Report on a

short term consultancy on

Forest Resources Management Planning

Preparation of Forest Management Planning Code of Bhutan

Chapters on:

II a: Forest Resources Potential Assessment
II b: Reconnaissance Survey
IV a: Forest Function Mapping

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Bhutan

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Forest Resources Potential Assessment

Section	Selection of Forest Management Units	II
Sub-Section	Forest Resources Potential Assessment	a

Keywords	forest resources, identification of FMU, protected areas, managed areas, production potential, demand, supply,
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ACRONYMS

ARCINFO	GIS computer software
DEM	Digital Elevation Model
EXCEL	Spreadsheet software
FMU	Forest Management Unit
FRPA	Forest Resources Potential Assessment
FRDS	Forest Resources Development Section
FSD	Forestry Services Division
GIS	Geographic Information System
GIS-Cell	GIS-Cell of FRDS
IDRISI	GIS computer software
LUPP	Land Use Planning Project
LUWM	Land Use Working Maps
NTFP	Non Timber Forest Products
PIS	Pre-Investment Survey
RS	Reconnaissance Survey
SPOT	Type of satellite imagery

1 Objective

The FRPA should provide information, on a macroplanning level, on the forest resources within a dzongkhag, with special regard to their potential for future forest management. In particular it should:

- describe and quantify the different forest types and their production capacity;
- assess the production potential of the forest resources with special regard to present and future timber and wood demand (demand/supply scenario);
- identify areas which have a potential to be managed on commercial basis as self-sustainable[1] Forest Management Units.

The FRPA is the first step in the 5-level planning approach in forest resources management in Bhutan. With relevance to forest management planning, the identification of potential FMU areas is the main objective.

2 Administration

The FRPA should be prepared for each dzongkhag. It is, in general, a one time exercise, and not a periodically repeated planning process, like forest management planning or operational planning. The FRPA should be conducted by FRDS. While the preparation of the FRPA-Map, which provides the basic information on the location of potential forest areas, is done entirely by the GIS-Cell, the overall assessment of the forest resources within the dzongkhag and the estimation of the production capacity and its valuation in relation to the wood demand should be prepared by an experienced forest management planner. He also should have the overall responsibility on the FRPA preparation.

3 Approach and Sources of Information

The FRPA has been designed in such a way, that

- human and financial input is kept to a minimum;
- it can be implemented entirely by FRDS;
- It is compatible with LUPP data;
- it is applicable for all districts of Bhutan;
- it provides information precise enough for macro-planning purposes.

The FRPA is, therefore, based entirely on the analysis of already existing information, namely forest management inventory data and LUPP land use classification. The process of the FRPA is outlined in Figure 1.

The FRPA consists of the FRPA-Map and the FRPA-Report. The FRPA-Map is prepared at a scale 1:100.000 for the whole dzongkhag area and shows all potential forest areas according to forest type. The FRPA-Report contains the description of the general forest situation of the dzongkhag such as distribution of forest types, assessment of standing stock and increment and an analysis of the production potential of the forest resources.

[1] self-sustainable FMU in this context is defined as a FMU which produces continously in a sustainable way an approximately same amount of timber

Figure 1: Process of FRPA

insert FIGURE1.CFL

4 Identification of Potential Production Forest Areas (Preparation of FRPA-Map)

The preparation of the FRPA-Map is done by the GIS-Cell based on the land use information of the LUPP Land Use Working Maps, which are available in digital format. It has to be mentioned at this place, that it was experienced during field surveys, that LUPP sometimes misinterpreted the forest type and, more often, the density class. For the purpose of macroplanning, these misinterpretations are still acceptable. However, the FRPA-Map should not be used for the identification of the forest type and density of a particular area. For this purpose, the old PIS forest type maps provide better information. The forest/non forest boundaries, however, are quite accurately interpreted by LUPP.

4.1 Definition and Identification of Potential Forest Areas

The term potential in this context refers only to timber and wood production. At this macroplanning level, it is not possible to assess and quantify other aspects such as NTFPs, wildlife or pasture potential; this will be subject of the subsequent planning steps.

In order not to overload the GIS-System and to keep the FRPA practical, the number of criteria and parameters to be used for the identification of potential forest area has to be kept to the most essential ones which are the following:

4.1.1 Slope

According to § 14 a (iii) of the Forest and Nature Conservation Act (1995*) "no permits shall be issued to fell and to take any timber where the slope is greater then 45 degrees (100%) unless authorized under an approved management plan or by the Head of the Department."*

Therefore, all areas with a slope above 100% should be considered as inoperable and of having no potential for future forest management. The slope should be calculated by the GIS-Cell based on the digital elevation model (DEM). However, DEM generated maps based on 90 m contour intervals apparently underestimate the slope considerably. Tests in the field have shown, that areas above 75% are have a high percentage of inoperable areas due to difficult terrain conditions. Keeping this in mind, two categories of potential production forests should be identified by the GIS-Cell:

<u>Potential Areas (slope up to 75%)</u>

Generally suitable for forestry, percentage of inoperably areas such as narrow valleys, ridges, rock formations etc. is low.

