists of Cugenia dalbergioides, Carava arborea, Cordia myxa, Kydia calycina, Grewia tiliaefolia, Cassia fistula, Aegle marmelos Cleistanthus collinus, Gmelina arborea and Bauhinia species.

Climbers are common and mainly consist of Bauhinia vahlii Butea superba & Spatholobus roxburghii The other climbers are Acacia intria, Dioscorea hispera, Smilax rylanica, Derris scandens, etc

Along streams evergreen trees like Mangifera indica (wild variety) Syzigium cumunii, Xanthoxylum rhetsa, Trema orientalis and Artocarpus integrifolia are common, Terminalia arjuna, Anogeissus acuminata are also occasionally seen

Composition of the crop is influenced by moisture availability and topography. On hill slopes with fairly good soils Xylia xylocarpa, Anogeissus latifolia and Terminalia tomentosa predominate Along streams huge mango trees are present

The difference in Dry Deciduous and Moist Deciduous forest is not much so far as composition of species is concerned except that the former is inferior in height and density and experiences a longer leaf-less condition (February to May) In Moist Deciduous forest

regeneration of Xylia xylocarpa is invariably present but in the Dry Deciduous forest, it is totally absent

The Moist Deciduous forests are confined to relatively interior hilly tracts, which were till recently inaccessible and unhealthy Consequently these forest areas were less inhabited and incidence of biotic factors was negligible. The elevation varies from 300 - 1000 m and the mean annual rainfall is 150 - 200 cm with 80 - 100 rainy days Except for February and March the remaining months of the year have rainfall in these forests The summer is not very hot except for second half of May and winter is pretty cool, with dense fog formation The soils are generally red latsols of chestnut brown loams, rich in organic matter

6 3. Savannah Type Of Forests

The hill tops, generally 900 m and above in elevation above m.s l contain grassland vegetation with scattered and stunted tree growth They are locally known as Vanamas Some hill tops appear like meadows In some other places scattered Phoenix acaulis is found. Wherever some soil is present , a sprinkling of stunted tree growth is seen

The elevation of the region, where grasslands are found, varies from 800 - 13000 m above m s.l The climatic conditions on such hill tops go to extremes The annual rainfall varies from 100 - 150 cm. The winds are strong and temperatures go to extremes

i e 5^{o} c to 35^{o} c The winter is fairly severe but frosty conditions are not known The soils are very shallow and gravelly Frequently out-crops of bed rocks are exposed.

Coarse grasses like Themeda triandra, Heteropogon contortus, Aristi depressa, Crysopogon montenus, etc are common.

Though in certain places stunted tree growth of dry deciduous species appears, there are no signs of trees replacing the grass growth An aerial flight from Visakhapatnam towards west over Gudem and Rampa agency tracts upto the river Sabari reveals extensive nature of grasslands with scattered stunted tree growth over all the hill tops particularly Dummukonda and other hills in and around Chintapalli At places the grasslands descend over the steep concave slopes and merge with the tree growth down below. At the marginal belts the plant growth is sparse and stunted. Annual fires in the hot season are common in these grasslands

6 4 Thorn And Scrub Forests

These types of forests are situated in dry belt where average annual rainfall is 80 - 100 cm only The soils are red murram derived from sand stones and are badly eroded and compacted by heavy grazing The forests are very inferior and height growth is 5 m. or so with low density. Examples of such poor forests are seen in Annavaram Kenda and in Tuni taluks Stunted trees of Soymida febrifuga, Acacia sundra and Zizyphus xylopyra are commonly seen Dodonea viscosa and Chomelia asiatica are the common shrubs

Besides the above, the following two types also need some mention.

6.5. Bamboo Forests

Bamboo is found throughout the area as an underwood and is more common in the Dry Deciduous type. Three species of bamboo are found in this tract:

(a) Dendrocalamus Strictus:- It is the most widely occurring bamboo and is common in Rampa and Gudem agencies. On hill slopes and in valleys of Addathigala range it is found gregariously as undergrowth. In Dry Deciduous forests it tends to form pure patches over small areas.

(b) Bambusa arundinacea:- It occurs in small patches or as single clump along stream banks and moist alluvia near village sites. Between Addathigala and Yelaswaram the eroded hills surrounded by cultivation are containing almost pure growth of stunted clumps of this species.

(c) Dendrocalamus hamiltonii:- It is found along moist stream banks in northern Rampa only in limited areas.

6.6. Shifting Cultivation (Podu)

Shifting cultivation is widely practised by Koya and hill Reddy tribals all over the area. Most of the forest area must have experienced shifting cultivation at one time or the other. There is every reason to believe that most of the hill tops, now

covered by extensive grasslands, must have experienced shifting cultivation in the past. The local tribals particularly hill Reddies have fascination to dwell over the hill tops and practise shifting cultivation. Shifting cultivation is also common on hill slopes and in valleys but here coppice growth of tree species occupies the abandoned shifting cultivation sites to the exclusion of grasses

In February or March the trees and bushes are cut and spread evenly During the hot season the slash is burnt. Hill cholam and samai are common crops grown by tribals

The shifting cultivation is practised with a rotation of roughly 7 - 8 years As soon as the cultivation is abandoned, forest species like Xylia xylocarpa, Anogeissus latifolia, Bridelia montana, etc; come up. The regrowth is generally of coppice origin with lot of thorny bushes Many coppice shoots on each stump are seen.

