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GOVERNMENT OF INDIA

MINISTRY OF AGRICULTURE & IRRIGATION
DEPTT. OF AGRICULTURE

REPORT ON PREINVESTMENT SURVEY OF FOREST RESOURCES IN CENTRAL AND EASTERN BHUTAN

VOLUME II

METHODOLOGY

PREINVESTMENT SURVEY OF FOREST RESOURCES
DEHRA DUN
~~1979~~
1980

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REPORT ON PREINVESTMENT SURVEY OF FOREST RESOURCES IN CENTRAL AND EASTERN BHUTAN

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INTRODUCTION

This Volume II, as in Phase I Report, explains the details of methodology for investigations and studies, carried out to collect the data and arrive at the results presented in Volume I of this Report.

The basic techniques remain the same as in Phase I Report. The design for survey in Phase II & III was modified to get a better 'scatter' of samples in the area. '2-point sample' clusters were spaced 3 x 3 km as against '8-point sample' cluster spaced 6 x 6 km in Phase I. Based on experience of the first survey in Bhutan for this survey, more vegetation classes were differentiated; stocking, slope and attitude classes were eleborated; soil texture and other characteristics were studied; data for accessibility was collected; stock mapping was done during inventory studies and incidence of grazing and fire incidence determined. These studies were not done in Phase I Survey. 78 tree species were codified for Phase II & III as against 36 species differentiated in Phase I. All these sophistication of studies were based on the experience gained after Phase I Survey in Bhutan.

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All details of inventory field work, volume cull studies, photointerpretation, data processing have been given in this Volume. In addition, the techniques for Market and Demand Studies, with proformae and questionnaire have been reproduced so that data is appreciated in proper prospective and further surveys can be planned on similar lines.

Illustrations and diagrams have been given to understand the text better.

It is hoped that this Volume will enable the readers to understand and appreciate technical aspects of Volume I in a comprehensive manner.

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Guest House,
THIMPHU, BHUTAN

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Project Director
Preinvestment Survey of Forest
Resources in Bhutan

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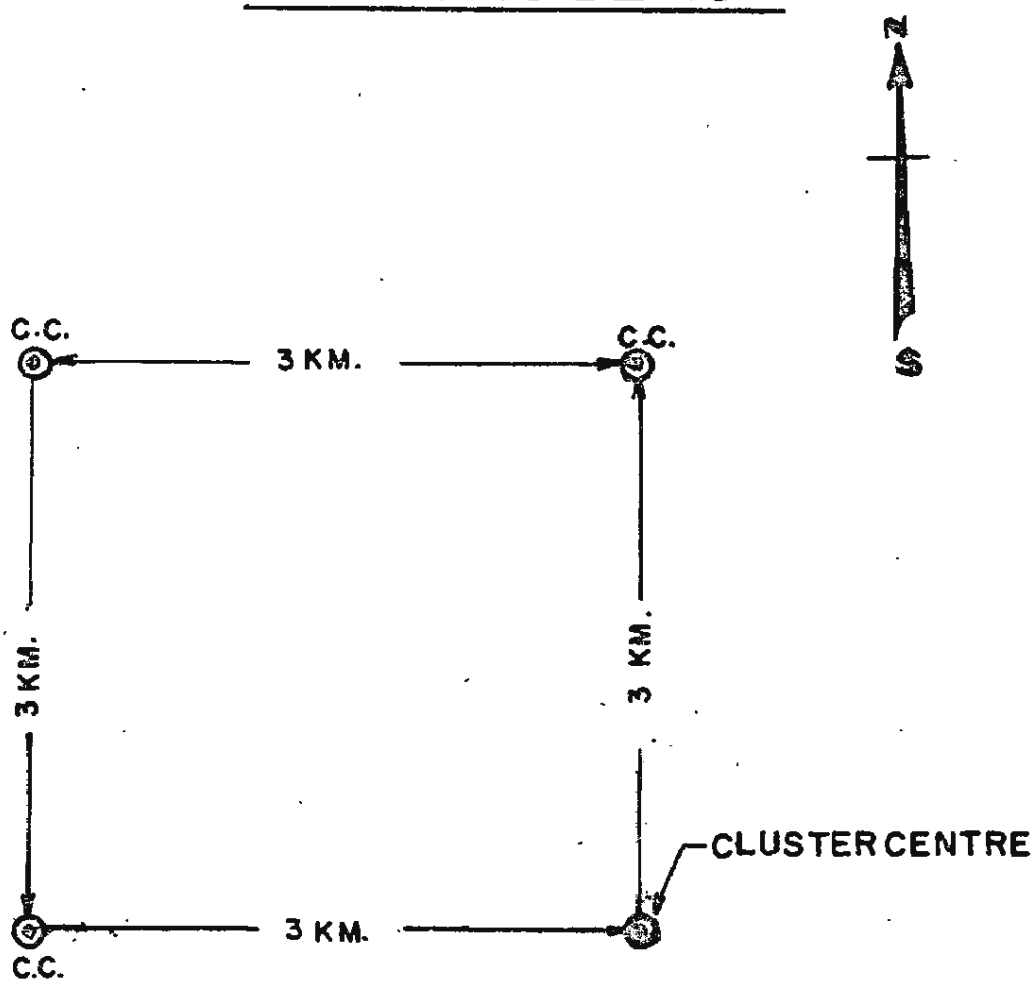

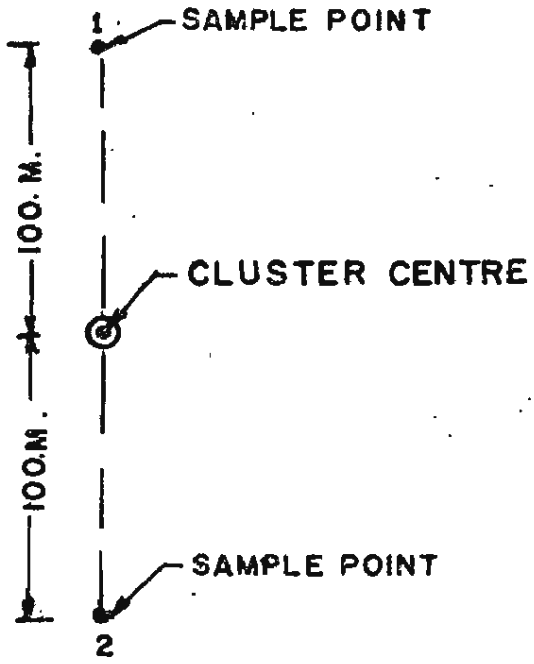

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CHAPTER - I

INVENTORY

1.1.1 SAMPLING DESIGN

To decide the sampling intensity and design to be followed for the survey area, 107 random samples were drawn spread over the entire area in different forest strata.

1.1.2 From the analysis of data carried out in the Data Processing Unit, Dehradun, it was found that about 330 clusters of two sample points would be sufficient to achieve the precision of ± 10% error for total growing stock at 95% probability level.

1.1.3 On the basis of experience gained in Phase I survey and the trial sampling carried out in Phase II area, it was decided to slightly modify the Phase I sampling design for Phase II & III. Two point single cluster sampling, by spacing the clusters 3 km x 3 km, was considered more suitable and adopted for the survey. Each cluster had two sample points, situated at 100 m. from cluster centre, in North-South direction as depicted in the diagram on the facing page.

1.2.1 SAMPLING CLUSTERS AND POINTS

The cluster centres were marked on 1:50,000 grided map sheets with a random start and identified by serial numbers and grid references of the map sheet.

1.2.2 The following table gives the distribution of clusters and sample points over the entire survey area by catchments:

Catchment	No. of clusters	No. of sample points (inside survey area)
Sankosh	114	228
Ai Chu	74	148
Mangdechu (Tongsa)	333	666
Bhumthang	241	482
Kuru Chu	139	278
Gamri or Dangme	140	280
Manas	128	256
Nyera Ama	60	120
Total	1229	2458

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1.2.3 Since systematic sampling design was adopted, the representation of each sample point is approximately proportionate to the geographical area under different catchments. Distribution of sampling clusters in the survey area is shown in two diagrams on the facing page. The sampling cluster and points were transferred on to aerial photographs for facilitating location.

1.2.4 Out of a total of 2458 sample points inside the survey area, 1401 points falling in forests were actually visited and complete data, collected and vicinity of 131 forested points was visited. In addition, 497 sample points falling under habitation, cultivation, barren land and pasture etc. were also visited to check if any changes have taken place from the time when photography was carried out. 429 forested sample points could not be visited due to inaccessibility.

1.3.1 FIELD PROCEDURE

8 Crews were deployed for carrying out inventory work. The Crews were led by Junior Technical Assistants having long experience of inventory work in the Himalayan region. Each Crew Leader was assisted by one Dy. Ranger and 3 trained Fieldmen.

1.3.2 The sampling clusters were located on the ground with the help of topographic map sheets and aerial photograph by following the traversing procedure. An accurate record of the approach followed by the Crew for locating the sample points, by giving proper references on prominent trees and other objects was kept. This was to enable the check crew to locate the sample point.

1.3.3 Field Forms: The Crews collected inventory data at each sample point in the following field forms:

1). Plot Description Form - BHI-1
2). Tally Sheet (Live Tree) - BHI-2
3). Tally Sheet (Dead Tree) - BHI-3
4). Sample Tree Form - BHI-4

1.3.4 Instruments: The modern instruments like Spiegal Relascope, Blume Leiss Hypsometer, Silva Compass, Pressler's Borer etc. were used for measurements and data collection.

1.3.5 Detailed instructions issued to the Crew Leader for filling up the codified data in various field forms were contained in a Field Manual. The important technical details of the methodology adopted are given in the following paragraph.

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INDEX MAP SHOWING CLUSTER CENTRES

PHASE II

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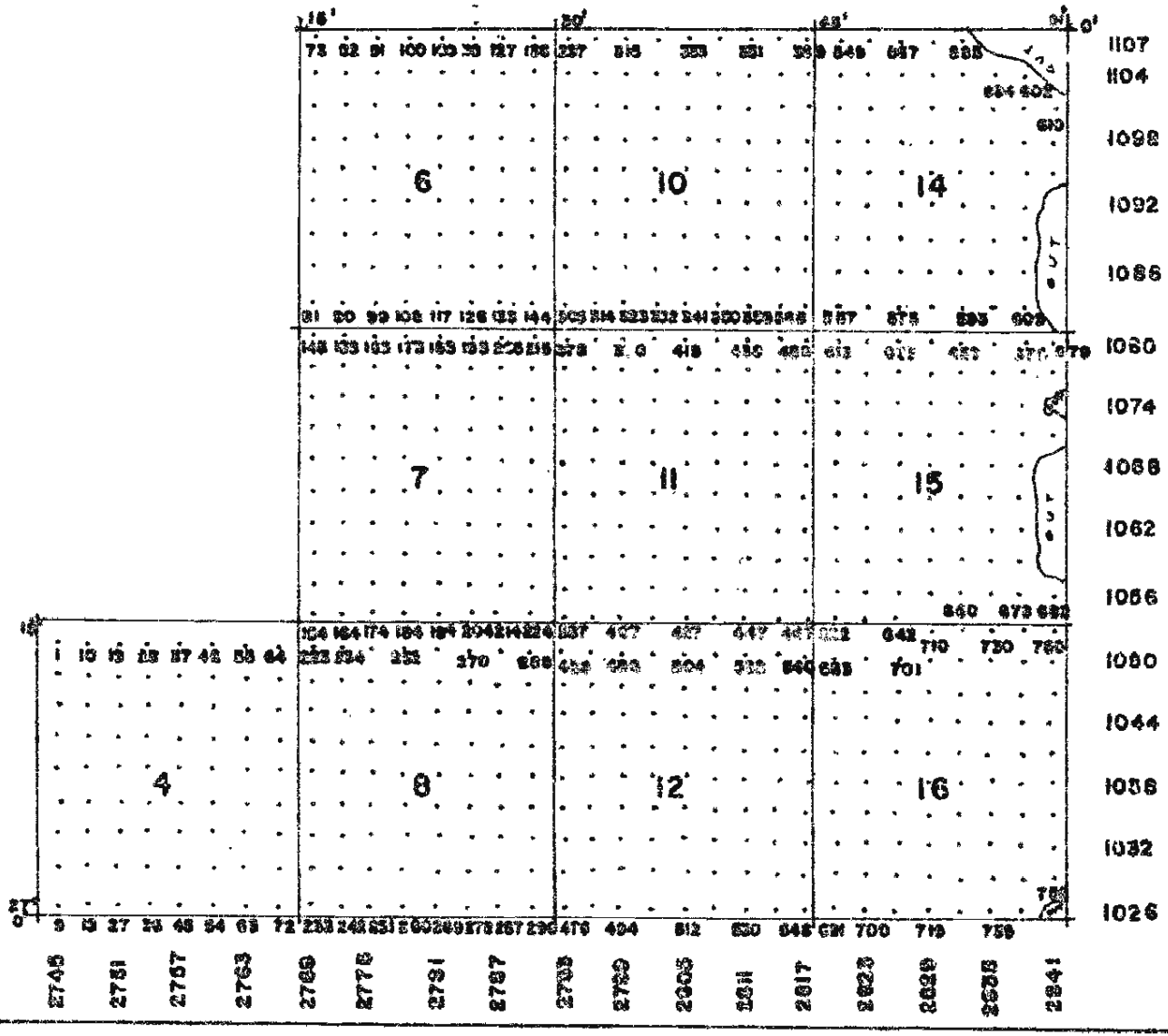