<u>Limited Potential Areas (slope 76-100%)</u>

Principally suitable for forestry, however high percentage of inoperable areas. Terrain condition is generally difficult. The potential for forest management is low, due to high costs (road construction, harvesting) and related ecological risks of timber harvesting (e.g. soil erosion, etc). These areas should be highlighted on the FRPA map with red lines. The decision, whether these areas are suitable for timber production, or not, can only be done based on field checks (refer to chapter Reconnaissance Survey of the Forest Management Planning Code of Bhutan).

4.1.2 Forest Land Use Type and Density

In general, all forest types of Bhutan have a potential for forest production except forest shrub. However, open forests with a density below 40% does not have that much potential for timber harvesting at the moment. Either, those forests are used for intensive grazing (silvo-pastural systems) and/or fulfill other production objectives than timber production, or they are already in the regeneration or building phase and there is low potential for timber harvesting within the next future. That does not mean, however, that they should not be managed.

Therefore all forest types above 40% density are considered as potential. They should be further subdivided into <u>potential</u> and <u>high potential</u> forests.

High Potential Forests (high management priority)

All forest types having a high standing volume, particularly in the upper diameter classes, are considered as high potential. In general these forests are over-mature and sometimes already in the fragmentation phase. According to the analysis of inventory data, this is the case for most of the forests of LUPPs density class 2, except for pine forests. Therefore, the following forest types (LUPP classification) are considered as high potential:

FCf2, FCb3, FCc2, FBc2, FB2

They should have priority for forest management as the trees should be harvested before they decay or rot and are no longer usable. In addition, it is important to regenerate these forests, either naturally (control of grazing) or by planting.

Potential Forests

These forests are of comparatively good condition, they are in general younger in age and well stocked. They also have a comparatively high standing volume, which is distributed more in the middle diameter classes. They are mature forests, with a high potential for timber production, but there is not such an urgent need for forest management (timber harvesting and regeneration) as it is the case for the high potential forests. The following forest types are considered as potential forests:

FCf3, FCm3, FCb2, FBc3, FB3

Chirpine forests of density class 2 (FCc2) are usually intensively used by the local people as silvo-pastoral systems. Therefore, they should not be considered as potential forests for intensive forest management with the objective of timber production.

Low Potential Forests (low management priority)

The remaining forests are classified as of low potential for forest management, which are:

FCf1, FCm1, FCb1, FCc1, FCc2, FBc1, FB1

4.1.3 Management Status

National parks, reserves and other protected areas should be considered as non production forests. For otherwise managed areas (ie. water catchment areas for hydroelectric power plants), etc. the relevant institutions should be contacted to identify the imposed management restrictions. The final decision, whether the area should be included in the FRPA as potential production forest area or not, should be taken by the Joint Secretary of FSD.

4.2 GIS-Analysis and Map Preparation

4.2.1 Process of GIS-Analysis

The whole process of the GIS-analysis is briefly described in the following:

The land use information (LUWM) from LUPP is available as vector based ARC/INFO coverages based on individual toposheet (scale 1:50.000) format. Therefore, first of all, for each dzonghkag the land use information has to be joined and edgematched. Due to misinterpretations, in some cases, the polygons will not match from one map sheet to the other. It is, therefore, necessary to check the joined LAND USE coverage and to correct mismatching polygons with the help of SPOT satellite imagery or aerial photos (if available). For large dzongkhags, it might be possible, that the memory of the computer is too small to join all the coverages into one. Therefore, the area of the dzonkhag has to be splitted first into a number of separate land use coverages which have to be joined together at the end of the analysis.

The slope should be anlysed based on the satellite-derived digital elevation model (DEM) which has approximately a 90 m resolution and which is available at LUPP and FRDS. Using the raster-based IDRISI software and the DEMO3 coverage of Bhutan, the area covered by the concerned dzongkhag should be clipped by indicating reference x and y coordinates. The slope should then classified into three categories (<76%, 76-100%, >100%) and this SLOPE coverage has to be converted into a vector based ARC-file. All further analysis can then be carried out by using the PC-ARC/INFO software.

The next step is, to create a LANDSLP coverage by joining the LAND USE and SLOPE coverages. Then all protected or otherwise managed areas (ie.g. national parks, FMU´s, community forests, etc.) have to be digitized, coded and and saved as FMU coverage. LANDSLP and FMU coverage should be joined to create FINAL1 coverage.

A coverage named CONTOUR containing altitude classes in 1000 m intervals should be prepared and joined with FINAL1 to create the FINALX coverage. Then a GEWOG coverage needs to be prepared and joined with FINALX to FINALXX.

Before the FRPA-Map can be printed, the map lay out and the legend needs to be prepared. As all areas, which are already under some type of management, are left blank on the map (Note: this helps to identify potential production forests, which should be taken under management in future (potential FMUs), for each of these areas, a separate map should be prepared indicating the potential forest areas and forest types.

The tables below specify the GIS coverages and variables used for the GIS-analysis.