AVAILABILITY OF BASE MAPS

The following 1" = 1 mile (1:63,360) topo maps surveyed between 1924 and 1932 are available for the entire survey area in East Godavari:-

65 C/3, 5, 6, 7, 9, 10, 11, 13, 14 and 15	= 10
65 K/1, 2, 3 5, 6 and 9	= 6
	= 16

In the year 1970 field survey of 65 G/14 sheet was taken up by 70 Survey (Forest) Party on the request of the Project in order to prepare topo maps on 1:25,000 scale These large scale topo maps on 1:25,000 scale (6 sheets covering one inch sheet 65 G/14) have since been printed.

8 AERIAL PHOTOGRAPHIC COVERAGE

1 : 60,000 scale photography of specification 564 A taken in January to mid February 1968 with Eagle IX MK II camera, using a 6" focal length lens, is available for the entire area The actual scale varies from 1 : 59,000 to 1 : 62,000 The flying height above the average ground datum is 650 m above m s l The format size of the prints is 23 x 23 cm with a forward overlap of about 70% and lateral overlap of 25% approximately with flight direction East-West The resolution of Eagle IX MK II camera with 6" lens cone is tolerable within the effective area of the photographs, but the details are not clear around the edges In general, the quality of aerial photography is satisfactory.

ACCEPTANCE OF EXISTING SMALL SCALE PHOTOGRAPHY FOR PHOTOINTERPRETATION

Looking to the mixed miscellaneous nature of the forest, comprising over a hundred species, absence of Teak and Sal in the area, lack of intensive forest management and difficulty of obtaining fresh photography within a short period as well as difficulty

of identifying individual species in such mixed miscellaneous forests even on large-scale photography, it was decided to use the existing small-scale photography (1 : 60,000 Scale) for photointerpretation of broad landuse and forest strata The idea of detailed interpretation such as recognition of various forest types and species, height classes, etc; was given up in favour of broad landuse and forest strata Thus the objectives of photo-interpretation were modified accordingly and the ground sampling work was designed to get volume per hectare by strata and by species, diameter classes etc , and aerial photo-interpretation to be used for getting area information and for preparing maps

10 OBJECTIVES OF PHOTO INTERPRETATION

Thus the objectives of aerial photointerpretation on small-scale photography were:

10 1. To reduce field work by eliminating non-forested plots from ground cruising and using photographs in locating the ground plots correctly

10 2 To prepare maps on 1 : 63,360 scale showing various forest strata and other land use classes for further planning and management

10 3 To prepare maps of selected areas showing suitable sites for Teak and Eucalyptus plantations

10.4. To calculate areas of different landuse, forest strata and plantation sites from 1 : 63,360 scale maps prepared from aerial photo-interpretation in order to improve the accuracy of total volume estimates.

11. INTERPRETATION OF GROUND PLOTS FOR ELIMINATING THE NON-FORESTED PLOTS FROM GROUND CRUISING.

This work was done only in one sheet i.e. 65 C/14 for special survey. According to the ground sampling design the whole of 65 C/14 sheet covering an area of 734 sq. km. was systematically divided into grids of 1' longitude and 1' latitude. Thus there were 225 such grids in the sheet. In each grid a cluster of two plots was systematically laid out with the centre of the first plot coinciding with the grid centre whereas the centre of the second plot was situated 400 metres apart due east from the centre of the first plot. The size of plot was 0.1 ha. square.

All the plots were transferred on aerial photographs by matching the details on photos and 1" topo map. Efforts were made to locate the plots on photos as accurately as possible. This was done visually under the stereoscope. As the scale of photo and map was small and as the local details on map for reference were not adequate enough there was a possibility that the location of some plot centres on photos may be off by about 100 - 120 m. from their true planimetric positions. If the plot centre was surrounded by a big forest patch of several hundred hectares, the slight error in

location was inconsequential. In marginal cases where the plot centre was near the boundary of two landuse classes, the error in location might affect the result. To minimise this error in border cases, the plot centre was included in "Forest" category, if it fell on the border of forest and cultivation, or forest and blanks. In case of shifting cultivation, the plot was included in "cultivation" if the plot fell in actual cultivation, or in "shifting cultivation" if the plot fell in regrowth area. Thus plots falling in forest and shifting in agriculture, cultivation and blanks were to be omitted from field work. Even if one plot of a cluster in the grid fell in forest or shifting cultivation the field parties were to visit such grids.

As a result of photo-interpretation of 450 plots in 65 G/14 sheet the following results were obtained:-

		NO. OF PLOTS
1.	Forested	303
2	Shifting cultivation (regrowth) excluding area under actual cultivation.	52
3	Blanks	15
4	Agriculture including area under actual shifting cultivation without regrowth	80
	TOTAL:	450

Thus out of 450 plots the ground parties had to visit only 355 plots (303 plots in forest and 52 plots in regrowth on abandoned shifting cultivation). The remaining 95 plots fell in agriculture, actual shifting cultivation (without regrowth), grassland or blanks.

and hence were not to be visited on the ground by the field parties for enumeration Thus aerial photointerpretation of ground plots straight away reduced the ground work, in terms of plots not to be visited, by about 21%.