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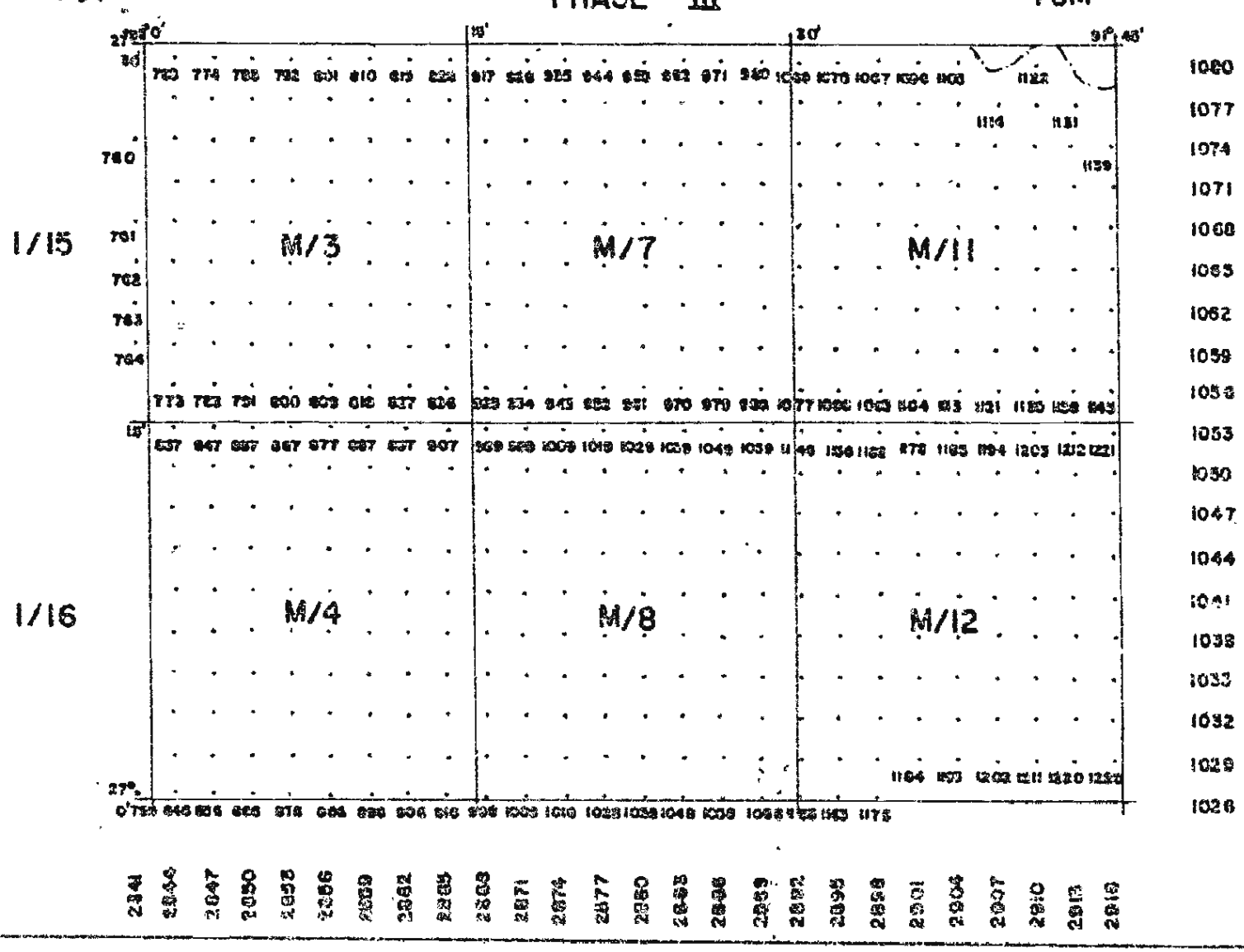
PREINVESTMENT SURVEY OF FOREST RESOURCES IN BHUTAN

INDEX MAP SHOWING CLUSTER CENTRES

PHASE - III



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1.4.1 PLOT DESCRIPTION FORM: A specimen form is given at page No. 4. The instructions for filling up this form are given below:

Item No.	Col.No.	Code	Instructions
1	1-3	JOB	) Leave these columns blank (to be filled by Data Processing Unit).
2	4-5	CARD DESIGN	
3	6-7	REPORT NO.	
4	8	SUB REPORT NO.	
5	9-10		CREW LEADER: The appropriate Code No. of Crew Leader should be entered.

The following general instructions should be noted for filling up Col. 15 to 18, 32-41 and 47-61:

(i) If point classification (Col. 11) is 2, Col. 15 will be filled up with the help of photo classification and Col. 47-50 will be filled up with the help of map in the office.

(ii) If Col. 11 is having Code 3, Col. 15-16 will be filled up from photo classification and so also Col. 17-18 if not already filled up in the field. Col. 47-61 will be filled up from the map.

(iii) If Code in Col. 11 is 4, Col. 41 (regeneration) will not be filled up even if the sample point has actually been visited and only tally could not be taken.

(iv) If Code in Col.16 is 4, Col. 32-40 will not be filled up.

(v) If Code in Col. 33 is 1, Col. 32 and 34-40 will not be filled up. Put (-) in these columns.

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PLOT DESCRIPTION FORM

PREINVESTMENT SURVEY OF FOREST RESOURCES (BHUTAN)

PHASE II-BHI.I

Job	Card Design	Report No.	Sub Rep. No.	Crew Leader
1-3	4-5	6-7	8	9-10

Cluster centre Grid Reference.	Cluster No.	Inventory Design.
67-74	75-78	79-80

Name of C.L.

Date of Survey:

Plot classification	Forest Division	Catchment	Land class	Vegetation	Forest Type	SPECIES STOCKING IN FOREST: Species	%	Species	%	Species	%	%	CROP DATA: No. of storeys	Size class	Top Height	Top D.B.H.(O.B.)	Spacing	Crown Density	Regeneration	SOIL DATA: Leaf litter	Humus	Depth	Texture	Stoniness	TERRAIN DATA: Altitude	Slope	Aspect	ACCESSIBILITY DATA: Distance to road	Distance to mule path	Distance to river/stream	Katcha road distance to market outlet	Pucca road distance to market outlet	River distance to market outlet	Grazing incidence	Fire incidence	Map sheet No.	Plot No.
11	12	13-14	15	16	17 18	19-21	22	23-25	26	27-29	30	31	32	33	34-35	36-38	39	40	41	42	43	44	45	46	47	48-49	50	51	52	53	54-55	56-58	59-61	62	63	64 65	66

Contents

Specific instructions for filling up Columns 11 to 80 are as follows:

Item No.	Col.No.	Code	Instructions
6	11		POINT CLASSIFICATION: Write the appropriate Code depending upon the classification given as under:
		1	Sample point falls outside the survey area.
		2	Sample point rejected by aerial reconnaissance or by the study of map or aerial photographs. These are the non-forested points.
		3	Forested or non-forested sample point which could not be approached due to inaccessibility.
		4	Forested or non-forested Sample point whose vicinity visited but tally and other measurements could not be taken. All Cols. in PDF are filled up except the regeneration Column in case of forested sample points. It will include points visited where tally could not be taken due to sudden fall or any other obstruction.
		5	Sample point visited and all data collected. This includes all visited Sample points whether forested or non-forested.
		6	Sample points lying on gaps for which maps and/or photographs are not available.
7	12		FOREST DIVISION: Write the Code of the Forest Division in which the Sample point lies.
		1	Thimphu
		2	Samchi

Item No.	Col.No.	Code	Instructions
		3	Sarbhang
		4	Samdrup Jongkhar
8	13-14		CATCHMENT: Write the appropriate Code of the catchment.
			05 Sankosh
			06 Mangde chu
			07 Bumthang
			08 Ai Chu
			09 Kuru chu
			10 Gamri or Dangme
			11 Manas
			12 Nyera Ama
9	15		LAND CLASS: Consider the present land use of the area represented by the Sample point and classify in one of the appropriate land classes given below. The minimum area to be reckoned for this purpose is 2 ha. around the Sample point.
		1	Forest land
		2	Cultivation and habitation
		3	Alpine pastures and scrubs
		4	Snow covered land
		5	Barren land
		6	Water spreads
		7	Other lands

Contents

Item No.	Col.No.	Code	Instructions

The following definitions of the above referred classes will help in determining the land class of the Sample point:

1 Forest Land: It includes all lands with forest cover whether natural or man made. The following categories of land also come under this class.

(a) Temporarily understocked or unstocked areas e.g. recently worked forests yet to be restocked.

(b) Young natural regenration and forest plantations at any stage of growth.

(c) Bamboo bearing areas either in pure form or in mixture with other species.

(d) Land surface covered with degraded forests containing stunted and/or scattered tree growth and scrubs.

(e) Roads passing through forests, forest nurseries and other establishments, small streams, small grassy blanks and open areas (upto 2 ha.) which constitute an integral part of the forest.

(f) Abandoned shifting cultivation with or without regrowth of trees. Isolated tree groups smaller than 2 ha falling in habitation and cultivation areas will be excluded.

Contents

Item No.	Col.No.	Code	Instructions
		2	Cultivation and habitation: Land primarily used for agricultural purposes including horticulture and fallow lands with or without scattered tree growth. Current shifting cultivation will be classified as cultivation. Cultivation would also include plantation raised for non-forestry purposes by any public or private agency mainly for raising crops of commercial importance e.g. Apple, Plum, Orange, Peach, Cardamom etc. Areas set aside mainly for residential and industrial purposes, both for civil and defence e.g. villages, towns, cities, factories and defence establishments etc. shall be classified as habitation. Habitations will also include air strips and roads etc.
		3	Alpine pastures and scrubs: This includes grassy blanks in temperate region above 3000 m elevation. These may or may not have scattered tree growth and may or may not be surrounded by forests. In case the alpine pastures are surrounded by forests and are smaller than 2 ha in extent these should be classified as forests. Areas covered by scrub vegetation in the alpine zone will be included in this category (e.g. dwarf rhododendrons and straggling junipers).
		4	Snow covered land: Areas above the tree line which are more or less covered with snow through out the year. Areas getting seasonal snow cover are not included in this class.

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Item No.	Col.No.	Code	Instructions
		5	Barren land: Lands covered with exposed rocky overlays, precipitous slopes and over hanging cliffs, ridge tops etc., where vegetation growth is absent due to adverse climatic, edaphic or biotic conditions will be classified under this category. Normally, productive soil cover is missing from such sites.
		6	Water spreads: Area of land covered permanently or seasonally with water such as lakes, reservoirs, tanks and ponds of more than 2 ha, rivers and streams with a bed of 100 m or more in average width shall be classified as water spreads.
		7	Other lands: Land not included under any of the above categories will be classified under this class.
10	16		VEGETATION: This column is to be filled up only for those sample points that have been classified as Forest Land under the land class Column. Observe the growth in the locality to an extent of 2 ha or more and classify it in one of the following classes:
		1	Natural forest: Areas having natural vegetation cover of more than 20% crown density used primarily for the purposes of forestry shall be put under this class. This will include:
			(a) temporarily understocked or unstocked areas due to clear cutting, regeneration felling or burning;
			(b) young natural regeneration;

Item No.	Col.No.	Code	Instructions
			(c) bamboo bearing areas either in pure form or mixture with other species and
			(d) roads passing through forests, forest nurseries, small streams, small open areas or grassy blanks (less than 2 ha.) which constitute an integral part of forest.
		2	Man Made forests: All plantations primarily used for forestry purposes at any stage of growth are included in this category.
		3	Degraded forests: Forest land badly degraded due to biotic influences such as grazing, lopping, indiscriminate felling, repeated fire etc. Scattered malformed trees may be present, crown density of trees is generally less than 40%, foot paths and grazing trails are commonly noticed. Such areas occur mostly near habitation and are easily accessible. Shifting cultivation with poor re-growth may also be classified in this category.
		4	Low Land scrubs: This includes areas having mostly scrubs, bushes and grasses almost devoid of trees and occuring mainly on poor sites. Soil erosion may be present. Foot paths and grazing trails are commonly noticed. This will not include the scrubs occuring in alpine zone above 3000 m elevation.

Contents

Item No.	Col.No.	Code	Instructions
11	17-18		FOREST TYPE: Observe an area of 2 ha around the sample point and classify the crop into one of the following forest types:
		01	Chir pine
		02	Blue pine
		03	Fir-spruce
		04	Hemlock
		05	Larch
		06	Juniper
		07	Mixed conifers
		08	Conifers mixed with broad leaved species
		09	Upland hardwoods (broad leaved)
		10	Oaks
		11	Low land hardwoods (broad leaved)
		12	Sal
			If the proportion of a species is 50% or more of the crop, it will form its own forest type. In case of mixed conifers, the proportion of conifers should be more than 50% of the total crop. When the conifers and broad leaved species occur in more or less same proportion, it should be classed under conifers mixed with broad leaved species type. Broad leaved species found below the elevation of 1200 m shall be categorised under Forest Type No. 11 or 12. Similarly, broad leaved species found above 1200 m altitude shall be classed under Forest Type No. 09 & 10.

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Item No.	Col.No.	Code	Instructions
12	19-31		SPECIES STOCKING IN FOREST: Write the appropriate code of species and percentage code in the columns provided for each. For filling up these Columns, observe the forest in at least 2 ha around the sample point in the forest type in which point lies and occularly assess the composition of tree species present. Columns are provided for recording the percentage of three species in order of the percentage of their occurrence starting with the species that constitutes the highest percentage of the crop. If there are more than three species, group the remaining ones under the category of "rest of the species" and give their percentage in Col. No.31. No species Code Column is provided for this item. If the number of species is less than three, write "000" in the unused species Code Columns and '0' in the percentage Column. The percentage Codes will be as under:
		1	Less than 20%
		2	20% to less than 30%
		3	30% to less than 40%
		4	40% to less than 50%
		5	50% to less than 60%
		6	60% to less than 70%
		7	70% to less than 80%
		8	80% to less than 90%
		9	Equal to or more than 90%

Item No.	Col.No.	Code	Instructions
			Write the code for stocking percentage for species indicated in Cols. 19-21, 23-25 & 27-29; in Cols. 22, 26 & 30 respectively. In Col. No. 31, write the stocking percentage code for species grouped as "rest of the species".
13	32		NUMBER OF STOREYS: Observe the forest around the point in an area of 2 ha or more and find out the vertical distribution of heights of trees. If it is possible to see distinct layers of forests at different heights formed by the tree crowns, classify the forest in the following categories:
		1	Single storeyed forest: Where all the trees are more or less of the same height forming single canopy. A small variation of height may exist in this case.
		2	Two storeyed forest: Where variation in heights is such that the crop shows two distinct canopies at two different heights.
		3	Multi-storeyed forest: Where more than 2 storeys or canopies forming different layers of crown are distinctly visible. In coniferous zones such forests are generally not met with.
			Note: Scrubs should not be considered as separate story.