Table 1: GIS coverages prepared for FRPA

Coverage	**Content**	**Variable name**
LAND USE	land use classes, forst types	SYMB
SLOPE	slope classes	GRID_CODE
FMU	areas excluded from analysis	CODE9
CONTOUR	altitude classes	CNLNVALUE
GEWOG	gewog boundary	NAME
LANDSLP	LAND USE joined with SLOPE	
FINAL1	LANDSLP joined with FMU	
FINALX	FINAL1 joined with CONTOUR	
FINALXX	FINALX joined with GEWOG	

Table 2: Definition of variables used for preparation of GIS-coverages and statistical calculation

Variable name	**Content**	**Code**
SYMB	land use class	i.e. FCf2, FCf3, FBc2, FB3
GRID_CODE	slope class	1: <76% 2: 76-100% 3: >100%
CODE9	protected area name	i.e. Dawakha, Rimchu, JDNP
CNLNVALUE	altitude range	1: <1000 m 2: 1000-2000 m 3: 2000-3000 m 4: 3000-4000 m 5: >4000 m
NAME	gewog name	i.e. Nyisho, Khazi

4.2.2 The FRPA-Map

The FRPA-Map should be prepared at a scale 1:100.000 and should include drainage, infra-structure (e.g. villages, settlements, roads, etc.) and 200 m altitude lines.

For potential production forests, the different forest types should be distinguished by colour. High potential forests should be given a darker colour tone than potential areas. Non potential forests should be joined together as "low density forests", and they should be indicated on the FRPA-Map, too. Limited potential areas having a slope of 76-100%, should be highlighted with red lining. Already managed areas should be labelled with their respective name, however, no

forest types should be indicated here. As already mentioned, separate maps should be prepared for these areas.

4.2.3 Statistics on Potential Production Forest Areas

The calculation of the area statistics has to be done based on FINALX and FINALXX coverages using the PC-ARC/INFO software.

For the whole dzongkhag, for each individual geog, each individual protected area and each identified potential FMU, a statistic on the potential production forest areas should be prepared according to 1000 m altitude intervals and potential category. An example for Ruepaisa Geog, Wangdue-Phodrang Dzongkhag, is given in Table 3 below.

Table 3: Potential production forest area of Ruepaisa Geog

RUEPAISA GEOG

Total area: 16360 ha
Total forest area: 14615 ha
Total potential area: 10122 ha

Potential area without FMU's and protected areas

	Altitude in m											
LUPP	< 1000		1000 - 2000		2000 - 3000		3000 - 4000		> 4000		Total	
landuse	< 75%	75-100%	< 75%	75-100%	< 75%	75-100%	< 75%	75-100%	< 75%	75-100%	< 75%	75-100%
FCf2	0	0	0	0	0	0	0	0	0	0	0	0
FCf3	0	0	0	0	0	0	0	0	0	0	0	0
FCm2	0	0	0	0	332	196	138	99	0	0	470	296
FCm3	0	0	0	0	10	3	38	15	0	0	47	18
FCb2	0	0	0	0	252	42	37	11	0	0	289	52
FCb3	0	0	0	0	0	0	0	0	0	0	0	0
FCc3	0	0	0	0	0	0	0	0	0	0	0	0
FBc2	36	0	699	78	83	3	0	0	0	0	818	81
FBc3	0	0	0	0	297	12	85	21	0	0	383	32
FB2	57	18	103	19	308	15	100	8	0	0	568	59
FB3	0	0	983	86	2822	311	136	38	0	0	3941	434
Total	**93**	**18**	**1785**	**183**	**4104**	**582**	**534**	**192**	**0**	**0**	**6516**	**972**

Potential area including FMU's and protected areas

	Altitude in m											
LUPP	< 1000		1000 - 2000		2000 - 3000		3000 - 4000		> 4000		Total	
landuse	< 75%	75-100%	< 75%	75-100%	< 75%	75-100%	< 75%	75-100%	< 75%	75-100%	< 75%	75-100%
FCf2	0	0	0	0	0	0	0	0	0	0	0	0
FCf3	0	0	0	0	0	0	0	0	0	0	0	0
FCm2	0	0	0	0	519	196	244	103	0	0	762	299
FCm3	0	0	0	0	382	4	781	53	0	0	1163	57
FCb2	0	0	0	0	934	48	386	13	0	0	1320	61
FCb3	0	0	0	0	32	0	0	0	0	0	32	0
FCc3	0	0	0	0	0	0	0	0	0	0	0	0
FBc2	36	0	699	78	83	3	0	0	0	0	818	81
FBc3	0	0	0	0	1040	12	152	22	0	0	1192	35
FB2	61	18	103	19	308	15	100	8	0	0	571	60
FB3	0	0	983	86	3135	312	146	38	0	0	4264	436
Total	**97**	**18**	**1785**	**183**	**6433**	**590**	**1809**	**237**	**0**	**0**	**10122**	**1029**

4.3 Identification of Potential Forest Management Units

It is one of the objectives (see chapter 1) of the FRPA to

- identify areas which have a potential to be managed on commercial basis as self-sustainable Forest Management Units.