12 HUNDRED PER CENT INTERPRETATION FOR PREPARING MAPS OF LANDUSE AND FOREST COVER TYPES

The object of hundred per cent interpretation was to prepare maps on 1 : 63,360 (1" = 1 mile) scale showing different landuse classes and forest cover types and strata The forest cover types were further stratified by five crown density classes and three broad volume classes The interpreted details were transferred on 1 : 63,360 scale (1" = 1 mile) topo maps and the areas of various landuse and forest cover types were obtained by dot grid method from these maps

12 1 Preparation Of Aerial Photographs For Hundred Percent Interpretation

Hundred percent interpretation was done on the effective area of all photographs in order to minimise the errors due to relief displacement The principal points (PP), which are already marked on the aerial photographs, were transferred on the adjoining photographs. Match lines were drawn in the middle of PP and Conjugate PP, parallel to the eastern edge of each photographs Upper and lower limits of the effective area were also indicated

by red lines half way between the sidelap

12 2 Landuse & Forest Cover Types

Considering the difficulty of identifying individual species on such small-scale photographs as well as 1 : 63,360 scale of the forest cover type maps to be prepared, a broad classification system was adopted for delineating broad landuse and forest cover types Height measurement was not considered practicable

The definitions and symbols for various landuse classes and forest cover types adopted for photo-interpretation were as follows

(1) C - Agricultural crop land including orchards, habitation and waste land within agricultural tract. Permanent type of cultivation within forest or on hill slopes was included in this. Agricultural tree lands were also included in this

(2) B - Blanks and grasslands including barren land. If scattered trees were present their density was 5% or less The grassy blanks on flat hill tops as well as on steep hill slopes or out-crop areas were included in this category

(3) S - Shifting cultivation including regrowth on abandoned shifting cultivation sites. In such areas the area under actual cultivation at a

particular time may form about 20 - 30% of the total area affected by shifting cultivation.

(4) F - Good site forest i.e. good forest sites irrespective of volume and tree density. Moist type of forest with medium and high volume were generally found on such sites.

(5) f - Poor site forest i.e. poor open forest generally found on steep slopes, exposed out-crop areas and southern aspects. The forest growth was of dry deciduous type and generally understocked with low to medium volume. Bamboo was often found in such sites.

(6) P-2 Middle aged plantations of teak and other species. Individual crowns were discernible on aerial photographs. Tree height was generally 10 m. or more.

(7) p - Young plantation areas or recently clear-felled plantations sites.
Individual crowns were not visible on aerial photographs. Height generally less than 10 m.

12.3. Crown Density Classes

The forest cover types (F and f) were further stratified into five crown density classes on aerial photographs -

Crown Density Class	Code
More than 5% to 20%	1
More than 20% to 40%	2
More than 40% to 60%	3
More than 60% to 80%	4
More than 80% +	5

Crown density may be used as one of the factors for delineating unworkable forest areas as well as for prescribing any silvicultural treatment

Bamboos and scrubs were not descernible on photographs and hence have not been taken into consideration while eNoting crown density.

Density code was given in the numerator after the Forest condition class symbol e g F. 4. No density class was shown for plantations (P and p) and shifting cultivation (S)

12.4. Volume Classes

Following three volume strata were recognised on aerial photographs for forest cover types except plantation areas (P and p). This was based on the past experience

	CODE
Low Volume	1
Medium Volume	2
High Volume	3

The actual class limits of various volume strata was obtained from the ground inventory data . However, the limits of the various volume classes as well as those obtained from ground inventory are indicated below:

STRATA	ESTIMATED ON PHOTOS	OBTAINED FROM GROUND INVENTORY
1 Low Volume	15-50 m^3/ha	48 3 m^3/ha
2 Medium Volume	50-100 m^3/ha	70 9 m^3/ha
3. High Volume	Over 100 m^3/ha	98 6 m^3/ha

These volume class limits are based on the visible crowns on aerial photographs While alloting volume class to a stand not only the crown density but also size of trees (i e height of stands and texture of tree canopy) have been considered. There are cases where a stand of 60-80% density has low volume as compared to a stand of 40-60% density, because of difference in height growth and size of trees No volume class has been shown for plantation and shifting cultivation as the growth was young and both the strata would fall in low volume category

Volume class code was given in the denominator

Example - $\frac{F-4}{3}$ means forest on good site (F) with 60-80% density (4) and volume class high (3) i e more than 100 m^3/ha

12 5 Minimum Size Of Area To Be Delineated On Aerial Photographs

Due to the small scale of photography the minimum size of the area delineated on aerial photographs was 10 ha (i e 0 25 cm^2

on aerial photograph) for landuse and forest cover types Wherever there was intimate mixture of different landuse classes or different forest cover types, each one occupying a smaller area of less than 10 ha., a generalization has been done to delineate such pattern into one cover type For example, in shifting cultivation area, there were patches of forest regrowth, interspersed with small plots of actual cultivation They were too small and numerous to be delineated individually and hence they were recognised as one pattern of "shifting cultivation"

Linear areas such as rivers, roads, tree strips, transmission lines, reserve forest boundary, narrow blanks etc , have not been recognised as a separate cover type unless their average width was 120 m or more i e at least 0 2 mm on photo

13. INTERPRETATION OF PLANTATION SITES FOR TEAK AND EUCALYPTUS

Small scale photography was also used for interpreting suitable sites for Teak and Eucalyptus plantations over an area of 734 sq. km covering topo sheet 65 G/14.