Item No.	Col.No.	Code	Instructions
14	33		SIZE CLASS: In about 2 ha area around the Sample point, observe the most prevalent diameter class of the species constituting the forest type in which the Sample point falls. Measure the diameters of about 10 trees representing the average size of the main species and classify the crop as follows:
		1	Less than 5 cm
		2	5 cm to less than 20 cm
		3	20 cm to less than 30 cm
		4	30 cm to less than 40 cm
		5	40 cm to less than 50 cm
		6	50 cm to less than 60 cm
		7	60 cm to less than 70 cm
		8	70 cm to less than 80 cm
		9	80 cm and above
15	34-35		TOP HEIGHT: Select a minimum of three dominant trees from the top canopy of the main species of the forest type in which Sample point lies and measure their heights. Average out the heights and record to the nearest metre.
16	36-38		TOP DIAMETER: The dbh (ob) of the trees selected for top height measurement should be measured, averaged and recorded to the nearest cm.

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Item No.	Col.No.	Code	Instructions
17	39		SPACING: Measure spacing of ten trees representing top canopy in the vicinity of the sample point within the forest type in which the point lies and calculate the average spacing. Record it in one of the following classes:
		1	Less than 1.5 m
		2	1.5 to less than 3.0 m
		3	3.0 to less than 4.5 m
		4	4.5 to less than 6.0 m
		5	6.0 to less than 7.5 m
		6	7.5 to less than 9.0 m
		7	9.0 to less than 10.5 m
		8	10.5 to less than 12.0 m
		9	12.0 metres and above
18	40		CROWN DENSITY: The crown density indicates the degree of closeness of the tree crowns. As the openness of the crown increases, the density decreases. Examine the crown density of the crop represented by the sample point and record one of the following Codes:
		1	Less than 0.2 (20%)
		2	0.2 (20%) to less than 0.4 (40%)
		3	0.4 (40%) to less than 0.6 (60%)
		4	0.6 (60%) to less than00.8 (80%)
		5	0.8 (80%) and above

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Item No.	Col.No.	Code	Instructions
19	41		REGENERATION: All seedlings and saplings of less than 5 cm in dbh (ob) of commercial tree species are to be considered as regeneration. Draw a circle of 2 metre radius around the sample point and count the number of seedlings and put the appropriate Code.
		1	Profuse - 15 and more
		2	Adequate - 8 to less than 15
		3	Scanty - 1 to less than 8
		4	Nil
20	42		LEAF LITTER: Select a site near the plot centre which is not disturbed by the Crew during its work. A pit of 30 cm depth or more will be dug at this site for collection of soil data. The undecomposed leaves, needles and twigs on the forest floor are known as leaf litter. Measure the thickness of leaf litter and record one of the Codes given below:
		1	Leaf litter absent
		2	Less than 2 cm
		3	2 to less than 5 cm
		4	5 cm or more
21	43		HUMUS: Humus is the decomposed leaf litter or organic matter forming the top horizon of the soil. In case leaf litter is present, remove the same after recording its measurement and dig the soil slightly to measure the depth of humus. Care should

Contents

Item No.	Col.No.	Code	Instructions
			be taken to differentiate humus from dark coloured mineral soil and leaf litter. Depending upon the thickness of humus, the Codes will be as follows:
		1	Humus absent
		2	Less than 2 cm
		3	2 cm to less than 5 cm
		4	5 cm or more
22	44		SOIL DEPTH: The pit for measuring soil depth should be dug upto 30 cm depth or upto the parent rock, whichever is less. Measure the depth of mineral soil and record with one of the Codes given below:
		1	No soil (when rock surface is exposed or only boulders/ pebbles are present upto a depth of 30 cm)
		2	Less than 5 cm
		3	5 to less than 10 cm
		4	10 to less than 20 cm
		5	20 to less than 30 cm
		6	30 cm or more
23	45		SOIL TEXTURE: Texture refers to the size of soil particles. For determining the texture examine soil below the humus layer (when present). Soil particles should be felt between the fingers. Classify the texture in one of the following Codes:

Contents

Item No.	Col.No.	Code	Instructions
		1	Clayey
		2	Clayey loam
		3	Loam
		4	Sandy loam
		5	Sandy
		6	Pebbles
		7	No soil
24	46		STONINESS: Observe the area of about 2 ha around the Sample point and consider the extent of rocks/boulders greater than 25 cm in diameter. Any thing less than 25 cm in dia. weighs less than about 40 kg and can easily be moved manually. Classify the Sample point in one of the following classes and write the appropriate Code.
		1	Stones/boulders are absent
		2	Less than 30% of the land surface is covered with stones/boulders.
		3	30% to 60% of the land surface is covered with stones/boulders.
		4	More than 60% of the land surface is covered with stones/boulders.

TERRAIN DATA: Terrain refers to the altitude, slope, aspect and the accessibility. This data is to be read, measured on ground and calculated with the help of 1:50,000 maps and/or photographs of the area and recorded as follows:

Item No.	Col.No.	Code	Instructions
25	47		ALTITUDE: Altitude of the Sample point shall be coded into one of the following classes depending on its elevation from Mean Sea Level as read from 1:50,000 maps.
		1	0 to less than 500 m above msl
		2	500 to less than 1000 m above msl
		3	1000 to less than 1500 m above msl
		4	1500 to less than 2000 m above msl
		5	2000 to less than 2500 m above msl
		6	2500 to less than 3000 m above msl
		7	3000 to less than 3500 m above msl
		8	3500 to less than 4000 m above msl
		9	4000 m and above
26	48-49		SLOPE: Measure the slope in degrees with an angle measuring instrument, uphill and downhill, over as long a stretch as possible. Take the average of the two slopes and record as per the Codes given against each range of slope. Also cross check with the slope as calculated from the map.
		01	0 to less than 5°
		02	5° to less than 10°
		03	10° to less than 20°
		04	20° to less than 30°
		05	30° to less than 40°
		06	40° to less than 45°
		07	45° to less than 50°

Contents

Item No.	Col.No.	Code	Instructions
		08	50° to less than 55°
		09	55° to less than 60°
		10	60° to less than 65°
		11	65° to less than 70°
		12	70° to less than 75°
		13	Over 75°
27	50		ASPECT: Refer to the general direction of the slope in which the Sample point falls. For this purpose, study prominent features on the map and determine the general direction of the slope. With the help of compass, determine the aspect keeping in view the general direction of the slope as studied on the map. Aspect should be recorded in one of the following classes:
		1	North
		2	North-East
		3	East
		4	South-East
		5	South
		6	South-West
		7	West
		8	North-West
		9	None

ACCESSIBILITY: Accessibility refers to the approachability of the Sample point from a motor road, mule path or a floatable river/stream within the same drainage in which the point falls. Measure the horizontal distance of the Sample point from the nearest motorable road, mule path or river on the map and record one of the following codes in Column Nos.51, 52 & 53.

Contents

Item No.	Col.No.	Code	Instructions
		1	Less than 1 km
		2	1 to less than 3 km
		3	3 to less than 5 km
		4	5 to less than 7 km
		5	7 to less than 10 km
		6	10 to less than 15 km
		7	more than 15 km
		8	Not applicable
28	51		DISTANCE TO ROAD: Distance to the nearest motorable road should be measured on the map sheet and appropriate Code as above should be recorded.
29	52		DISTANCE TO MULE PATH: Measure the hrizontal distance to the nearest mule path, bridle path or foot path with a minimum width of 2 metres and record the appropriate distance Code given above.
30	53		DISTANCE TO RIVER/STREAM: Measure the horizontal distance to the nearest perennial river/stream which are marked in blue colour on the maps and record appropriate Code. In hardwood forests Code No.8 ("not applicable") should be filled up.
31	54-58		ROAD DISTANCE TO MARKET OUT LET: The actual distance between the nearest road point from the cluster centre and the predetermined market outlet will be recorded in these Columns. In the first two Cols.(54-55), the truckable Kaccha road distance will be recorded in km.

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Item No.	Col.No.	Code	Instructions
			In the next three Columns (56 to 58), the pacca road distance between the nearest road point from the cluster centre and the market out-let will be recorded in km.
			Note: Col. 54-55 Kaccha road distance: Crew Leader will not fill up these Cols. but write the actual distance on the back of PDF. Nearest road points should be taken on the road in the catchment in which the cluster lies. The distance will be rounded off into 10 km classes. 15 will be 10 and 16 will be 20. Then the last digit will be struck off and the remaining two digits entered in this Col. Thus entries will be recorded in Code as under:

Distance in km	Entry to be recorded
15	01
83	08
126	13

32	59-61		RIVER DISTANCE TO MARKET OUTLET: The river distance between the nearest floatable point from the Sample point and the market outlet will be measured on the map and recorded in km. This information shall be filled up in the office.
33	62		GRAZING INCIDENCE: Observe an area of about 2 ha around the Sample point to find out whether the area has been subjected to grazing by domestic cattle including Yak. The following Codes should be given depending on the intensity of grazing -

Contents

Item No.	Col.No.	Code	Instructions
		1	Grazing absent
		2	Moderately grazed
		3	Heavily grazed
34	63		FIRE INCIDENCE: Make a general observation of the area to detect signs of fire incidence e.g. fire scars on trees, burnt stumps etc. Classify in the following Codes.
		1	No fire incidence
		2	Area subjected to occasional fires
		3	Area subjected to frequent fires
35	64-65		MAP SHEET NO: Give appropriate Code of map sheet in which Sample point falls. A list of map sheets with their Codes is given below:
		01	78 I/4
		02	78 I/6
		03	78 I/7
		04	78 I/8
		05	78 I/10
		06	78 I/11
		07	78 I/12
		08	78 I/14
		09	78 I/15
		10	78 I/16
		11	78 M/3

Contents

Item No.	Col.No.	Code	Instructions
		12	78 M/4
		13	78 M/7
		14	78 M/8
		15	78 M/11
		16	78 M/12
36	66		PLOT NO: Write the plot no. for which data is being collected.
37	67-74		CLUSTER CENTRE GRID REFERENCE (CCGR): Write the grid reference of the cluster centre.
38	75-78		CLUSTER NO: Give the serial No. of the cluster.
39	79-80		INVENTORY DESIGN: Leave the Columns blank to be filled up by Data Processing Unit.

1.5.1 Tally sheet: A specimen form is given at page No.25a & 25b . The instructions for filling up this form are given below:

1.5.2 The Tally sheet is required to be filled in only when the point classification is 5 and land class is forest and vegetation class is 1-3 (natural forests, man made forests and degraded forests).

1.5.3 Tally sheet is used to record the data of all the 'IN' trees which have been tallied with BAF-2.

1.5.4 The BHI-2 is used for recording the data of all live trees tallied 'IN' whereas the data for dead trees tallied 'IN' is to be recorded on BHI-3. The format of various items for which data is to be collected is same on both forms.

1.5.5 Data collection: Tally should be taken by standing at the Sample point by Relascope using BAF-2 starting from North and moving in clockwise direction in a full circle.

All live trees tallied 'IN' should be blazed and serially numbered in the same sequence in which tally is taken. Trees of less than 5 cm dbh (ob) should be ignored. However, the dead trees should be tallied and blazed. No serial number should be given to the dead trees.

Contents

TALLY SHEET (LIVE TREES)

PREINVESTMENT SURVEY OF FOREST RESOURCES (BHUTAN)

PHASE II

BHI-2

Job	Card Design	Report No.	Sub R. No.
1-3	4-5	6-7	8

Total No.of trees	S.P. No.	Cluster Centre Grid Ref.	Cluster No.	Inventory Design
64-65	66	67-74	75-78	79-80

Name of C.L.:

Date of Survey:

Species			Species			Species			Species			Species			Species		
Code	Dia.	Dia.	Code	Dia.	Dia.	Code	Dia.	Dia.	Code	Dia.	Dia.	Code	Dia.	Dia.	Code	Dia.	Dia.
9-11	12-14	15-17	18-20	21-23	24-26	27-29	30-32	33-35	36-38	39-41	42-44	45-47	48-50	51-53	54-56	57-59	60-62

Contents

TALLY SHEET (DEAD TREES)

PREINVESTMENT SURVEY OF
FOREST RESOURCES
(BHUTAN)

PHASE II BHI-3

Job	Card Design	Report No.	Sub.R. No.
1-3	4-5	6-7	8

Total No. of trees	S.P. No.	Cluster Centre Grid Ref.	Cluster No.	Inventory Design.
64-65	66	67-74	75-78	79-80

Name of C.L.:

Date of Survey:

Species			Species			Species			Species			Species			Species		
Code	Dia.	Dia.	Code	Dia.	Dia.	Code	Dia.	Dia.	Code	Dia.	Dia.	Code	Dia.	Dia.	Code	Dia.	Dia.
9-11	12-14	15-17	18-20	21-23	24-26	27-29	30-32	33-35	36-38	39-41	42-44	45-47	48-50	51-53	54-56	57-59	60-62

Contents

The species of tallied dead trees should be identified and diameters recorded separately on BHI-3. Identification of dead coniferous trees should not pose much problem. However, in case of broad leaved species, the trees may be classified as miscellaneous if correct identification is not possible.

While taking tally with Relascope, if there are any marginal trees, the diameter of the tree and its horizontal distance from the centre of the tree to the Sample Point should be measured in order to ascertain whether the tree is 'IN' or 'OUT'.

1.5.6 Diameter measurement: The dbh (ob) should be measured with calliper for all 'IN' trees. Two diameter measurements should be taken-first towards the Sample point and second perpendicular to the first diameter to the nearest centimetre. (round off 0.5 cm to nearest even number e.g. 11.5 will be 12 and 10.5 will be 10).

Note: (i) In hilly areas the bh point (1.37 m) from the ground level should be reckoned from the uphill side.

(ii) In case there is abnormality like swelling or hollowness etc. at the bh point, another point for measurement either little above or little below the actual breast height point should be taken.

(iii) In case a tree is forking below or at the bh point, each stem originating from the point of forking will be considered as a separate tree and each will be measured separately for diameter.

(iv) If the forking is just above the bh point and the breast height shows some abnormality on account of the effects of forking, the diameter should be measured at a point below the bh point.