The following criteria should be used for the preliminary identification of potential Forest Management Units based on the information available on macroplanning (FRPA) level. Additional criteria will be applied and checked during the Reconnaissance Survey (refer to chapter on Reconnaissance Survey of the Forest Management Planning Code of Bhutan).

Forest Condition

The area should be well stocked and should consist of a high percentage of valuable (commercial) species in order provide sustainable yield for long term management. Especially areas with a high percentage of conifer forests are well suited for the establishment of a FMU on commercial basis.

This information can be directly derived from the FRPA-Map. High potential areas of coniferous forests should have priority.

Accessibility

The area must be easily accessible with a minimum of forest road construction.

Based on the FRPA-Map the approximate need for road construction can be estimated. Detailed cost calculation will be subject of the Reconnaissance Survey.

Size

The area of the proposed Unit should be of reasonable size, i.e. around 5000 ha, in order to allow self-sustainable long term forest management.

Boundary

The boundaries of the proposed FMU should form a part of sub-catchment of the main watershed. The proposed Unit should encompass all barren and degraded areas adjacent and within the Unit for the purpose of rehabilitation. The preliminary boundary should be defined by visual assessment of the FRPA-Map. It is the task of the Reconnaissance Survey to finally verify and to determine the FMU boundary.

5 Calculation of Production Potential

Based on the area statistics provided by the GIS-Cell, an estimate of the overall standing stock and the increment should be calculated for the whole dzongkhag, each individual geog and for proposed FMUs. This should be done with the help of the EXCEL-file named FRPACALC.XLS by inserting the area in ha of each individual potental forest type in the INPUT-sheet. The result of the calculation is given in the RESULT-sheet. (Note: This spreadsheet contains average standing volume and increment estimates per ha, for the different potential forest types which has been derived from the analysis of selected forest management inventories).

An example of this spreadsheet is attached in Annex 1 and the EXCEL-file itself is available at FRDS.

The calculation of average standing stock and increment will allow a rough estimate of the production potential of the concerned area. This information is required for the assessment of the wood demand/supply scenario which should be included in the FRPA-Report.

6 Preparation of FRPA-Report

The FRPA should contain a brief description of the physiographic and socio-economic conditions of the dzonkhag. The forest resources and their distribution, including an assessment of their production capacity, should be described in more detail. Already existing protected or otherwise managed areas should be described and areas with a potential for future forest management should be identified and described in more detail, too. Finally, the production potential of the forest resources in relation the wood demand should be analysed. In the annexes, area, volume and growth statistics should be attached for the whole dzongkhag area, for each individual geog, protected or otherwise managed area and proposed potential FMU.

The table of content including some keywords and/or examples are given below:

Table of Content

1 Introduction
Objective of FRPA, sources of information, prepared by whom;

2 General Description of Physiography
2.1 Location and Size
- include location map

2.2 Drainage and Aspect
2.3 Altitude
2.4 Slope
2.5 Geology
2.6 Soil
2.7 Climate
2.8 Vegetation

3 Socio-Economic Conditions
3.1 Population
- Rural/urban, number of households, average household size, population density and estimated growth rate

3.2 Human Natural Resource Use
- Describe main natural resource uses, agriculture, cattle numbers, wood consumption figures, exploitation rates, effects of resource uses, etc.

3.3 Wood-Based Industry
- Describe existing and planned wood based industries in the dzongkhag area, including production figures; describe their demand on wood (species, quality, present origin of roundwood supply, etc.), present market structures, etc.

4 Forest Resources Potential Assessment
- This chapter contains a general description of the forest resources.
- Distribution of forest/non forest areas, existing FMUs and protected areas, etc.
- Include following type of table (example):

Table 4: Area distribution of Wangdue-Phodrang Dzongkhag (Source: BG-IFMP, 1996)

Management Status	Non-Forest	Forest Area			Total Area
		Non-Potential	Limited Pot.	Potential	
	(ha)	(ha)	(ha)	(ha)	(ha)
Nahi FMU	888	1079	283	5386	7636
Kothoka FMU	701	1161	90	7427	9379
Kamichhu FMU	388	3568	1013	3716	8685
Chendebjie FMU	0	39	50	1485	1574
Total FMU	**1977**	**5847**	**1436**	**18014**	**27274**
Black Mountains NP	1772	14139	12292	29920	58123
Phobjika Protected Area	4075	1768	166	6334	12343
Basechhu Hydel	1435	1886	1431	20034	24786
Total Protected	**7282**	**17793**	**13889**	**56288**	**95252**
Unmanaged Areas	**130489**	**21879**	**21943**	**106983**	**281294**
Total Dzonkhag	**139748**	**45519**	**37268**	**181285**	**403820**

4.1 Potential Forest Area Distribution

- Description of total area, forested areas, managed areas, different forest types, etc.;
- Include following type of tables and figures (examples):

Table 5: Potential areas of Wangdue-Phodrang Dzongkhag (Source: BG-IFMP, 1996)

Potential Class	FMU etc.		Protected		Unmanaged		Total	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
high potential	6274	3	20823	12	53938	30	81035	45
potential	11740	6	35465	20	53045	29	100250	55
total potential	**18014**	**9**	**56288**	**32**	**106983**	**59**	**181285**	**100**
limited potential	1436	4	13889	37	21943	59	37268	100