On the basis of information provided by State Forest Department and limitation of interpretation on such small scale photographs, the following criteria were fixed for delineating suitable areas for plantations:

13.1 Lower one-third slopes, the gradiant not generally exceeding 25^{0} were treated as suitable for plantations.

13 2 Areas containing good forest growth with high volume and density, located on easy slopes, were considered suitable

13 3 Poor forest growth situated on exposed rocky areas was considered unfit for plantation site

13 4 Areas under shifting cultivation or with regrowth on abandoned shifting cultivation sites, though may be considered suitable for plantations, were excluded from consideration

13 5 Blanks, grasslands and permanent cultivation have not been considered suitable.

13 6 The minimum area for delineating plantation sites was fixed at 30 hectares Smaller patches than 30 ha , though may be suitable, were considered unfit for plantations on account of practical reasons Any area less than 300 m. in width on ground was also excluded.

On the basis of above considerations 29 sites have been delineated in sheet 55 G/14. The area of each site varies from 33 to 2553 hectares While delineating the boundaries of suitable plantation sites on aerial photographs efforts were made to keep the boundaries reasonably straight avoiding minor kinks, etc. This would facilitate laying out of the boundaries on the ground and also for calculating the area

The plantation sites delineated on aerial photographs have been transferred on 1:63,360 topo maps All the plantation sites have been serially numbered on the map and their areas calculated with the help of a dot grid template.

TABLE - 1.

AREA OF SUITABLE PLANTATION SITES IN SHEET 65 G/14.

Plantation Site No.	Area in Hectare	Plantation Site No.	Area in Hectare
1.	2353	16	194
2.	443	17	119
3.	69	18	183
4.	158	19	66
5.	327	20	141
6.	152	21	64
7.	235	22	138
8.	33	23	180
9.	59	24	144
10.	58	25	169
11.	396	26	194
12.	158	27	78
13.	138	28	174
14.	158	29	55
15.	105		
		Total Approx.	6553

Thus the total area considered fit for Teak and Eucalyptus plantations in 65 G/14 sheet on the basis of aerial photo-interpretation is 6553 hectares. These sites, however, require detailed inspection on the ground to confirm the results. In the beginning only such sites need be taken for plantation which are easily accessible. An estimate of the total standing volume in such plantation area can also be

obtained from the forest density volume map.

14. TRANSFER OF DELINEATED DETAILS FROM AERIAL PHOTOGRAPHS TO BASE MAPS AND PRINTING OF LAND USE AND FOREST COVER TYPE MAPS

14.1. Transfer Of Details On To Base Maps:

After the interpretation and matching of details on aerial photographs, the boundaries of various landuse classes and forest cover types were transferred on to 1 : 63,360 (1" = 1 mile) scale topo maps by 70 Survey (Forest) Party, Survey of India. As the scale of photography does not differ much from the scale of map and as limited time was available for this job, the photo details were transferred visually by seeing the model under stereo and by matching local details on maps.

The transferred boundaries were given appropriate symbols and verified by photointerpreters. These maps on which the land use and forest cover boundaries were transferred were used for area calculation of different cover types by dot grid method.

14.2. Preparation And Printing Of Landuse And Forest Cover Type Maps:

Koda line prints on 1 : 63,360 scale showing landuse and forest cover types as well as some natural and cultural features, but no contours, were made in Survey of India through 70 Survey (Forest) Party. These kodaline prints will be kept as master copies to be used for printing large number of copies of the surprints, whenever required. For project use adequate number of ammonia prints were obtained from

the Kodaline prints. However, Landuse and forest cover type map of 65 G/14 sheet on 1 : 63360 scale was printed (500 copies).

The ammonia prints on 1" scale were also used for generalization of landuse and forest cover types in order to compile and print a quarter inch forest resources map for general planning and orientation. For quarter inch map crown density was omitted and poor site forest (f) and plantation areas (P and p) were included in the adjoining good site forest (F). The minimum size of the landuse class or forest cover type shown on quarter inch map was kept 1 x 1 cm. or 640 hectares. Thus the quarter inch map shows cultivation, shifting cultivation and forest areas by three volume classes in addition to important drainage and cultural features in appropriate colours. 500 copies of Forest Resources map on 1/4 inch scale have been printed for use.

The title of these maps will be as under

PRE-INVESTMENT SURVEY OF FOREST RESOURCES

CENTRAL ZONE (EAST GODAVARI)

LAND-USE & FOREST COVER
TYPE MAP

15. AREA CALCULATION

15.1. Area of different landuse and forest cover types was calculated from 1 : 63,360 scale maps with the help of a dot grid template. Each dot represents 1.457 ha. on 1 : 63,360 (i.e. 1" = 1 mile) scale. Smallest unit of area compilation was 5' x 5' grid. The area calculation was done in 70 Survey (Forest) Party, Survey of India.

The details of area estimates as obtained from 1 : 63,360 scale maps, prepared from photo-interpretation, are given in Table - 2.

TABLE - 2. Source - Photo Interpretation.