(v) While taking bh diameter measurements, the arms of the calliper should be kept perpendicular to the axis of the trees. While measuring the diameter of the tree towards the Sample point, the longer arm of the calliper should be pointing towards the

Contents

Sample point, whereas while measuring the diameter in the direction perpendicular to the Sample point, the longer arm of the calliper should be pointing in the direction at right angle to the direction of the Sample point.

(vi) When due to the large diameter of the tree it is not possible to measure the diameter by calliper, measure the girth by tape in centimetre and multiply by 0.318 to get the diameter in centimetre. If the girth is 150 cm, then diameter will be 150 x 0.318 = 47.7 or 48 cm. This value should be recorded in both the dia-measurement Columns.

(vii) If the two diameters differ from each other by more than 50%, give reasons for variation. The percentage will be calculated with respect to lower diameter measurement.

(viii) In case of callied trees diameter measurements of which is not possible for one reason or another, the measurements should be recorded by occular estimate giving reasons in a foot note.

1.5.7 The following coding format should be followed for filling up data on both forms of Tally sheet.

Item No.	Col.No.	Code	Instructions
1	1-3	3	Job No. (leave it blank to be filled by Data Processing Unit).
22	4-5	2	Card design (-do-)
3	6-7	2	Report No. (-do-)
4	8	1	Sub Report No. (-do-)
5	9-11	3	Species Code
6	12-14	3	Diameter 1 in cm(towards P.C.)
7	15-17	3	Diameter 2 in cm (at right angle to dia 1)
8	18-20	3	Species Code

Item No.	Col.No.	Code	Instructions
9	21-23	3	Diameter 1 in cm
10	24-26	3	Diameter 2 in cm
11	27-29	3	Species Code
12	30-32	3	Diameter 1 in cm
13	33-35	3	Diameter 2 in cm
14	36-38	3	Species code
15	39-41	3	Diameter 1 in cm
16	42-44	3	Diameter 2 in cm
17	45-47	3	Species code
18	48-50	3	Diameter 1 in cm
19	51-53	3	Diameter 2 in cm
20	54-56	3	Species code
21	57-59	3	Diameter 1 in cm
22	60-62	3	Diameter 2 in cm
23	64-65	2	Total no. of trees in the tally.
24	66	1	Sample point number
25	67-74	8	Cluster centre Grid reference
26	75-78	4	Cluster No.
27	79-80	2	Inventory design(leave it blank to be filled by Data Processing Unit).

Note: If there is no tally, fill up only Column No 64 to 78 of BHI -2 and BHI-3. In such cases write "00" in Column 64-65.

1.6.1 Sample Tree Form: A specimen form is given at page No. 30. The instructions for filling up this form are given below:

1.6.2 The sample tree form is to be filled up for all the Sample points whose point classification is 5 and land class is Forest and vegetation class is 1-3 (natural forests, man made forests and degraded forests).

1.6.3 After taking the tally with BAF-2 (tally of live trees recorded on BHI-2), alternate live trees with odd serial No. (i.e. Sl.No. 01 03, 05, etc.) should be selected as sample trees. The tally of dead trees recorded on BHI-3 should be ignored while selecting the sample trees. Sample tree cards should be fixed on all sample trees and a serial No. given to each of the sample trees so selected. Thus, tree No.01 in tally sheet of live trees will be sample tree No.01, tree No.03 will be sample tree No.02, tree No.05 will be sample tree No.03 and so on.

1.6.4 In case there is no tally and consequently there is no sample tree (e.g. in scrubs and degraded forests) "00" should be written in Col. No.64-65.

1.6.5 The data about each sample tree should be recorded on the sample tree card (fixed to tree) by the Assistant Crew Leader. It is necessary for the Crew Leader to check the correctness of the details filled in the sample tree card by Assistant Crew Leader before the data is transferred on to the sample tree form.

1.6.6 The following instructions should be carefully followed for filling up data pertaining to various items in STF.

Item No.	Col.No.	Code	Instructions
1	1-3		Job) Leave these Columns blank.(To be filled by Data Processing Unit).
2	4-5		Card Design)
3	6-7		Report No.)
4	8		Sub Report No.)
5	9-10		Write the serial No. of the sample tree. This will be the sample tree No. and not the serial No. of the tree in Tally sheet. The last No. in this Col. shall be equal to the total No. of trees written in Col. 64-65.

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PREINVESTMENT SURVEY OF
FOREST RESOURCES
(BHUTAN)

SAMPLE TREE FORM

PHASE II - BHI-4

Job	Card Design	Rep. No.	Sub Rep No.
1-3	4-5	6-7	8

Forest Type	Total No.of trees	S.P. No.	Cluster Centre Grid Ref.	Cluster No.	Inv. Design
62-63	64-65	66	67-74	75-78	79-80

Name of C.L.

Date of Survey:

Species name (Local or botanical name)	Serial No.	Species code	Dominance	D.B.H (OB) (cms)		Height (mt.)		Defects natural	Defects others	Radial increment and B.T. at BH					
										Towards P.C. (in m.m.)			Opposite P.C. (in m.m.)		
				Towards P.C.	⊥ to P.C.	Total	Clear bole			Bark thickness	Radial increment Last 10 years	Radial increment Last 20 years	Bark thickness	Radial Incrmt Last 10 years	Radial Incrmt Last 20 years
	9-10	11-13	14	15-17	18-20	21-22	23-24	25	26	27-28	29-31	32-34	35-36	37-39	40-42

Contents

Item No.	Col.No.	Code	Instructions
6	11-13		SPECIES CODE: Write down the code of the species. In case of the un-identified species or no separate code has been given for that species, write 998 in this Column.
7	14		DOMINANCE: Classify the tree into one of the following classes and write the appropriate code for it.
		1	Dominant
		2	Dominated
		3	Suppressed
		4	Tree of under storey
		5	Solitary
		6	Abnormal tree

The following definitions will help in determining the dominance classes.

DOMINANT TREE: is one which forms the upper most canopy and whose leading shoot is more or less free.

DOMINATED TREE: is one which does not form part of the uppermost canopy but the leading shoot of which is not definitely over topped by the neighbouring trees and its crown is not fully free. Its height is usually about 3/4th of the dominant tree.

SUPPRESSED TREE: is one whose leading shoot is definitely over topped by its neighbours. Height of such trees is usually about 5/8th of the dominant trees. Such trees usually suffer from slow growth due to suppression.

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Item No.	Col.No.	Code	Instructions
			TREE OF UNDER STOREY: is one which is a part of the under-storey.
			SOLITARY TREE: is one which is standing alone in a blank.
			ABNORMAL TREE: includes wolf trees, trees of abnormal form and top broken trees.
			DIAMETER AT BREAST HEIGHT:
8	15-17		Diameter 1 in cm
9	18-20		Diameter 2 in cm
			Measure with calliper two diameters over bark at breast height (at a point 1.37 metres above the base of the tree from the up-hill side) to the nearest centimetre.
			(a) Dia.1: Towards the point centre
			(b) Dia.2: Perpendicular to dia. 1. Round off 0.5 cm to the nearest even number and record it in the form. Example: 08.5 cm is to be written as 08 cm and 09.5 cm is to be written as 10 cm.
			Note: While measuring the diameter, observe the precautions listed under 'diameter measurement' (Tally sheet).
10	21-22		TOTAL HEIGHT: Measure the height of the tree from the base to the top with Blume Leiss Hypsometer to the nearest metre. 0.5 should be rounded off to the nearest even number.

Item No.	Col.No.	Code	Instructions
11	23-24		CLEAR BOLE: Measure the height along the stem of the tree from the base on the up-hill side to the beginning of the regular crown or where the main stem bifurcates with Blume Leiss Hypsometer to the nearest metre. Beginning of regular crown in conifers is the point where the first complete live whorl starts. For broad leaved species this point may be recognised as the point from where the first main live branch takes off or from where the main stem forks. In case of trees which form below the bh and are treated as separate trees, the clearbole should be measured from the point of forking to the first live whorl (for conifers) or first live branch (for broad leaved).
12	25		DEFECTS NATURAL: Under this category all those abnormalities are included which are very natural and normal for the tree e.g. knots, callus formation, twisted or spiral grain etc. Examine the stem of the tree and classify as under on the basis of the extent of "Natural Defects" and write the code.
		1	Complete stem length free of natural defects
		2	One third stem length with natural defects
		3	Two third stem length with natural defects
		4	Full stem length with natural defects

Contents

Item No.	Col.No.	Code	Instructions
13	26		DEFECTS OTHERS: This includes damage caused to the tree stem by pathological, entomological, climatic and/or biotic agencies. Damage by these agencies may result in loss of cellulose material and weakening of the strength properties of the timber. These include borer attack, fungal attack, fire damage, hollowness, snow and wind damage etc. Examine the stem and classify as under on the basis of the extent of defects caused by "External Agencies" and write the codes.
		1	Complete stem free of any defect.
		2	One third of stem length with defects.
		3	Two third of stem length with defects.
		4	Full stem length with defects.
14	27-28		BARK THICKNESS TOWARDS P.C.: Blaze the tree and remove the bark making a neat cut at the breast height point towards the Sample point where the shorter arm of the calliper touches the stem, while taking the diameter measurement "Diameter-1". Measure the bark thickness with a scale to the nearest mm and record.

Note:

(1) Whenever more than 25% difference is found between the reading taken towards the P.C. and opposite to P.C. the Crew Leader will verify the measurement in the field and give an explanatory note at the back of the form. The percentage will be calculated with regard to lower (bark thickness) measurement.

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Item No.	Col.No.	Code	Instructions
			(2) Whenever the BT and increment measurement are not possible on both the sides i.e. towards and opposite P.C., write '00' for bark thickness and '000' for increment. If it is possible to take measurement one one side, leave the other side blank and give reason at the back of the form.
			RADIAL INCREMENTS TOWARDS P.C.:
15	29-31		Last 10 years
16	32-34		Last 20 years
			Collect a core with the increment borer at the breast height point towards plot centre. Count the number of annual rings from the periphery towards the pith with the help of magnifying glass and measure the increment in millimeters for the last 10 years and the last 20 years.
			Note:
			(1) For counting the annual rings apply flouroglusin or water on the core before counting. This will make the rings distinct.
			(2) Use a transparent scale for measuring the increment.
	35-36		BARK THICKNESS OPPOSITE TO P.C.: Measure the bark thickness at breast height opposite to the point centre in the same way as described under item No.14 and record.

Item No.	Code No.	Code	Instructions
			RADIAL INCREMENTS OPPOSITE TO P.C.
18	37-39		Last 10 years
19	40-42		Last 20 years
			Measure the increments opposite to the point centre in the same manner as done under item No. 15 and 16.
20	43-61		Blank
21	62-63		FOREST TYPE: Fill up the code of Forest type as written in PDF Col. 17-18.
22	64-65		TOTAL NO. OF TREES: Fill up the total No. of trees recorded in sample tree form.
23	66		SAMPLE POINT NO.: Write the serial No. of the Sample point No. in the cluster.
24	67-74		CLUSTER CENTRE GRID REFERENCE: Write the C.C.G.R. as written in the same Cols. of PDF.
25	75-78		CLUSTER NO.: Write the Cluster No. as written in the same Cols. of PDF.
26	79-80		INVENTORY DESIGN: Leave it blank. To be filled up by Data Processing Unit.

1.7.1 Stock mapping instructions: The instructions for stock mapping of forests are as under:

1.7.2 The inventory crews will be provided with aerial photographs of 1:30,000 scale for the location of Sample points. These photographs will also be used for the field photointerpretation work and stock mapping on 1:50,000 scale map traces. All the hill slopes that are already visible and the area traversed during field work will be stock mapped on map traces.

Contents

1.7.3 Before leaving the camp for work, the Crew Leader should thoroughly study the area to be traversed on map sheet and photographs. The photographs will be studied under the pocket stereoscope and different land classes and forest types observed on the ground will be transferred on to the photograph and map trace. The following classification and symbols will be used for the purpose

A-NON FORESTED LAND

Sl. No.	Land class	Symbol	Remarks
1.	Cultivation and habitation	A 1	The definition of various items listed under land class in Col.11 of PDF. holds good for stock mapping also.
2.	Alpine pastures and scrubs.	A 2	
3.	Snow covered land	A 3	
4.	Barren land	A 4	
5.	Water spreads	A 5	
6.	Other lands	A 6	

B - FOREST LAND

Sl. No.	Land class	Symbol	Remarks
1.	Chir pine	F 1	Description of forest types given under Col.17-18 under Forest Land under Col.16 of PDF should be followed for stock mapping also.
2.	Blue pine	F 2	
3.	Fir spruce	F 3	
4.	Hemlock	F 4	
5.	Larch	F 5	
6.	Juniper	F 6	
7.	Mixed conifers	F 7	
8.	Conifers mixed with broad leaved species.	F 8	
9.	Upland hard woods	F 9	
10.	Oaks	F 10	
11.	Low land hard woods	F 11	
12.	Sal	F 12	
13.	Degraded forests	F 13	
14.	Scrubs	F 14	

1.7.4 PROCEDURE: Observe the area which is clearly visible and identify the various land uses and their extent. Also study the same area on the aerial photographs under a pocket stereoscope. When the stereovision is clear, demarcate the various land classes on the photographs by comparing with the observed ground details. The boundary of a particular type will be marked by a continuous line with a stebilo pencil and the land class and the forest type, if any, will be denoted by the specified symbol.

1.7.5 Texture and shape of the crowns etc. on photographs will provide good indication of the various types. With the help of observations made on ground and the aerial photographs, it would be easy to delineate the various land classes and forest types on map trace with fairly good accuracy.

1.7.6 Since the photographs are of 1956, there may be some areas where the forests have been subsequently cleared for cultivation etc. In such cases the details seen on the ground will not fully tally with details available on the photograph. Therefore, the Crew Leaders are advised to keep this in mind and give due importance to details observed on the ground at the time of traversing.

1.7.7 Field interpretation and stock mapping is carried out :

(i) to serve as a ground check for main photointerpretation work carried out in the office.

(ii) to help the Crew Leader to get good practice in the study of aerial photographs.