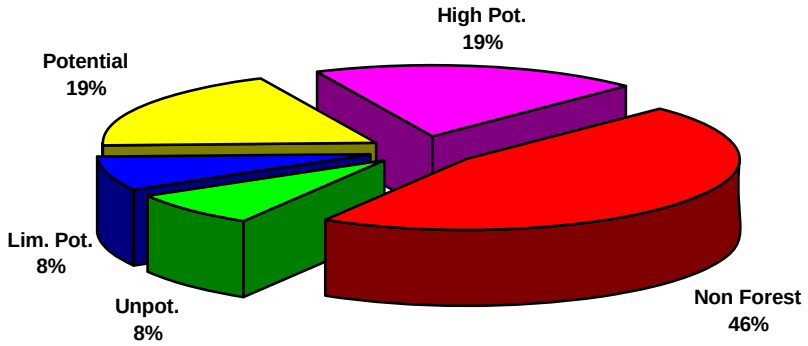

Figure 2: Potential area distribution in unmanaged areas of Wangdue-Phodrang Dzongkhag (Source: BG-IFMP, 1996)

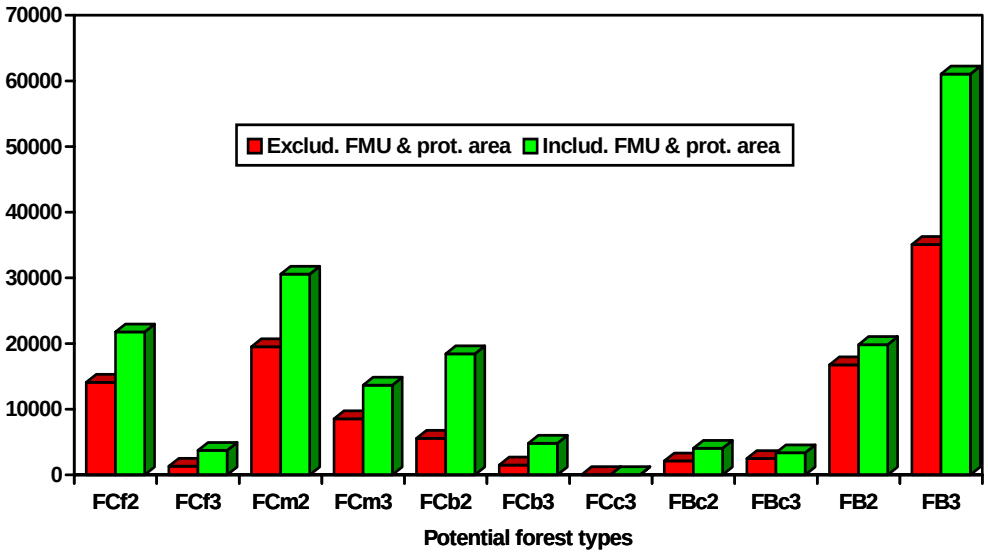

Figure 3: Distribution of potential forest areas in Wangdue-Phodrang Dzongkhag (Source: BG-IFMP, 1996)

4.2 Growing Stock and Growth

- Describe for whole dzongkhag total growing stock, increment, species distribution, diameter distribution;
- statistics for geogs are attached in annexes;
- include following type of tables:

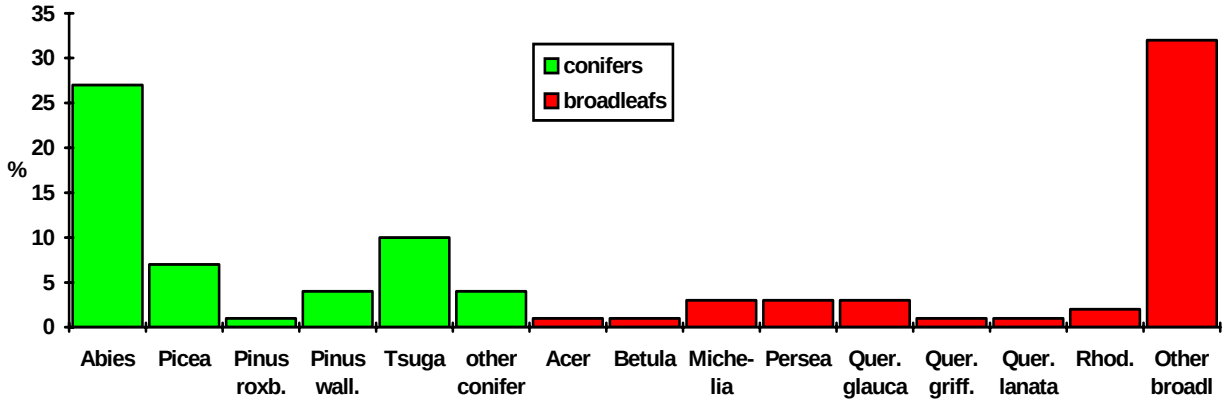

Figure 4: Species distribution of gross volume in Wangdue-Phodrang Dzongkhag (Source: BG-IFMP, 1996)