AREA STATEMENT BY LAND-USE CLASSES (IN HECTARES) EAST GODAVARI

Map Sheet No.	Forested Area					Non-Forested Area				Grand Total
	F	f	P	S	Total	B	C	W	Total	
1	2	3	4	5	6	7	8	9	10	11
65 G/3	34979	3412	1643	7154	47188	172	26133	-	26305	73493
" G/5	6057	433	83	297	6870	-	1844	320	2164	9034
" G/6	33036	3225	961	4500	41702	180	15651	2098	17909	59611
" G/7	34341	2585	331	2684	39941	1374	10600	1578	13552	73493
" G/9	25486	377	88	1496	25447	1296	1983	891	4130	29577
" G/10	60085	3745	1295	6163	71288	1307	3800	-	2107	73395
" G/11	40135	4756	38	10738	55667	425	13915	3488	17826	73493
" G/13	45288	261	-	8643	54179	5856	1992	433	8281	62460
" G/14	46077	3207	-	7848	56132	4088	15287	-	17365	73395
" G/15	18855	3229	1001	2588	25483	3760	44250	-	48010	73493
" K/1	60098	1025	128	1644	62895	7005	3005	-	10400	73295
" K/2	43259	4893	264	1108	49524	4006	19865	-	23871	73395
" K/3	31374	2884	761	30	35048	3226	35209	-	38435	73493
" K/5	41185	1211	466	1443	44305	3390	25690	-	28990	73295
" K/6	39832	4215	414	591	44852	1313	27230	-	28543	73395
" K/9	35508	3211	14	3420	42153	4137	27035	-	31142	73295
Total:	618085	42676	7467	80456	723684	41323	268709	8806	318928	1042612

Note: The symbols used in column 2 to 5 and 7 to 9 in the above table indicate:

F = Good site forest
f = Poor site forest
P = Existing plantations
S = Shifting cultivation including regrowth.
B = Flanks and grasslands
C = Cultivation and habitation
W = Water surface

In Table - 2 shifting cultivation has been included in forested area. The total forested area including shifting cultivation is 722584 ha., which forms 69.38% of the total survey area. The distribution of forested area by volume and crown density classes as obtained from photointerpretation is given in Table .

TABLE - 3.

Distribution of Forest Area by Volume and Crown Density Classes (In Hectares) East Godavari.

Source: Photointerpretation

Volume Classes	Crown Density Classes					Total
	5-30%	30-40%	40-60%	60-80%	80% +	
1. Low volume (15-50 m^3/ha.)	23550	87360	11597	202	-	122709
2. Medium Volume (50-100 m^3/ha.)	42	21816	166948	23530	448	212893
3. High volume (100 + m^3/ha.)		-	4120	250093	64946	319159
	23592	109176	182066	273934	65394	654761
4. Plantation area			-	-	-	7467
5. Shifting cultivation	-	-	-	-	-	60456
Grand Total:						722684

Note:- Plantation and shifting cultivation areas were not stratified by Volume and density. Both these classes fall in low volume class.

About 8.36% of the forested area (i.e. 5.8% approximately of the total/survey area) is affected by shifting cultivation. An area of 34213 hectares of the poor site forest has got a crown density of less than 40% and can, therefore, be treated as unworkable. Thus out of 662228 ha. under forest (excluding shifting cultivation), 34213 ha. or 5.16% can be treated as unworkable. To this should be added some good site and high density forest area situated on steep slopes or in in-accessible

localities, which will have to be left out from exploitation on silvicultural and economic grounds.

The detailed break-up of area by crown density and volume classes in each map sheet is given in Appendix - I.

15.2. Area Calculation Of Special Survey Area Of 65 G/14 Sheet:

The area by landuse classes based on 100 percent interpretation as obtained from forest cover type map of 65 G/14 sheet by dot grid method is as follows:-

TABLE - 4.

Area by Landuse Classes in 65 G/14 Sheet
East Godavari

Source - Photointerpretation- 100%

Landuse Class	Area in Hectares	Percentage of the Total area
1. Forested area	48,884	65.79
2. Shifting cultivation including regrowth	7,848	10.69
3. Blanks	4,026	5.48
4. Cultivation & habitation	13,237	18.04
Total:	73,395	-

Legally the forest land includes forested area, shifting cultivation and blanks. Thus the percentage of forest land to the total geographical area comes to 65.79 + 10.69 + 5.48 = 81.96%.

The break-up of the forested area by crown density and volume classes is as follows:-

TABLE - 5.

Forested area by Crown Density and Volume Classes in 65 G/14 Sheet East Godavari.

Source: Photointerpretation 100%

Crown Density Classes	Volume Classes			Total
	Poor Volume 15-50 m^3/ha.	Medium Volume 50-100 m^3/ha.	High Volume 100+ m^3/ha.	
5-20%	469	-	-	469
20-40%	7135	1923	-	9058
40-60%	760	11345	198	12303
60-80%	159	1815	14525	16499
80% +	-	43	9912	9955
Total.	8523	15126	24635	48284

The break-up of the forested area in 65 G/14 sheet by crown density and site quality is shown in Table - 6.

TABLE - 6

Forested area by Crown Density and Site Quality in 65 G/14 Sheet, East Godavari

Source: Photointerpretation - 100%

Crown Density Class	Good site Forests	Poor site Forests	Total
5-20%	284	185	469
20-40%	6,970	2,088	9,058
40-60%	11,369	934	12,303
60-80%	16,499	-	16,499
80% +	9,955	-	9,955
Total	45,077	3,207	48,284

Thus the poor site forest forms 6.6% of the total forested area in 65 G/14 sheet This poor site forest is located mostly on steep upper slopes, exposed out-crop areas and is generally understocked. Out of 3207 ha. of poor site forest, 70% area has got less than 40% crown density Therefore, poor site forests with crown density less than 40% (i e. 2273 ha.) can be treated as unworkable in 65 G/14 sheet.