CHAPTER - II

VOLUME AND CULL STUDIES

2.1.1 In order to arrive at volume and cull factors, trees of important species of various diameter classes were felled over the survey area and also in areas falling in Phase IV area. This was done to obviate felling of trees again in Phase IV, because a large number of species were common. It is proposed to use these factors for Phase IV areas also.

2.2.1 SELECTION OF TREES:

To give proportionate representation to the entire survey area, fellings were carried out in representative localities identified all over the survey area and some parts of Phase IV. Selection of trees of various species above 10 cm diameter was made at random in 10 diameter classes. Studies were conducted for the following species. The number of trees felled for each species are also indicated hereunder:

Sl.No.	Species	No. of trees felled
1.	Chir (*Pinus roxburghii*)	83
2.	Fir (*Abies dencc*)	95
3.	Spruce (*Picea spinulosa*)	72
4.	Bansum (*Phoebe goalparensis*)	34
5.	*Castanopsis* spp.	82
6.	Champ (*Michelia* spp.)	94
7.	Gokul (*Ailanthus grandis*)	104
8.	Hollock (*Terminalia myriocarpa*)	60
9.	Kawla (*Machilus* spp.)	122
10.	Kharane (*Symplocos spicata*)	69
11.	Lahasune (*Amcora rohituka*)	48
12.	Maina (*Tetrameles nudiflora*)	86

Contents

Sl.No.	Species	No. of trees felled
13.	Mapple (*Acer* spp.)	93
14.	Mauwa (*Engelherdtia spicata*)	40
15.	Odal (*Sterculia villosa*)	76
16.	Simul (*Salmalia malabaricum*)	81
	Total	1239

2.3.1 COLLECTION OF DATA

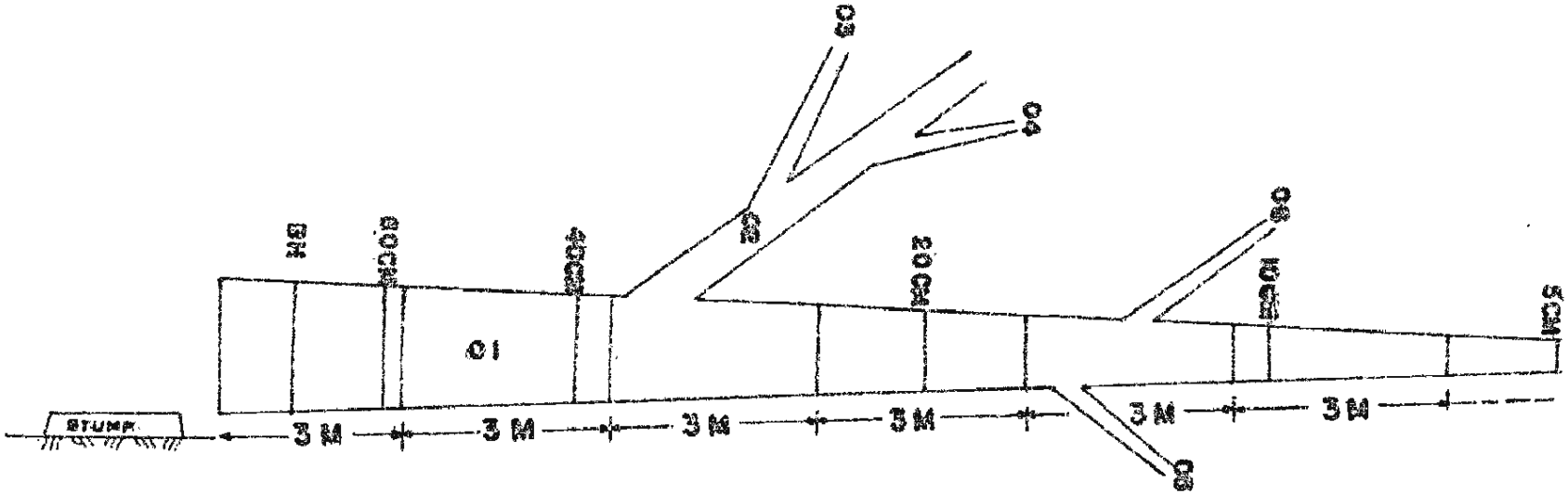
The trunk and branches of each felled tree were numbered as shown in the diagram on the opposite page. In case of conifers, only the main stem was considered for these studies and branches were ignored. Sections were made at every 3 metres interval from the ground level. In addition, sections were made at stump level, breast height and at points of 60 cm, 40 cm, 20 cm, 10 cm, and 5 cm diameters over bark. Measurements in respect of various diameters and defects if any, were taken at each section and recorded in the form BHV-2. In case of conifers, annual rings were also counted at stump level and at breast height. The diagram on the facing page illustrates the marking of sections on felled tree.

2.4.1 CODING INSTRUCTIONS FOR TREE VOLUME STUDY FORM (BHV-1)

All the Columns in this form are filled in or left blank as explained below:

Item No.	Col.No.	Description	Instructions
1	1-3	Job No.	To be left blank for use by Data Processing Unit.
2	4-5	Card Design	
3	6-7	Crew Leader	Code of concerned Crew Leader to be filled in.
4	8-9	Tree No.	Serial number of the tree felled in the locality to be given.

Contents



MARKING OF TREE PORTIONS AND SECTIONS ON A FELLED TREE

PREINVESTMENT SURVEY OF FOREST RESOURCES (BHUTAN)

TREE VOLUME STUDY FORM (for all tallied 'IN' trees 5 cm and over dbh

BHV-1

Job	Card Design	Crew Leader
1-3	4-5	6-7

Date:

Name of Crew Leader:

Total No. of trees	Catchment	Forest Division	Altitude	Slope	Aspect	Crown Density	Forest Type	No. of storeys	Cluster No. of Inventory	S.P. No.	S.P. No. of Inventory	Block No.	Block Centre Grid Reference	Inventory Design
50-51	52-53	54	55-57	58	59	60	61-62	63	64	65	66	67-70	71-78	79-80

Tree No.	Species code	Dominance	DBH(OB)		Total Height	Clear Bole	DEFECTS		Tree felled or not felled	INCREMENT									Total No. of portions.
										TOWARDS P.C.				OPPOSITE TO PC					
			Towards PC	Perpendicular to P.C.			Natural	Others		Last 5 yrs	Last 10 yrs	Last 15 yrs	Last 20 yrs	Last 5 yrs	Last 10 yrs	Last 15 yrs	Last 20 yrs		
8-9	10-12	13	14-16	17-19	20-21	22-23	24	25	26	27-28	29-30	31-33	34-36	37-38	39-40	41-43	44-46	47-48	

Contents

Item No.	Col. No.	Description	Instructions
5	10-12	Species code	Appropriate code for the species to be given.
6	13	Dominance	To be filled up as per instructions for filling S.T.F. in the Inventory Manual for Phase II & III.
7	14-16	dbh (ob) towards P.C.	dbh (ob) measured with callipers to the nearest cm. with graduated arm pointing towards the direction of slope is to be recorded in these Columns.
8	17-19	dbh (ob) perpendicular to P.C.	As above, except that graduated arm of the calliper is to be kept perpendicular to the direction of slope.
9	20-21	Total Height in metres.	These Columns will be filled up as per instructions laid down for filling up STF in the Inventory Manual.
10	22-23	Clear bole in metres.	
11	24	Defects natural	
12	25	Defects others	
13	26	Tree felled/ not felled	One of the following Codes have to be given:

	Code
Tree felled	1
Tree not felled	2

Contents

Item No.	Col.No.	Description	Instructions
14	27-28	Last 5 years increment towards P.C.	To be filled up in accordance with instructions for filling up radial increment for 10 years and 20 years for S.T.F. contained in the Inventory Manual, taking care to record measurements for downhill and uphill sides in Columns meant for towards P.C. and opposite to P.C. readings respectively.
15	29-30	Last 10 years increment towards P.C.	
16	31-33	Last 15 years increment towards P.C.	
17	34-36	Last 20 years increment towards P.C.	
18	37-38	Last 5 years increment opposite to P.C.	
19	39-40	Last 10 years increment opposite to P.C.	
20	41-43	Last 15 years increment opposite to P.C.	
21	44-46	Last 20 years increment opposite to P.C.	
22	47-48	Total No. of portions.	Total number of tree portions will be given in this Column for felled trees only. In case of conifers, it will always be 01 and in case of broad leaved species it can be any number depending upon the number of branches.
23	49	Blank	-
24	50-51	Total No. of trees.	Total number of trees felled at a particular location should be given.

Item No.	Col.No.	Description	Instructions
25	52-53	Catchment	To be filled up as per appendix 4 of Inventory Manual.
26	54	Forest Division	To be filled up as per coding instructions for Col. 12 of P.D.F. of Inventory Manual.
27	55-57	Altitude	To be filled up in accordance with instructions for filling up relevant Columns of P.D.F. as laid in the Inventory Manual.
28	58	Slope	
29	59	Aspect	
30	60	Crown Density	
31	61-62	Forest Type	
32	63	No. of storeys	
33	64	Cluster No. of Inventory	To be left blank
34	65	Plot No.	Serial number of the locality in which fellings are carried out is to be given.
35	66	Plot No. of inventory	
36	67-70	Block No.	To be left blank.
37	71-78	B.C.G.R.	To be left blank.
38	79-80	Inventory Design.	To be left blank for use by Data Processing Unit.

CODING INSTRUCTIONS FOR TREE VOLUME STUDY FORM (FELLED TREES) BHV-2: Various Columns have to be filled up in proper sequence as explained below:-

Item No.	Col.No.	Description	Instructions
1	1-3	Job No.	To be left blank.
2	4-5	Card Design	To be left blank.
3	6-7	Tree No.	A number same as for the concerned tree in BHV-1 is to be filled in.
4	8-10	Species	Appropriate code for the species to be given.
5	11-12	Tree portion	Tree portion number for which the data will be recorded in the subsequent Columns is to be recorded. For conifers, this is always 01, but for the broad leaved species the main stem is numbered as 01 and the branches/sub-branches are separately numbered as 02, 03,04.....depending upon their number. Data for all the sections of a portion must be completed before taking up another portion.
6	13-14	Section No.	Section number is to be written here.
7	15-18	Height of Section	The height of the section above ground level in case of 01 portion and above the junction of the branch and stem or junction of two branches in case of other tree portions will be given in this Column. The height is to be recorded correct to the nearest centimetre.

Contents

TREE VOLUME STUDY FORM (Felled Trees)

PREINVESTMENT SURVEY OF FOREST RESOURCES (BHUTAN)

EHV-2

Job No.	Card Design	Tree No.	Species Code
1-3	4-5	6-7	8-10

Size Class	Total length of tree	S.P. No.	S.P. No. of Inventory	Block No.	Block Centre Grid Ref.	Inv. Design
60	61-64	65	66	67-70	71-78	79-80

Date:

Name of Crew Leader:

Tree Portion	Section No.	Height above buttress/branch junction	DOB		DUB		No. of rings at Section	Type of Defect		Measurement of Defects						Straightness	Shape of Section	Anticipated outturn % in round	Total No. of Sections
			Towards P.C.	Perpendicular to P.C.	Towards P.C.	Perpendicular to P.C.				Size of rectangle				Size of rectangle					
										Length	[illegible]	Type of Defect		Length	Breadth				
11-12	13-14	15-18	19-22	23-26	27-30	31-34	35-37	38	39	40-42	43-45	46	47	48-50	51-53	54	55	56	57-59

Contents

Item No.	Col.No.	Description	Instructions
8	19-22	d.o.b. towards P.C.	Diameter over bark and under bark at the point of each section in appropriate direction will be measured upto the nearest millimetre with the help of a scale and recorded in appropriate Columns.
9	23-26	d.o.b.perpendicular to P.C.	
10	27-30	d.u.b. towards P.C.	
11	31-34	d.u.b. perpendicular to P.C.	
12	35-37	No. of rings at the section	Two average radii (u.b.) as far apart as possible are to be marked on the face of the section and the number of rings from the pith to the periphery of the section on both the radii are to be counted. Average of the two numbers so counted will be written in this Column. If the rings cannot be counted (e.g. in case of hollowness at the centre), then '999' is to be written in this column and '000' will be recorded if there is no annual ring formation as in the case of broad leaved species.
13	38-39	Type of defect	In case there is no defect, '0' is to be recorded in both Col. numbers 38 and 39. In case there is defect, it will be classified into one of the following main classes and appropriate code will be recorded in Column 30 as given below:

Type of defect	Code
Rot	1
Knots	2
Cracks	3
Insect damage	4
Others	5

Contents

Item No.	Col.No.	Description	Instructions
			In Column 39, appropriate Code for further classification of above defects to be recorded according to the description given below:

ROT	Code
Fibrous	1
Pocket	2
Spongy	3
KNOTS	
Loose	1
Tight	2
CRACKS	
Superficial (not deeper than 0.5 cm and no wider than 1 mm)	1
Radial shake (Crack from surface inward deeper than 2.5 cm and wider than 1 mm)	2
Star shake (crack from pith outwards).	3
Cut shake (cracks along the rings).	4
OTHERS	
Fire damage	1
Hollowness	2

Contents

Item No.	Col.No.	Description	Instructions
14 15	40-42) 43-45)	Size of rectangle	Defective portion is to be enclosed in a rectangle or square and measurements of the sides in mm to be recorded in appropriate Column. In case of no defect '000' will be recorded as the measurement for both the sides.
16 17 18	46-47) 48-50) 51-53)		In case of two defects, these Columns will be used as Cols. 38-45. When there are more than two defects, the same will be recorded in the next line below Cols. 38 to 53.
19	54	Straightness	Each section has to be examined in respect of it's straightness. It will be classified into the following classes and the appropriate Code will be filled in.

	Code
Straight	1
Slightly bend (less than 10°)	2
Pronounced bend (one bend more than 10°)	3
Crooked (more than 1 promounced bend).	4

20	55	Shape of the section	End face of the section will be classified into one of the following classes and appropriate code will be entered.