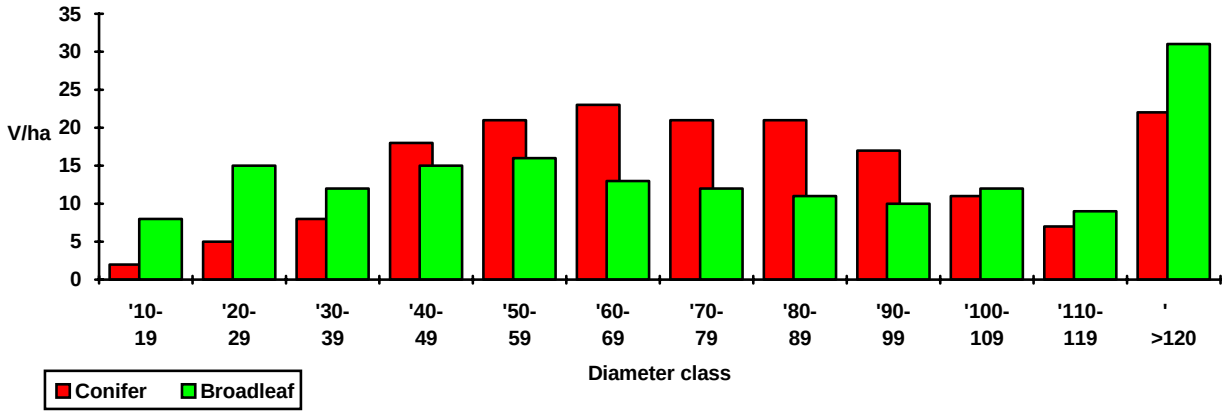

Figure 5: Diameter distribution of gross volume for Wangdue-Phodrang Dzongkhag (Source: BG-IFMP, 1996)

4.3 Already Managed and Protected Areas

- Describe for each FMU and protected/managed area: location, size, physiography, management status, management responsibility, production capacity, existing plans, problems, etc.

4.4 Identified Potential Forest Management Units

- Describe for each identified potential FMU: location, size, proposed boundary, land use and forest types, estimated standing stock and increment, estimated production capacity, accessibility, proposed harvesting and silvicultural systems, etc.

5 Valuation of Production Capacity with Special Regard to Wood Demand

- Describe present rural, urban and industrial wood demand (fuelwood, construction wood, etc.).
- Assess import/export of wood from dzongkhag, timber flow, market structures.
- Valuate present and future demand/supply with special consideration of production capacity within and outside existing and potential FMUs.
- Propose solutions, if demand cannot be met by local production.

Annexes:

1 Potential Forest Area Statistics for Whole Dzongkhag
2 Geog Statistics
3 Protected Areas
4 Potential FMUs

These annexes should contain the area statistics for the individual units (dzongkhag, geog, protected area, potential FMU) and the estimate on the cross volume and increment as calculated by FRPACALC.XLS.

Annex 1

Calculation of Production Potential Using FRPACALC.XLS

insert ANNEX1.XLS

Reconnaissance Survey

Section	Selection of Forest Management Units	II
Sub-Section	Reconnaissance Survey	b
Paragraph		

Keywords	reconnaissance survey, inventory, socio-economic study, rapid rural assessment, preliminary environmental assessment, economic feasibility study, field check, sustainable AAC, operable area, wildlife, environment, road alignment, accessibility
Author(s)	Forest Resources Development Section, Thimpu

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Acronyms

AAC	Annual Allowable Cut
API	Aerial Photo Interpretation
CV%	Coefficient of Variation (%)
DEM	Digital Elevation Model
DFO	District Forest Officer
EFS	Economic Feasibility Study
FDC	Forest Development Corporation
FMU	Forest Management Unit
FRPA	Forest Resources Potential Assessment
FSD	Forest Services Division
GIS	Geographic Information System
GPS	Geographic Positioning System
LUPP	Land Use Planning Project
NCS	Nature Conservation Section
NEC	National Environment Commission
PEE	Preliminary Environmental Assessment
PIS	Pre-Investment Survey
RFI	Reconnaissance Forest Inventory
RRA	Rapid Rural Assessment
RS	Reconnaissance Survey
RSPB	Royal Society for the Protection of Birds
SE%	Sampling Error Percent
SES	Socio-Economic Study

1 Introduction

1.1 Objective

It is the objective of the Reconnaissance Survey to provide the decision makers of the FSD and FDC with all social, environmental and economic information required to decide whether a FMU should be opened and managed on a commercial basis or not. It is a more detailed assessment of a particular forest area which has been defined as a potential FMU during the FRPA.

1.2 Administration

The Reconnaissance Survey should be implemented by the Reconnaissance Survey Section of FRDS which should be supported by the GIS-Cell, API-Cell and the Forest Inventory Section.