16. INVESTIGATIONS ON THE COMPARABILITY OF PHOTO AND GROUND DATA

16.1. Land-use Class Data On Photo And Ground:

The ground and photo data of 450 plots belonging to 225 clusters laid out systematically over an area of 73395 ha. of 65 G/14 sheet have been compared.

450 plots were marked on 1 : 60,000 scale aerial photographs and interpreted under stereoscope as regards landuse classes. On ground only 398 plots were tackled as the remaining 54 plots fell on non-forested landuse such as agriculture or blanks.

The size of ground plot was 0.1 ha. square. On photo the size of plot was about 4.6 ha. and the shape was circular. It was not practicable to have the same size and shape of plot both on photo and ground, due to small scale of photography The classification of 450 plots according to plot photointerpretation and ground inventory is summarised in Table - 7.

TABLE - 7.

Classification of Plots by Landuse Classes on Photos and Ground in 65 G/14 Sheet, East Godavari

As per Ground Inventory	Plot Photointerpretation on Aerial Photographs				Total
	Forest	Shifting cultivation	Blanks	Cultivation & habitations	
1. Forest	291	30	3	18	351
2. Shifting cultivation	6	5	-	1	12
3. Blanks	2	-	11	-	13
4. Cultivation	5	8	-	61	74
Total	305	52	14	80	450

Source: Plot Photointerpretation

Note. Shifting cultivation on photos includes only regrowth on abandoned shifting cultivation whereas actual cultivation (shifting) is included in agriculture.

The data in Table 7 show that out of 52 plots allotted to 'Shifting Cultivation' on photos, 39 have been allotted to "Forest" on ground. This is not surprising as regrowth on abandoned shifting cultivation is 5-10 m. high and looks like a young forest on the ground. On aerial photograph such regrowth on abandoned shifting cultivation can be easily distinguished from natural forest. Whereas on ground such distinction is rather difficult. Similarly out of 80 plots shown as "agriculture" on photos, 18 plots are allotted to forest on ground. On photos even such plots which form part of shifting cultivation but are actually under "cultivation" at the time of photography are allotted to agriculture. Moreover, the distinction between agricultural tree land, which is synonymous to regrowth on shifting cultivation, and forest is not always apparent on the ground.

It may also be interesting to compare the plot classification into different landuse classes as per ground inventory, plot photo-interpretation and hundred percent delineation on photos. For 100% delineation a minimum area of 10 ha. was considered as compared to 4.5 ha. for plot interpretation and 0.1 ha. in ground inventory. The data is summarised in Table 8.

TABLE - 8.

Classification of Plots in 65 G/14 Sheet as per Ground Inventory, Plot Interpretation and 100% Interpretation.

Land use Class	No. of Plots as per		
	Ground Inventory	Plot Photointerpretation	100% Photointerpretation
1. Forest	351	303	295
2. Shifting Cultivation	12	52	52
3 Blanks	13	15	28
4. Cultivation habitation	74	80	77
Total	450	450	450

Note: Shifting cultivation under Col. 2 & 3 includes only regrowth on abandoned shifting cultivation sites, whereas cultivation and habitation under Col. 2 & 3 includes actual crop land in shifting cultivation.

Some of the discrepancies between photo and ground data can be explained by the different sizes and shapes of plots as well as different minimum areas for interpretation. Some of the discrepancies are also due to errors in plot location on photo and ground with the help of 1 : 63,360 topo maps. Actual pin pointing of the plot centre on the ground is rather

difficult with the help of this map. An error of about 50 m. in the planimetric position is possible.

16 2. Percentage Of Actual Shifting Cultivation To Total Forest Area Affected By Shifting Cultivation:

Though a large chunk of forest area may be affected by shifting cultivation, yet the actual area under cultivation (crop land) by tribals at a particular time is much smaller, the rest being covered by coppice growth. The shifting cultivation is practised normally on a cycle of 6-8 years. The tribals, practising shifting cultivation, clearfall a small patch of forest, grow some crops for 1-2 years, abandon this area and then clearfall adjoining forest growth for cultivation. They usually return to the original site after about 6-8 years by which time the site is covered with 5-8 m. high coppice growth (termed here as regrowth) and the fertility of the site is supposed to have been restored.

In order to find out what percentage of the total area affected by shifting cultivation is actually cultivated by tribals in a particular year, a study was made on aerial photographs.

450 plots distributed systematically in cluster of two each in 65 G/14 sheet were interpreted on aerial photographs. Photo plots falling in shifting cultivation were further classified into two categories:-

(1) Plots falling in regrowth on abandoned shifting cultivation.

(2) Plots falling in actual cultivation (crop land)

Out of 70 plots falling in shifting cultivation, 52 were classified as 'regrowth' and 18 plots as 'actual cultivation' (crop land).