Contents

Item No.	Col.No.	Description	Instructions	Code
			Circular	1
			Elliptical (one diameter longer than other by more than 25%)	2
			Fluted (where the periphery of the section is wavy)	3
21	56	Anticipated out-turn (round wood %)	Anticipated percentage of wood in round that can be obtained from the tree is to be assessed. While assessing the utilizable wood, due consideration has to be given to loss in felling, defects natural and others etc. The assessment will be done for entire tree and not section wise. The following codes will be used to denote the various utilization percentages:	

	Code
10%	1
10 to < 20%	2
20 to < 30%	3
30 to < 40%	4
40 to < 50%	5
50 to < 60%	6
60 to < 70%	7
70 to < 80%	8
above 80%	9

Contents

Item No.	Col.No.	Description	Instructions
22	57-59	Total number of sections	Total number of sections for each tree portion have to be recorded separately in these Columns.
23	60	Size class	The tree is to be classified into the following classes according to it's dbh (ob) and appropriate Code to be given.

	Code
10 cm to less than 20 cm	1
20 " " 30 "	2
30 " " 40 "	3
40 " " 50 "	4
50 " " 60 "	5
60 " " 70 "	6
70 " " 80 "	7
80 " and above	8

Note: Above classification is not the same as one given in the Inventory Manual.

24	61-64	Total length of the tree	Length of the tree from bh point to the tip along it's axis is to be measured and recorded to the nearest cm. in this Column after adding 1.37 m. to the reading thus obtained.
25	65	S.P. No.)	Serial number of the locality in which fellings are carried out is to be recorded.
26	66	Plot No.of Inventory)	
27	67-70	Block No.)	To be left blank
28	71-78	B.C.G.R.)	
29	79-80	Inventory Design	To be left blank for use by Data Processing Unit.

CHAPTER - III

AERIAL PHOTOINTERPRETATION AND MAPPING

3.1.1 AERIAL PHOTOGRAPHS

The entire survey area, except 88.59 km^2 of photographic gaps, is covered by black & white panchromatic aerial photography of task No.167-B on 2" = 1 mile (1:32,000 approx.) scale carried out by M/s Air Survey Company, Calcutta during November 1956 and December 1958. Camera RC 5(A), No.245, with 4.5" and 4.3" (about 11 cm.) focal length lenses has been used for photography. The format size of the print is 18 cm x 18 cm. The forward overlap is between 60 and 80% and side overlap is from 10 to 30%. The aerial photographs have good resolution, clarity and contrast. The scale is reasonably good for the stratification of forest types.

3.1.2 Since photography is about 20 years old, latest land use and forest conditions are not available on these photographs. Field checking has shown that very little changes have taken place in the land use pattern during the last two decades in the survey area. In view of this fact, it was considered that 1956-58 available photography will be good enough for this survey. No other photography was available.

3.1.3 During November-December 1978, fresh photography has been carried out on 1:20,000 scale covering the entire area to be surveyed in Bhutan. Fresh aerial photographs are being procured by the Project and they can be used for updating the land use information of the areas surveyed after the present work is over.

3.2.1 METHODOLOGY

100% photointerpretation was carried out by stereoscopic examination of 717 aerial photographs. The work consisted of marking of principal points, their transference, marking of effective areas on aerial photographs & interpretation. While marking the effective area it was ensured that no area is either left out or included twice. Photointerpretation was confined to the effective area marked on each photograph. There were photographic gaps due to cloud cover (16.42 km^2) or non-availability of the photographs (72.17 km^2). These gaps have been shown as photographic gaps and area under cloud cover in forest resources maps and area statement.

Contents

3.2.2 Before final interpretation was undertaken, a field reconnaissance survey was carried out by the photointerpretation section during January 1976 for establishing a correlation between field observations and photo details. During the reconnaissance survey, it was observed that the general land use pattern and distribution of forest types in the survey area were more or less similar to that of Phase I. Keeping this in view, the photointerpretation key and methodology adopted for Phase I was continued for Phase II & III also. The photointerpretation carried out was checked in the field during October-November, 1976 and November-December, 1977. The discrepancies noticed in the field checking were corrected on the photographs. The stock maps prepared by the inventory crews while crusing forest areas were also made use of for checking the interpreted details on photographs.

3.2.3 Key for Photointerpretation: The following key, based on field observations, quality of photography and possibilities of photointerpretation was adopted.

A NON-FORESTED

Sl.No.	Type	Code
1	Snow covered areas	A1
2	Lakes and water spreads	A2
3	Exposed rocks and barren slopes	A3
4	Cultivation and habitation (including orchards & terraced cultivation)	A4

B. FORESTED LAND

Sl. No.	Corresponding ground forest type	Ground type code	Sl. No.	Photointerpretation type	Photo type code
1.	Alpine pasture	-	1.	Alpine pastures and scrubs	F1
2.	Fir-Spruce	03	2.	Fir	F2
3.	Hemlock	04	3.	Mixed conifers (Tsuga, Larix, blue-pine, junipers, fir & spruce)	F3
4.	Larch	05			
5.	Juniper	06			
6.	Mixed conifers	07			

Contents

Sl. No.	Corresponding ground forest type	Ground type code	Sl. No.	Photointerpretation type	Photo type code
7.	Conifers mixed with broad-leaved	08	4.	Broadleaved mixed with conifers	F4
8.	Blue-pine	02	5.	Blue pine	F5
9.	Chir pine	01	6.	Chir pine	F6
10.	Upland hardwoods (broadleaved)	09	7.	Broadleaved forests	F7
11.	Oaks	10			
12.	Lowland hardwoods (broadleaved)	11			
13.	Sal	12			
			8.	Blanks in the forests	B

3.2.4 Density Classification: The forested lands were further classified according to density of the crop as follows:

Density	Percentage	Code
i) Low Density	20%	III
ii) Medium Density	20-60%	II
iii) High Density	over 60%	I

NOTE: No density is indicated for F1 and B

Method of Annotation

	Land use type / Density		Numerator / Denominator
Example No.1.	A1	=	Snow covered
Example No.2	F2/I	=	Fir / High Density

3.2.5 Minimum area for delineation: An area of 0.5 cm x 0.5 cm on aerial photographs (equal to about 2.25 ha on ground) was taken as the minimum area to be delineated. Smaller areas were not recognised and were included in the adjacent stratum.

Contents

3.3.1 MAPS AND MAPPING

The survey area is covered by Map Sheet Nos.78 I/4, 6, 7, 8, 10, 11, 12, 14 (part), 15, 16 and 78 M/3, 4, 7, 8, 11 (part) & 12 published by Survey of India on 1:50,000 scale. These maps have been prepared on precision plotters using aerial photographs. They were used as base maps for preparation of forest resources maps after transferring the photointerpreted details from the aerial photographs.

3.3.2 The map sheet-wise break-up of area under the Project, photo gaps and clouds is given in the following statement.

(Area in ha)

Sl. No.	Map sheet No.	Total area of sheet	Area within the Project	Out of area under Col. 4		
				Area under (photo) gaps	Area under clouds	Area under blanks
1	2	3	4	5	6	7
1.	78 I/4	68646	68646	-	-	417
2.	78 I/6	68342	68342	-	-	344
3.	78 I/7	68496	68496	-	-	589
4.	78 I/8	68646	68646	-	-	536
5.	78 I/10	68343	68343	-	-	1068
6.	78 I/11	68496	68496	-	-	686
7.	78 I/12	68646	68646	-	-	1708
8.	78 I/14	68343	63136	-	-	1035*
9.	78 I/15	68496	68496	-	-	922
10.	78 I/16	68646	68646	-	-	2680
11.	78 M/3	68495	68495	2808	656	711
12.	78 M/4	68646	68646	1882	-	82
13.	78 M/7	68495	68495	270	986	96
14.	78 M/8	68646	68646	-	-	129
15.	78 M/11	68495	66970	-	-	163**
16.	78 M/12	68646	68646	2257	-	72
	Total	1096523	1089791	7217	1642	11238

Note: * Remaining area of sheet No.78 I/14 in Kuru catchment has been excluded from survey area.
** Remaining area of sheet No.78 M/11 outside Bhutan has been excluded from survey area.

Contents

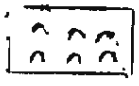
3.3.3 Aerial photographs were interpreted and checked by the experienced photo-interpreters of the Preinvestment Survey of Forest Resources, Dehra Dun. Photointerpreted details were transferred on the base map by the 70 Forest Party of Survey of India, Dehra Dun with the help of Vertical Sketch Master and sometimes by desk Projector. The transference was checked by the interpreters.

3.3.4 In view of the delay involved in printing of maps in Survey of India, it was decided to prepare forest resources maps on astrofoils (a transparent and dimensionally stable material) in 70 Forest Party. Requisite number of ammonia prints were then made from astrofoils.

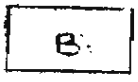
3.3.5 The different symbols for various land uses, forest types and density classes used on the forest resources maps are as follows:

Non forested land - denoted by symbols only e.g. A1, A2 etc.

Forested land - F1 = by inverted semi circles



- B = by symbol B



All other forest types by respective symbols i.e. F2, F3, F4, etc.

Contents

Density of a stratum was denoted by superimposing hatchures, 2 mm apart, on the stratum itself in addition to the symbol, as follows:

High Density	60%	F 3	vVertical lines
Medium Density	20-60%	F 2	Crossed diagonals
Low Density	20%	F 7	Horizontal lines

3.4.1 AREA CALCULATION

Catchmentwise calculation of area under various land uses, forest types and density classes was done by 70 Forest Party of the Survey of India by dot grid method.

CHAPTER - IV

DATA PROCESSING.

4.1.1 GENERAL

The Data Processing involves manual processing, processing on unit record machines and electronic computers. The main operations involved are:

4.2.1 MANUAL PROCESSING

(i) Documentation of field forms.

(ii) Coding the information in the field forms where this had not already been done.

(iii) Manual checking of the field forms for detecting inconcistencies and discrepancies.

(iv) Reconciliation of the discrepancies and removal of inconsistencies, in consultation with field officers and photo-interpreters.

(v) Preparation of scatter diagrams for rejection of abnormal trees in felled tree data.

(vi) Preparation of scatter diagram for rejection of abnormal trees in sample tree data.

4.3.1 PROCESSING ON UNIT RECORD MACHINES

(i) Punching the coded data contained in the field forms on the punch cards.

(ii) Verification of punched cards.

(iii) Sorting and collating the cards for proper input to the computer.

(iv) Listing and tabulating the punched data for detecting omissions, duplications and mistakes.

4.4.1 PROCESSING ON ELECTRONIC COMPUTER

(i) Loading the data on magnetic tape.

(ii) Calculations of cull volume, utility volume and total volume of felled trees.

Contents

(iii) Derivation of general volume equations.

(iv) Calculation of sample tree volume.

(v) Derivation of local volume equations.

(vi) Calculation of tree volume and volume/ha. and stems/ha. at each sample point.

(vii) Calculation of sampling error.

(viii) Preparation of stem distribution and growing stock tables for each forest type.

(ix) Preparation of total growing stock tables for different forest types and catchments.

4.4.2 Input for the computer:- After manual checking of field forms, the data was punched on cards in punching machines. The punched cards were verified in Card Verifier, properly sorted in Card Sorter and arranged in proper sequence with the help of Card Collator.

4.4.3 Listings of the data punched on cards were taken on an Electronic Computer. This was done to see if the data had been correctly transferred and the cards in each deck were in proper sequence. The number of cards for transfer of data in various card designs are given below:-

Card Design	No. of cards used
1. Point Description Forms (CD 01)	2458
2. Tally Sheet (CD 02) Dead Trees	1398
3. Tally sheet (CD 03) Live Trees	3795
4. Sample Tree Form (CD 04)	9854
5. Tree Volume Study Form BHV.1 (CD 05)	1239
6. Tree Volume Study Form BHV.2 (CD 06)	40784

4.5.1 AREA

The Photointerpretation and Mapping Unit of the PIS Headquarters provided the area under various land use classes in different catchments and area under different forest types.

4.5.2 The area under each forest type was further divided into different classes of size, spacing, crown density, regeneration, leaf litter, humus, soil depth, soil texture, stoniness, altitude, slope, aspect, grazing incidence and fire incidence on the basis of number of sample points falling in each category. Percentage distribution of area in various categories was worked out for each forest type.

Contents

It may be noted that the field sampling design was not drawn to estimate the area under various sub populations with high degree of accuracy. Moreover, some of the sample points falling in the forested area could not be visited due to inaccessibility. Therefore the the estimates of percentage distribution of area calculated on the basis of number of sample points falling under different categories indicate only approximate distribution of area under various categories.

4.6.1 NUMBER OF STEMS

The calculations were as under:

4.6.2 Stems per ha at a sample point:- The trees tallied at each sample point were classified by species and diameter classes. The estimate of stems per ha by species and diameter classes at each sample point were obtained by using the following formula:

$$\text{Stems/ha} = \text{BAF} \times \sum_{i=1}^{m} \frac{1}{B_i}$$

where B_i = Basal area of the ith tallied tree at a sample point.

m = Number of trees tallied at a sample point.

BAF = The basal area factor of the relaskop.

4.6.3 Stand Tables:- From the tally of trees at each sample point an estimate of stems/ha by species and diameter classes over all sample points in each forest type was obtained.

4.6.4 Total Stems:- An estimate of total stems under each forest type was obtained as a product of the stems/ha as calculated in para 4.6.3 and the area (in ha) of the concerned forest type. Estimates of total stems by species and diameter classes over all the forest types were also calculated.

4.7.1 GENERAL VOLUME TABLES

Since the felled tree data in respect of species *Pinus roxburghii*, *Picea spinulosa*, *Abies densa* and *Acer* species were also available from Phase-I, it was decided to combine the data of all phases to derive general volume equations for these four species. For other species, general volume equations were derived from the data of Phase II & III only.

4.7.2 The general volume tables constructed for Phase I report were adopted for this report also in respect of (i) Pinus wallichiana (ii) Tsuga brunoniana (iii) Quercus species (iv) Betula species and (v) other misc. hardwoods. Fellings of these species were not done for this report.

4.7.3 The following forms of regression equations were tried on the data on each species:

$$V = a + b\,D^2H$$

$$V = a + bD + cD^2H$$

$$V = a + bH + cD^2H$$

$$V = a + bD + cH + dD^2H$$

$$V = a + bD + cD^2$$

$$\text{Log } V = a + b \log_e D + c \log_e H$$

$$V/D^2H = a + b/D^2H$$

where V = Under bark volume (m^3) upto 5 cm top over bark diameter

D = Overbark diameter (m) at breast height.