1.3 Components of the Reconnaissance Survey

Before the actual Reconnaissance Survey takes place a *Pre-RS Field Check* must be carried out to check whether the area is suitable at all for commercial forest management. If this check comes to a positive result, the actual Reconnaissance Survey is carried out, which consists out of the following four components:

- *Socio-Economic Study (SES)*
- *Reconnaissance Forest Inventory (RFI)*
- *Preliminary Environmental Examination (PEE)*
- *Economic Feasibility Study (EFS)*

The *Socio-Economic Study (SES)* is based on a Rapid Rural Assessment (PRA). Beside key social data information on local resource use should be collected. The most important result, however, is to identify whether there is any social opposition, perception or constraint which might affect commercial forest management. If there is a very strong opposition against forest management out of whatever reason, the planning process should stop and the area should not be further considered as a potential FMU.

The implementation of *a Reconnaissance Forest Inventory (RFI)* provides the most essential information for the economic analysis: an estimate of the potential annual allowable cut (AAC) and defines the priority areas for management.

The *Preliminary Environmental Examination (PEE)* is based on the results of the Pre-RS Field Check, the RFI and the SES and it should valuate the suitability of the concerned area for commercial forest management from the environmental point of view.

The *Economic Feasibility Study (EFS)* is the last step to be implemented. It should valuate the suitability of the concerned area for commercial forest management from the economic point of view.

The results of the individual components have to be compiled into a *Reconnaissance Survey Report* by the Head of the Reconnaissance Survey Survey Section and has to be submitted to the Head of FSD for decision taking.

Figure 1 shows the process of conducting a Reconnaissance Survey.

Figure 1: Process of Reconnaissance Survey
(insert FIGURE1.CFL)

2 Selection of Potential FMU for Reconnaissance Survey

There will be a number of areas which will be identified by the FRPA as potential FMUs. To decide on the priority for further investigation, to answer the following questions will help:

Is the FMU in a dzonkhag that currently does not have an FMU?

It is the policy of the government that each dzongkhag should have at least one FMU.

Is the FMU located close to existing roads?

Check that there is in fact currently road access to, or close to, the FMU boundary. Even a small length of road or a bridge which must be built can be very expensive. Are there any relevant planned roads?

Does the FMU meet an urgent demand on forest products?

The products and the source of the demand (if possible with estimates of quantities) should be identified. Is there any wood based industry in the region which should be supplied? Include demand from within and outside the dzongkhag or territory.

Does the FMU fit into the dzongkhag or regional development plan?

With decentralization, it will be necessary to make sure that the planning and objectives of the new FMUs fit in with regional and dzongkhag development plans. For example for road development expansion.

Will the FMU be a simple one to implement?

Staff are in short supply and some FMUs will be easier to implement than others (ease of interal FMU access, access to markets and consumers, fewer people in the forest, less difficult topography, etc.).

It is the task of the Reconnaissance Survey Section to answer these questions and to submit a proposal of selected FMU(s), where a reconnaissance survey should be conducted in the next field season, to the Head of FRDS. The final approval for implementing the reconnaissance survey has to be given by the Joint Secretary of FSD.

3 Preparation of Reconnaissance Survey

Before the actual reconnaissance survey is carried out in the field, a thorough preparation of the survey in the office is required.

3.1 Identification of FMU and Verification of Boundary

The FRPA has identified, on a macroplanning level, areas which might be suitable to be managed as Forest Management Units on a commercial basis. This preliminary identification was based on the following criteria:

- topography (slope)
- forest condition (type and density)
- excluding already protected and/or managed areas.

At this stage, the boundaries of the proposed FMU should be checked whether they are practical and logical. The initial location on the map will have to be dicussed with the DFO. Once, the boundary has been identified, it has to be marked on a topographic map 1:50.000 and set of photocopies should be prepared (at least 10).

Before, however, actual work starts, it needs to be ensured, that the proposed FMU is really not located in a new established protected or otherwise restricted area, nor included or under plan to be included under some other conflicting form of management. The FMU boundary has to be discussed, therefore, with the following agencies:

- Nature Conservation Section, FSD;
- Forest Protection, Land Use and Utilization Section, FSD;
- Social Forestry and Afforestation Section, FSD;
- Territorial Coordinating Section, FSD;
- Relevant Forest Division (DFO), FSD;
- Responsible Dzonkhag Administration;
- Natural Resources Management Division of the National Environment Commission;
- Forest Development Corporation;
- Department of Power.

The above agencies should receive a copy of a 1:50.000 topographic map showing the proposed FMU boundaries. The object of the discussion is not to obtain formal approval from these agencies. It is to ensure that they have a chance to comment at an early stage and to avoid conflicts. Any serious problem has to be resolved before the RS continues further.

3.2 Collection of Information and Preparation for Field Work

All available information on forest cover and land use types should be collected. The objective is to prepare a base map indicating actual forest/non-forest boundary, preliminary forest types and potential operable and accessible areas. For this purpose, the following working documents are required:

1. topographic map with 40 m contour lines at a scale 1.50.000 (including FMU boundary);
2. PIS-map at a scale 1:50.000;
3. LUPP land use maps at a scale 1.50.000;
4. SPOT satellite image (if available);
5. Aerial photos (if available).