On the basis of plot photointerpretation 11417 ha. of forest area, which is about 15.6% of the total geographical area or 18.7% of the total forest area in 65 G/14 sheet, is affected by shifting cultivation Out of 11417 ha. forest area affected by shifting cultivation only an area of 2936 ha. or 25.7% was actually under cultivation (crop land) during the season of photography, the remaining 8481 ha. being abandoned shifting cultivation, was occupied by coppice regrowth. It shows that out of about 4 hectares forest area affected by shifting cultivation, only one hectare area is actually used for growing agricultural crops. In other words 4 hectares of forest area is destroyed for one hectare of subsistence agriculture. Therefore, shifting cultivation is a very wasteful system and earlier it is stopped better it is both for forest and agriculture.

17 VOLUME ESTIMATES BASED ON COMBINED GROUND AND PHOTO DATA:

On the ground systematic cluster sampling was used. The survey area was divided into regular grids, each of 2½' longitude and 2½' latitude on one inch topo maps. In each grip a cluster of two plots was systematically laid out with the centre of first plot coinciding with the grid centre and second plot located 400 m. eastwards from the centre of the first plot. Both plots were square in shape with an area of 0.1 ha. each, resulting in sampling intensity of about 0.01%. Due to non-availability of aerial photographs in time, pre-stratification could not be done and hence the samples in various strata were not independently distributed on the principles of optimum allocation. However, post-stratification was attempted for analysis of data.

The ground inventory data was analysed taking the stratum area from photo interpretation and volume/ha. information in each stratum from ground plots. The ground plot layout was superimposed on photo-interpretation maps and each ground plot was classified into one of the photo strata. Average volume per hectare in each stratum was then calculated on the basis of ground plots information.

Table - 9 gives necessary information on sampling error in estimating volume per hectare and total volume from ground data alone as well as from combined photo and ground method.

TABLE - 9.

Sampling error in Estimating Volume/Ha. and Total Volume

Stratum	Vol./ha in m^3		Area in Ha.		Total volume in $1000m^3$	Total Volume		Relative Precision
	Mean based on ground plots	SE%	Photo data	SE% if calculated from ground data alone		SE% ground data alone	SE% Photo and ground data combined	
1. High Vol. Forest	98.6	3.9	319159	6.4	31475.4	7.5	3.9	.27
2. Medium Vol. Forest	70.9	5.1	212893	8.4	15104.0	9.8	5.1	.26
3. Low Vol. Forest	48.3	7.1	122709	10.8	5928.0	12.9	7.1	.30
4. Plantations	27.2	24.4	7467	45.7	203.4	51.8	24.4	.22
5. Shifting Cultivation	19.0	24.4	60456	17.8	1146.8	30.2	24.4	.65
6. Blanks	24.2	25.7	41323	20.3	1001.4	32.6	25.7	.62
7. Cultivation and Habitation	12.2	16.3	268799	7.1	3303.1	17.8	16 3	.83

The relative precision given in the above table indicates that to get the same precision (as obtained from combined photo ground method) from ground sampling alone, we would need nearly four times the number of ground samples in High and Medium volume strata, and three times in Low Volume Strata.

In reality no stratification by volume class was done on the ground. Above results for ground data alone (Col. 3, 5 and 7) have been calculated assuming that field crews would have done the same stratification on ground as was done on aerial photographs. This is not strictly true.

The main point brought about by Table -9 is the high variance in estimating the stratum area by ground sampling alone Taking ground survey alone, errors associated with area are much higher for various volume strata compared to that of volume/ha. A lesser variance in estimating volume/ha. would not substantially alter the precision of total volume estimate. The main contribution of photo-interpretation lies in making error in area estimation very small. Following important conclusion can be drawn

Stratification from ground data may result in less variance so far as estimation of volume/ha. by strata is concerned, but estimation of stratum area is associated with high variance Therefore, estimation of total volume by strata from ground data alone is subject to high sampling error Use of aerial photographs with low intensity ground sampling results in significant gains It may, however, be remembered that this gain in precision is in addition to the landuse and forest cover type maps, which are important by-products of photointerpretation . Such maps

cannot be prepared with ground plot data alone.

18. TIME AND COST FOR PHOTO INTERPRETATION, PREPARATION OF LANDUSE AND FOREST COVER TYPE MAPS, AND AREA CALCULATION FOR THE PROJECT AREA:

The details of time and cost involved in photo-interpretation, transfer of details on base maps, area calculation of landuse and forest cover types and preparing traces and Kodaline prints of stock maps on 1 : 63,360 scale for the entire project area of 10,416 sq km. are given below The number of 1" sheets involved is 16. The prints of existing aerial photography on 1 : 60,000 scale with a format size of 23 x 23 cm. were used for photointerpretation.

18.1. Time Required For Photo-Interpretation:

18 11.	Total number of photographs covering the project area of 10,416 sq. km	300
18.12.	Average number of photographs interpreted per day per man.	3
18 13	Number of man-days required to interpret 300 photos covering the project area including Sundays and holidays	140
18.14.	Number of man-days required for field checks of photointerpretation including Sundays, Holidays etc.	100
	Total:	240

18.2. Time Required For Transfer Of Details From Photos To Base Maps and Area Calculation

18.21.	Number of man-days including 70 Sundays and holidays required for transfer of interpreted details on to 1" = 1 mile (1 : 63,360) scale topo maps	160

18.22.	Number of man-days required for area calculation of different landuse and forest strata by 5' x 5' grid including 80 holidays and sundays	320
	Total ..	400

18 3. Cost Of Aerial Photointerpretation, Area Calculation & Mapping:

18 31.	Cost of aerial photography on 1 : 60,000 scale for the entire project area	Rs 63,000
18.32. /man	Cost of photointerpretation (i e pay and allowances of one interpreter @ Rs. 450/- p m.) for 240/days or say 8 man-months	Rs 3,600
18.33	Cost of transfer of interpreted details on to base maps and area calculation (i e pay and allowances of one Surveyor @ Rs 250/- p.m.) for 480 man-days or say 16 man-months	Rs 4,000
18.34.	Cost of fair drawing, tracing paper, Kodaline prints, ammonia rolls and over-head charges.	Rs 9,400
	Total:	Rs 80,000

18.4: Summary Of Time And Cost:

18.41. The time required for photointerpretation, transfer of details on base maps, area calculation and mapping for an area of 10,416 sq. km is 720 man-days i.e. 7 man-days per 100 sq km area.

18.42. The cost of aerial photography and all other operations (excluding cost of ground sampling) is Rs 80,000/- for the entire project area of 10,416 sq. km which comes to Rs 768/- per 100 sq. km. or Rs. 8/- per sq. km.

19 CONCLUSIONS AND RECOMMENDATION

Identification of individual species even on large scale photographs (1 : 10,000 to 1 : 20,000) in these mixed miscellaneous forests, comprising hundreds of species, is rather doubtful. Teak and Sal (Shorea robusta) are practically absent and no other species is found in gregarious stands Identification of bamboo, atleast wherever it is common, is possible on such large scale photographs taken in proper season. For preinvestment survey of forest resources small scale photographs on 1 : 40,000 scale, taken with modern precision camera and 6" focal length lens in suitable season, appear to be more suitable Small scale photographs afford a relatively much wider view of the terrain and vegetation conditions and only a small number of photographs is involved Transfer of interpreted details on 1 : 50,000 or 1" map is also facilitated.

Broad landuse classes and main forest cover types (condition classes) can be easily interpreted on good quality 1 : 40,000 scale photographs. The forest can be further classified in three to four density classes, three broad volume strata and three site conditions Height estimation is of course difficult It is also not possible to identify bamboo on such small scale photographs Various forest cover types such as good site forest, poor site forest, degraded forests, plantation areas, shifting cultivation, blanks and grasslands etc. can be identified on such small scale photographs Even for location of plots on the ground, such small scale photographs are useful

The optimum season for aerial photography appears to be December-January, when one can distinguish between moist, evergreen and dry deciduous forests

Aerial and ground reconnaissance of the area by the photointerpreters to check their interpretation is of great value in increasing overall accuracy of interpretation. Model stereograms also proved useful in interpretation.

The location of Photo and Mapping Section and 70 Forest Survey Party at Dehradun was found to be of great advantage for quick transfer of interpreted details on base maps, area calculation and printing of maps It would be ideal if both these offices are located in one building for a better coordination of all interpretation and mapping work.

APPENDIX - I

Distribution of Forested Area by Crown Density and Volume Classes
East Godavari (In Hectares)

Source: Photointerpretation 100%

1:- Map Sheet Number	Crown Density Classes															Total
	5-20%			20-40%			40-60%			60-80%			80% +			
	Volume Classes															
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	
65 G/3	1080	-	-	5831	4009	-	-	14653	300	-	861	10696	-	114	847	38391
65 G/5	425	-	-	1162	24	-	-	1279	-	-	-	2747	-	-	853	6490
65 G/6	2282	-	-	3299	148	-	356	4515	-	-	617	19811	-	291	4942	36261
65 G/7	572	-	-	3691	460	-	-	9142	-	-	305	41354	-	-	1402	56926
65 G/9	603	-	-	2830	1100	-	330	4932	-	-	946	12294	-	-	1028	23863
65 G/10	178	42	-	1922	141	-	467	8359	570	-	1472	39544	-	-	12165	63330
65 G/11	2358	-	-	6086	2462	-	16	13939	1309	-	349	19899	-	-	1473	44891
65 G/13	907	-	-	4862	85	-	3304	10417	408	43	7872	11428	-	-	6212	45536
65 G/14	469	-	-	7135	1923	-	760	11345	198	159	1815	14525	-	43	9912	48284
65 G/15	1711	-	-	8079	538	-	311	6933	382	-	659	3181	-	-	-	21794
65 K/1	657	-	-	3955	147	-	698	9881	451	-	4664	24370	-	-	16300	61123
65 K/2	2264	-	-	10792	187	-	1796	14911	-	-	1379	14508	-	-	2963	48152
65 K/3	2464	-	-	7078	1934	-	834	14406	145	-	209	7039	-	-	149	34258
65 K/5	1590	-	-	5776	987	-	494	13425	357	-	1751	14590	-	-	3842	42336
65 K/8	4727	-	-	9150	-	-	1356	11677	-	-	78	13340	-	-	2358	43347
65 K/9	1303	-	-	5957	7691	-	875	1712	-	-	-	5769	-	-	-	38719
Total:	23550	42	-	87350	21816	-	11597	166948	4120	202	23639	250093	-	448	64926	651761
Plantations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7467
Shifting Cultivation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60456
Grand Total																723684

Note:- Volume Class I = 15 -50 m^3/ha.
Volume Class II = 50 - 100 m^3/ha
Volume Class III = 100 + m^3/ha

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