H = Total height (m)

4.7.4 The following equations were selected taking into consideration the standard error of the estimate, multiple determination coefficient and the applicability of the estimate in the entire range of data.

1. Pinus roxburghii (154)

$$V/D^2H = 0.32159 - 0.00156/D^2H$$

or

$$V = -0.00156 + 0.32159\,D^2H$$

2. Picea spinulosa (154)

$$\text{Log}_e V = -1.29816 + 1.86384 \log_e D + 1.03333 \log_e H$$

3. Abies densa (164)

$$\text{Log}_e V = -1.38883 + 1.77028 \log_e D + 1.04424 \log_e H$$

Contents

4. Acer species (150)

$V = 0.03873 + 0.36273\ D^2H$

5. Castanopsis species (82)

$V/D^2H = 0.34759 - 0.00794/D^2H$

or

$V = -0.00794 + 0.34759\ D^2H$

6. Michelia species (94)

$V/D^2H = 0.32947 + 0.00667/D^2H$

or

$V = 0.00667 + 0.32947\ D^2H$

7. Terminalia myriocarpa (59)

$V = 0.00635 + 0.35936\ D^2H$

8. Phoebe goalparensis (34)

$V = -0.04320 + 0.36220\ D^2H$

9. Amoora rohituka (48)

$V = -0.09768 + 0.01051\ H + 0.31875\ D^2H$

10. Tetrameles nudiflora (86)

$\text{Log}_e V = -1.33610 + 1.75959\ \log_e D + 0.99492\ \log_e H$

11. Ailanthus grandis (103)

$\text{Log}_e V = -1.94825 + 1.72730\ \log_e D + 1.16690\ \log_e H$

12. Machilus species (122)

$\text{Log}_e V = -0.56664 + 2.03335\ \log_e D + 0.87279\ \log_e H$

13. Symplocos spicata (69)

$V = 0.00155 + 0.34028\ D^2H$

14. Salmalia malabaricum (81)

$\text{Log}_e V = -0.70448 + 2.13777\ \log_e D + 0.91127\ \log_e H$

Contents

15. Sterculia villosa (75)

$$V/D^2H = 0.34018 + 0.00231/D^2H$$

or

$$V = 0.00231 + 0.34018\ D^2H$$

16. Engelherdtia spicata (40)

$$\text{Log}_e V = -0.14969 + 2.15320 \log_e D + 0.76463 \log_e H$$

The figures in the bracket against species name indicate the number of trees on which the regression equations are based.

4.8.1 LOCAL VOLUME TABLES

Using the General Volume Equation, volume of each sample tree of a species was estimated by substituting the diameter and height of the sample tree. Taking the estimated volume or a transformation of volume as dependent variable and the corresponding diameter at breast height or its functions as independent variable, local volume equations were developed. The following forms of equations were tried:-

$$V = a + bD^2$$

$$V = a + bD + cD^2$$

$$V = a + bD$$

$$V/D^2 = a + b/D^2$$

$$V/D^2 = a + b/D + c/D^2$$

$$\text{Log}_e V = a + b \log_e D$$

$$V = a + bD + cD^2$$

$$V = a + bD + cD$$

4.8.2 Since the sample tree data from inventory sample clusters for the species Picea spinulosa, Phoebe goalparensis and Engelherdtia spicata was not enough to derive local volume equations, it was decided to include the felled tree data also for developing local volume equations for these species. There was no felled tree data available for Rhododendron species in any Phase and the sample tree data was enough to derive a local volume equation. It was, therefore, decided to estimate

sample tree volume of Rhododendron species from the general volume equation for 'Rest of the species' of Phase-I area and obtain a local volume equation for this species. Local volume equation for 'Rest of species' in Phase II & III was also derived in a similar manner.

4.8.3 Considering the standard error of estimate, the multiple determination coefficient and the applicability of the equation in the entire range of the data, the following local volume equations were selected for various species.

1. Pinus roxburghii (272)

$$\sqrt{V} = 0.291801 + 6.041763\ D - 2.430993\ \sqrt{D}$$

2. Pinus wallichiana (119)

$$V/D^2 = 16.183975 - 3.040264/D + 0.185555/D^2$$

or $$V = 0.185555 - 3.040264\ D + 16.183975\ D^2$$

3. Picea spinulosa (263)

$$\text{Log}_e V = 2.763193 + 2.605962\ \log_e D$$

4. Abies densa (1871)

$$\sqrt{V} = -0.050899 + 3.087220\ D$$

5. Tsuga brunoniana (420)

$$\sqrt{V} = -0.480494 + 2.738112\ D + 0.948655\sqrt{D}$$

6. Quercus species (1420)

$$\sqrt{V} = 0.020144 + 4.292089\ D - 0.894675\sqrt{D}$$

7. Betula species (272)

$$\text{Log}_e V = 2.460537 + 2.447069\ \log_e D$$

8. Acer species (262)

$$\sqrt{V} = 0.374246 + 4.759591\ D - 1.891510\ \sqrt{D}$$

9. Castanopsis species (165)

$$\text{Log}_e V = 2.319413 + 2.653453\ \log_e D$$

10. Rhododendron species (746)

$$\sqrt{V} = 0.306492 + 4.315360\ D - 1.749908\ \sqrt{D}$$

Contents

11. Michelia species (208)

$$\sqrt{V} = -0.280741 + 3.515265\ D$$

12. Phoebe goalparensis (76)

$$\sqrt{V} = -0.253366 + 3.567924\ D$$

13. Machilus species (324)

$$V/D^2 = 12.734067 - 2.126400/D + 0.136186/D^2$$

or $V = 0.136186 - 2.126400\ D + 12.734067\ D^2$

14. Symplocos spicata (84)

$$\sqrt{V} = -0.212798 + 3.288996\ D + 0.046417\ \sqrt{D}$$

15. Engelherdtia spicata (84)

$$\text{Log}_e V = 2.535662 + 2.519379\ \log_e D$$

16. Rest of species (2804)

$$\sqrt{V} = 0.076137 + 3.979998\ D - 0.958937\ \sqrt{D}$$

Where V = Under Bark Volume (m^3)

D = Diameter at breast height (m)

The figures in brackets after the names of the species denote the number of observations on which the regression equation for a particular species is based.

4.9.1 FELLED TREE VOLUME

The overbark and underbark volume of each section of a tree portion was calculated by the Smalian formula:

$$V = \frac{\pi L}{8} (D_1^2 + D_2^2)$$

Where V is the volume, D_1 and D_2 the average diameters at the two ends of a section and L the length of the section. D_1 and D_2 represent overbark measurements for overbark volume and underbark measurements for underbark volume. In case of stump volume and the volume of the first section of each tree portion, the average diameter at the top of the stump or the section of the tree portion was considered to represent the mid diameter and the volume was calculated by the formula:

$$V = \frac{\pi D^2 L}{4}$$

Contents

Where D is the average diameter at the top of the stump or first section of the tree portion. The volumes of all sections when added up give overbark and underbark volume of the tree.

4.10.1 DETERMINATION OF GROWING STOCK:

This was done as follows:

4.10.2 Tree Volume:- The Breast Height Diameter of each enumerated tree was substituted in the selected local volume equation of the species and underbark volume of each enumerated tree was computed.

4.10.3 Volume per ha at a sample point:- Using the volume of each enumerated tree and estimate of volume per ha by species and diameter class as well as volume per ha irrespective of species and diameter class was obtained for each sample point from the following formula:

$$\text{Volume/ha} = \text{BAF} \times \sum_{i=1}^{m'} \frac{V_i}{B_i}$$

Where V_i = The volume of the ith tallied tree from local volume equation

B_i = Basal area of ith tallied tree

m = No. of tallied trees at the sample point.

BAF = Basal area factor of the relaskop

4.10.4 Growing stock/ha:- The estimate of volume/ha by species and diameter class was obtained for each forest type or a group of forest types from all the sample points falling in that type.

4.10.5 Total Growing Stock:- The product of estimate of volume/ha and the area of the forest type gives the total growing stock for the forest type.

4.10.6 Standard Error:- Stratification of different forest types could not be done at the time of preparation of inventory design for the survey but it was expected that the area of the forest types will be available from aerial photointerpretation at the time of data processing. Therefore, systematic sampling design was adopted. It was planned to analyse the data after survey is over by post stratification of the area. Standard error of the estimates of volume/ha for each forest type was obtained from the sample points falling in that forest type. An estimate for the whole survey area was also obtained.

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4.10.7 The sub-sample of clusters falling in each forest type was considered to constitute a random sample. Since both points of the cluster in many cases did not fall in the same forest type, the ratio method of estimation was considered appropriate for estimating the sampling error in each forest type. The estimates of variances and standard errors were derived as follows:-

Let

y_{ij} = Volume (m^3)/ha at the jth sample point of the ith cluster.

x_i = Number of sample points in the ith cluster.

y_i = Total of per ha volumes at ith cluster

$\bar{x}$ = Mean number of sample points per cluster

n = Total number of clusters

r_h = Mean volume per hectare in the hth stratum.

Estimate of variance of $r_h = v(r_h) = \dfrac{\sum_1^n y_i^2 - 2\, r_h \sum_1^n x_i y_i + r_h^2 \sum_1^n x_i^2}{n(n-1)\,\bar{x}^2}$

Ignoring finite population correction factor the

Standard Error of $r_h = S.E.(r_h) = \sqrt{v\,(r_h)}$

$$S.E.\% = \frac{S.E.(r_h)}{r_h}$$

Estimate of the variance of the total growing stock in hth stratum $= A_h^2\, v(r_h)$

Where A_h is the area of the hth stratum

Estimate of the variance of the total growing stock in the whole catchment is given by

$$v(y) = \frac{\sum_1^k A_h^2\, v(r_h)}{\left(\sum_1^k A_h\right)^2}$$

Where y = Total growing stock

k = Number of strata

$$S.E.(y) = \sqrt{v(y)}$$

$$S.E.\% = \frac{S.E.(y)}{y} \times 100$$

4.10.8 Cull Volume:- Measurements of defects were taken at each end of the section. The larger of the defective portion at the two ends was considered as defect area of the section and the defective volume calculated as follows:

Defective volume = defective area x length of the section.

4.10.9 The defective volumes were calculated separately for rot and hollowness in each section of the tree. These volumes were added over the whole tree to obtain total cull volume of the tree. Total cull volume of all the felled trees for each diameter class was calculated and expressed as percentage of the total underbark volume of the felled trees in that class.

4.10.10 Cull percentage figures for trees above 80 cm diameter were determined for three different classes viz. 80-90, 90-100 and above 100 cm diameters. However, volume for 80 cm and above diameter in combined (all the three classes taken together) form was computed. For calculation of cull volume, cull percentage figure of 80-90 cm class was adopted for volume above 80 cm diameter. Extrapolation was done to determine cull percentage figures for higher diameter classes where these could not be computed from felled tree data.

4.11.1 BARK VOLUME

As overbark and underbark volume of each tree was calculated, the bark volume of each tree was also estimated. The bark volume of all the trees in a diameter class was added up and expressed as percentage of total under bark volume of all felled trees in that class.

4.11.2 Similar procedure as described in para 4.10.10 for cull volume, was adopted to determine bark volume for higher diameter classes.

4.12.1 UTILITY VOLUME

Overbark and underbark measurements were recorded at 60 cm, 40 cm, 20 cm and 10 cm overbark diameter limit. Using this data, tree volumes (felled) upto top diameter limits of 60 cm, 40 cm, 20 cm and 10 cm were calculated in addition to the volume upto 5 cm top diameter limit. Underbark volume upto top diameter limits of 60 cm, 40 cm, 20 cm and 10 cm in different diameter classes were expressed as a percentage of total underbark volume upto 5 cm diameter in these classes. From these percentages the actual underbark volume for different top diameter limits under various diameter classes were worked out.

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4.13.1 GROWTH STUDIES

The following studies were made:

4.13.2 Age-diameter relation:- The number of rings at breast height of each felled tree of coniferous species was noted. To estimate the diameter at various ages, a smooth curve was drawn between the age and breast height diameter. From these curves, diameter at different ages at an interval of 10 years were read.

4.13.3 Age-height relation:- As in para 4.13.2, the height of each felled tree was plotted against breast height age and a smooth curve drawn. The height corresponding to different ages at an interval of 10 years were read.

4.13.4 Increment:- Radial increment at breast height during the last 10 years and 20 years were taken with the help of increment borer for coniferous species from STF data. Average radial increment during last 10 years and previous 10 years for each diameter class of trees was worked out.

4.13.5 Annual basal area increment during last 10 years and previous 10 years were expressed as a percentage of the average present basal area in each diameter class and was calculated as under:

$$\text{Annual increment percent (Last 10 years)} = \frac{1}{10} \times \frac{(D_u^2 - D_{10}^2)}{D_u^2} \times 100$$

$$\text{Annual increment percent (Previous 10 years)} = \frac{1}{10} \times \frac{(D_{10}^2 - D_{20}^2)}{D_{10}^2} \times 100$$

Where D_u = Breast height underbark diameter

$D_{10} = D_u - 2x$ (Last 10 years radial increment)

$D_{20} = D_{10} - 2x$ (Previous 10 years radial increment)

CHAPTER V

MARKET AND DEMAND STUDIES

5.1 GENERAL

The study included assessment of the following items within the survey area and adjacent portions of Sarbhang and Samdrup-Jongkhar Forest Divisions.

(i) Wood Production

(ii) Wood Consumption

(iii) Wood Export

(iv) Projection of demand for wood

5.2 METHODOLOGY

Methodology adopted for carrying out various studies is given in the following paras.

5.2.1 Assessment of Wood Production:- In the absence of separate timber accounts records in Range Offices and Divisional Offices, collection of out-turn figures of timber and other M.F.P. had to be done from the basic records maintained in Range Offices. Records of four years viz. 1974-75, 1975-76, 1976-77 and 1977-78 were examined and average production figures were compiled from the data. For the purposes of determining the production figures of survey area, records of Chirang, Shemgong, Tongsa, Bhumthang, Mongar, Tashigong and Wamrong forest ranges only were considered. Study of adjacent portions of survey area included areas covered by Gaylegphug, Phipsoo, Samdrup Jongkhar, Samrang & Diapham forest ranges.

5.2.2 The out-turn figures by purchasers' agency and special permits were compiled from the certificate of origin records and that of right holders and concessionists; free grantees and other agencies were derived from cash book entries and from the specially maintained registers (wherever they were available).

5.2.3 For the purpose of production studies the following agencies were recognised:-

(a) Forest lessees/contractors

(b) Through departmental working

Contents

(c) Concessionists

(d) Free grantees

(e) Allotments to Govt. departments

(f) Wood based industries

5.2.4 The procedure followed for collecting information under various agencies is given below:-

5.2.5 (a) Forest Lessees/Contractors: This category includes all forest produce extracted by forest contractors from sold coupes. It also includes allotments made to certain individuals in selected areas for commercial purposes on payment of royalty as per prevailing schedule of rates. The information was recorded for each range. The sale lists of coupes provided only information pertaining to number of trees under various diameter classes. As all the material removed from the coupes found entry in certificate of origin issued from time to time indicating the definite volume, this information was in such cases obtained from the Certificate of Origin records. Revenue figures were also collected from cash books, bill register and contractor's ledgers maintained in Divisional/Range Offices.

5.2.6 (b) Departmental Working: The material harvested by the Forest Department either by directly employing the labour or through piece-meal contractors is included under this category. Material is converted and brought out of the forest through the departmental agency and then disposed off.

5.2.7 (c) Concessionists:- This agency included timber extracted by villagers for bonafide house building, house repairs and agricultural implements on concessional royalty rates. It also includes certain wood requirements of community or institutions for which concessional royalty charges are levied. In case of firewood, the local population enjoy the privilege to collect dry wood from forests free of royalty. Althrough permits are issued to people living in townships for removal of firewood, bulk of firewood removed by local population is unrecorded. Only the quantity that has been issued through permits has been shown under production. But, this does not give any indication of firewood consumption. Hence the firewood consumption estimates are based on the population and is discussed in detail separately.

5.2.8 (d) Free Grants:- Timber is annually granted free of royalty to fire and flood victims, Dzongs, Monasteries, Educational Institutions & Community Centres. This information has been obtained from the free grant register maintained in the Range Offices.

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5.2.9 (e) Wood Based Industries: Saw mills and other wood based industries located within and nearby survey area are allotted certain quantity of timber annually. This information was obtained from bill registers and cash books of both Divisional Forest Offices and Range Offices. In addition to this, information was collected by visiting each wood based industry located within survey area as well as areas located south of survey area (within Bhutan) as per the Questionnaire BHD 1 (Annexure-2).

5.2.10 (f) Allotments to Govt. Departments:- Govt. departments get part of their timber and firewood requirements directly from forests through allotments. Cash books, bill registers and sanction orders of Divisional & Range Offices were gone through for getting the details.

5.3.1 ASSESSMENT OF WOOD CONSUMPTION

As there is no organised harvesting agency, most local consumers directly extract the wood allotted/sold to them from forests. The actual timber consumption by various wood consuming sectors like Government departments, free grantees, wood based industries etc. are derived from average production figures under these sectors. As the removals made for wood required for agricultural implements, fuelwood and in some cases even house building and house repair timber are mostly unrecorded, house sample survey was carried out as per details of items included in the proforma designed for this purpose. (BHD-3 Annexure I). A total of 154 samples were drawn from representative villages in various districts of survey area as per details given below. The number of samples drawn in various districts are proportionate to the area included in survey area.

S.No.	District	No. of houses sampled
1.	Samchi	3
2.	Chirang	8
3.	Shemgong	20
4.	Wangdiphodrang	6
5.	Tongsa	20
6.	Bhumthang (Bykar)	22
7.	Mongar	31
8.	Tashigang	35
9.	Shumar	7
10.	Lhuntsi	2
	Total	154

5.3.2 The proforma BHD 3 (Annexure I) included wide range of items pertaining to consumption of wood for house building and house repairs, agricultural implements and firewood. The details of studies carried out are as follows:-

5.3.3 (i) House Building Timber:- In each house sampled, the details of every piece of wood/bamboo used for the building was recorded. The total quantity of timber (m^3WRE) used was compiled in the office. Useful items like plinth area, No. of storeys, type of roof, the extent of land owned, annual income etc., were recorded to correlate with the quantum of timber used for house building.

5.3.4 (ii) House Repairs:- As considerable quantity of timber is annually utilized by the local population for house repairs, especially replacement of shingles of roof, the information pertaining to this item was collected in respect of cycle of minor and major repairs, kind and quantity of wood used for repairs, etc.

5.3.5 (iii) Agricultural Implements:- The study was conducted over 183 representative house holds. (A house hold may have more than one family). Details pertaining to the area of land owned, kind and number of implements used, frequency of replacement of implements, quantity of timber required for various implements, species preferences etc. were collected from the households sampled.

5.3.6 (iv) Firewood:- Special attention was paid for this study in view of the fact that the largest removals of wood for local consumption is made under this category. Apart from the assessment of per capita consumption of firewood, the species preferences by population in various regions was also studied. 183 house holds were sampled for the purpose.

5.4.1 EXPORT

Considerable quantity of timber and other forest produce of the survey area and areas located south of survey area (bordering Assam State in India) finds entry into Indian timber markets.

5.4.2 To ascertain the quantity exported, certificate of origin records of various ranges in the survey area and adjacent portions (within Bhutan) for last four years were examined. The average quantity of timber and other produce exported was worked out on the basis of data of four years.

Contents

5.4.3 Exchange transit passes issued by various forest offices in adjacent areas of Assam State (Goalpara, Kamrup and Darrang districts) for the forest produce exported from Bhutan through Assam were also examined for the year 1976-77 and compared with export figures obtained from certificate of origin records of various ranges of Samdrup Jongkhar and Sarbhang Divisions for the corresponding year.

5.5.1 STUDIES IN ASSAM AREA

As most of the surplus forest produce from survey area and adjacent portions of Bhutan finds entry into timber markets and wood based industries located in Goalpara, Kamrup and Darrang districts of Assam (India), a study was undertaken to determine the potential demand for wood in these areas.

5.5.2 The study included the following items:

5.5.3 Wood Based Industries: All the wood based industries located in the three districts were visited and information as detailed in proforma BHD 1 (Annexure-2) was collected. Apart from many other items, the study included the listing of the quantity of Bhutan Wood consumed by each industrial unit.

5.5.4 Wood Production: Wood out-turn figures for the years 1974-75 and 1976-77 of all the seven forest divisions covered by the three districts were collected from the records of Divisional Forest Offices. The Divisions covered were Kachugaon (Gosaigaon), Haltugaon (Kokrajhar), North Kamrup (Rangia), Goalpara (Goalpara), Dhubri (Dhubri), South-Kamrup (Gauhati), Darrang (Tejpur).

5.5.5 Export: For finding out the quantum of wood exported to different destinations in India and other countries from various timber markets of the three districts, the extracts from the transit passes issued by Range Officers, Depot Officers and Beat Officers during 1976-77 were taken. In addition to this, supplies made to various organised sectors like Railway, D.G.S.& D. etc. which consume considerable quantity, was ascertained from the despatch records maintained by Depot Officers. Contribution of Bhutan and other areas to the total exports through various timber markets was also determined from transit pass records.

5.5.6 Interviewing forest lessees and timber merchants:

All the leading forest lessees and timber merchants of Goalpara, Kamrup and Darrang districts and Bhutan areas were interviewed and information as detailed in proforma BHD-2 (Annexure-3) was recorded. Average selling price of timber of various species in round and sawn form prevalent

in various markets was obtained from this source. Other important information obtained by interviewing the merchants are landed costs, common marketable species, important buyers and destinations, etc.

5.6.1 CONVERSION FACTORS USED (IN ASSAM)

(a)	Volume of one tree	= 3 m^3
(b)	Volume of a pole	= 0.028 m^3 (1 cft)
(c)	Volume of electric transmission pole	= 0.122 m^3
(d)	1 m^3 of sawn wood in Bhutan area.	= 2 m^3 of round wood
(e)	1 m^3 of sawn wood in Assam area	= 1.428 m^3 round wood
(f)	One bag of charcoal	= 35 kg.
(g)	One tonne firewood	= 75 cft(stacked volume)
(h)	One standard stack of firewood (5'x5'x2½')	= 37.5 cft
(i)	One truck load of firewood	= 3 tonnes
(j)	One head load of firewood	= 25 kg.
(k)	One cubic foot	= 0.028 m^3
(l)	One tonne timber	= 1.2 m^3(u.b.)
(m)	One truck load timber	= 175 cft (3.5 tonne)
(n)	One truck load of cane	= 3 tonnes
(o)	One head load or one bundle of cane	= 12 kg.
(p)	One head load of cane	= 12 No. thick cane or 100 No. thin cane
(q)	One card load of firewood	= 2 quintals
(r)	One tin of resin	= 18 kg.
(s)	One head load of thatch grass, leaves etc.	= 18 kg.
(t)	One tree	= 2 tonnes firewood

Contents

ANNEXURE-1
BHD-3

PREINVESTMENT SURVEY OF FOREST RESOURCES
(BHUTAN)

MARKET AND DEMAND STUDIES

House Sampling Proforma

Name of Village/Town — Block:

No. of houses in the village/Town — Sub Division:

Name of Owner/Head of Family — District:

I. GENERAL

1. Year of construction
2. Plinth area of the house (sq.m.)
3. Type of roof (flat or leaning)
   (a) Roofing material used
4. No. of storeys — Single/double/triple
5. No. of persons living in the house
   (a) Children (upto 18 years)
   (b) Adults
6. No. of draught animals (including bullocks, cows, buffaloes etc. used for tilling the land)
7. No. of families (house-holds) residing in the house
8. Total agricultural land (in acres)
9. Annual income

II. CONSUMPTION OF TIMBER/BAMBOO

	Round	Sawn
10. (a) Timber (cu.m.)		
(b) Bamboo (nos.)		

11. How the timber obtained
    (a) Govt. forests/Private forest
    (b) Was it hand sawn or sawn in the mill

Contents

12. Repairs of house

	Round	Sawn
(a) Cycle of repair (Intervening period between repairs).		
(b) Timber used for repair (cu.m.)		
(c) Bamboo used for repair (Nos.)		

III. CONSUMPTION OF FIREWOOD ETC.

13. Consumption of fire wood per day

(a) Species used for fire-wood

(b) Species preferred for fire-wood

(c) Any other fuel used for cooking (Kerosene, electricity etc.) If yes, quantity

IV. AGRICULTURAL IMPLEMENTS

14. Type and No. of agricultural implements maintained.

	Round	Sawn
15. Quantity of timber required for agricultural implements (cu.m.) (species-wise)		

16. Life span of agricultural implements (Give separately for each type).

17. No. of bullock carts

	Round	Sawn
(a) Timber used (cu.m.)		
(b) Bamboo (Nos.)		

18. Any other information

Signature of recorder
Place:
Date :

Contents

ANNEXURE-2
BHD-1

PREINVESTMENT SURVEY OF FOREST RESOURCES
(BHUTAN)

Market and Demand Studies

Consumption of wood by wood based industries in the consumption zone.

I. GENERAL

1. Name and address of industry with year of establishment.

2. No. of band saws in operation

3. Horse Power of Engine

4. No. of workers employed.

   i) Skilled
   ii) Unskilled
   iii) Managerial

II. INTAKE AND OUT-TURN

5. Intake of round wood (m^3) per day.

   (a) Installed capacity

   (b) Actual intake

6. Average No. of mill working days/year

7. Total annual intake of wood

8. (a) Quantity of timber brought by others, if any, sawn/processed on payment of charges.

   (b) What are the charges of sawing/processing per unit volume.

9. Primary conversion out-turn/day(m^3) (in case of plywood it will be in sq.metres of veneer of specific thickness).

Contents

10. Quantum of wastage and mode of its disposal (give approximate break-up and price/unit, if sold).

11. Sources of timber (give percentage of material from different sources)

    (a) From Govt. forest of Lower Assam (Goalpara, Kamrup, Darrang Distt.) (Directly through purchase or indirectly through lessees etc.)

    (b) From forests of Bhutan (Directly through purchase or indirectly through lessees etc.)

    (c) From other sources

12. Landed cost of raw material

13. Important sizes sawn/finished products produced.

14. Any bulk supply of finished products to organized sectors.
    If yes, give details.

15. Destination to which the sawn wood/finished product is going.

16. Price of sawn wood/finished product (for important species and most popular sizes).

17. Cost of manufacture (e.g. cost of sawing, cost of manufacturing finished products etc.)

18. Break up of total intake of wood by species (Round wood in m^3).

19. Any expansion plan

20. Any other imformation.

Signature of Recorder.

Place:
Date :

Contents

ANNEXURE-3
BHD-2

PREINVESTMENT SURVEY OF FOREST RESOURCES
(BHUTAN) :

Market and Demand Studies

QUESTIONNAIRE

(To be filled up by interviewing the forest lessees, timber merchants etc.)

1. Name and address

2. Type of firm (i.e.proprietary, partnership etc.)

3. Total yearly turn-over of timber

	Quantity (m^3)	Value (Rs.)

4. Source/origin with distance.

5. Cost price

6. Whether purchased directly from Govt. Timber Depot, Govt. forests through Contractors, through other timber merchants, Commission Agents, Cultivators etc.)

7. Storage facilities

   (a) Area of yard

   (b) Type of shed, if any, whether rented or owned; if rented, what is the rent?

   (c) Period of storage and time

8. Cost of handling and storage

9. Is any processing done?

10. Main species stocked (Indicate the approximate percentage of stock)

Contents

11. Any grading done?

12. Main sizes in demand.

13. Method of sale

14. Selling price of different species and sizes (Ex-depot)

15. Destinations to which timber despatched.

16. Main buyers

17. What are the end uses of timber sold?

18. Total annual turn-over of timber in the market (particular town)

19. What is the current trend in timber market?

20. Any other information

Signature of Recorder

Place :

Date:

Contents