The preparation of the preliminary forest type map should be done based on LUPP- and PIS-maps and verified with SPOT imagery. Experiences made during field truthing exercise in forest management planning have shown, that LUPP maps are quite accurate as far as forest/non forest boundaries are concerned. Forest land-use, however, has been often misinterpreted by LUPP. On the other hand, it was observed, that, inspite of their age, the PIS-maps provide quite good information on the forest types, specially in remote areas, where there was hardly any

human impact since their preparation in the 1960´s. Therefore, the forest/non-forest boundary should be determined based on LUPP working map (if available, verify with Spot imagery or aerial photographs), the forest types, however, should be derived from the PIS maps.

The GIS-Cell should prepare a slope map at a scale 1:50.000 with 90 m contour intervals based on the Digital Elevation Model data (or better contour maps with smaller intervals if available), with the following slope classes marked on: < 26%, 26-50%, 51-75%, 76-100%, > 100 %. Using this slope map, delineate areas (generalize!) where most of the land has slopes above 75%. All areas above 75% can be considered as inoperable[1].

Transfer the inoperable area from the slope map to the preliminary forest type map. This will be the base map for the reconnaissance survey. This map should be available at a scale 1:25.000 and 1:50.000.

[1] According to § 14 a (iii) of the Forest and Nature Conservation Act (1995*) "no permits shall be issued to fell and to take any timber where the slope is greater then 45 degrees (100%) unless authorized under an approved management plan or by the Head of the Department."* However, DEM generated maps based on 90 m contour intervals apparently underestimate the slope considerably. Tests in the field have shown, that delineated areas below or above 75% are an acceptable accurate, efficient and objective estimate of operable and non-operable areas.

4 Pre RS-Field Check

This step is very important. A short field visit may provide a quite different view of the proposed FMU and should reveal any obvious errors. Information available may have been superseded or may be wrong. For example, an area may already have been logged. Local people should be informed at that stage, that the government has the intention to check whether this area is suitable to be opened as a FMU on a commercial basis. They should also be informed about the subsequent steps of the reconnaissance survey, in particular on the Reconnaissance Forest Inventory (RFI). Whenever possible, the Rapid Rural Assessment (refer to chapter 5.2.1), where they will have the possibility to express their views, wishes and perceptions in detail, should be linked with this Pre-RS Field Check. If this is not possible, the necessary arrangements and appointments for the RRA should be made at that stage.

During the Pre-RS Field Check, an experienced forester should assess:

- the FMU boundaries - confirm that they are reasonable;
- current road access - condition, suitable for heavy trucks, etc.;
- the forest types, including degraded areas;
- estimate of operable and non operable areas (basically checking and perhaps revising the estimate from the slope map);
- road construction difficulty;
- any possible environmental risk;
- current forest use;
- field conditions, transportation, food and accomodation for the reconnaissance survey crews.

This field check should take approximately two to three days. Based on it´s result, which has to be summarized in the form on Pre-RS Field Check (attached in Annex 1), the Head of FRDS should decide whether a Reconnaissance Survey will be carried out or not.

5 Socio-Economic Study (SES)

5.1 Objective

It is the objective of the Socio-Economic Study to:

- identify whether there is any social opposition, perception or constraint which might affect commercial forest management;
- to collect key social data;
- provide information on local resource use and potential forest management restrictions;
- to collect information on wildlife and flora for the PEE.

5.2 Data Collection and Source of Information

The information required for the SES are provided by the following sources:

- Rapid Rural Assessment
- Dzongkhag and other statistics.

The anlasysis of Dzonkhag and other statistics, namely that of the DFO, should be done before the RRA is conducted, in order to make the forester in charge familiar with the basic socio-economic information on the potential FMU area.

5.2.1 Analysis of Dzongkhag and Other Statistics

The following data should be collected from Dzongkhag statistics:

- number of villages and settlements;
- number of households and population;
- figures on livestock (number of cattle, horses, mules, goats and sheep);
- information on grazing rights (tsamdos).

From the district forest office, information on forest production, logging activities or afforestations should be collected. Furthermore, the demand of the local wood based industry in the vicinity of the potential FMU should be assessed.

5.2.2 Rapid Rural Assessment

The Rapid Rural Assessment, in this context, is an informal meeting with the villagers and local people living in the concerned FMU area. It should be conducted, whenever possible, during the course of the Pre-RS Field Check. Depending on the number of villages and settlements, it should not take more than two to three days. It is of importance, that the RRA is headed by a forester who has experience in participatory approaches and in the implementation of village meetings. During the RRA the following topics should be dealt with.

Information on the intention to open a FMU.

The objective of the RRA is, first of all, to inform the local people on the intention of the government to open a FMU within their area. The have to be informed at this early stage about the consequences and possible effects (positive and negative) of forest management on their livelihood and on the environment.

Informal discussions to identify objections and constraints.

During informal discussions (attention should be paid that male and female are equally adressed) the local people should be encouraged to point out their objections and fears, they have concerning the intended commercial forest management. It is not the objective of these meetings to convince the local people on the positive effects of forest management and to gain their support, but rather to identify potential management constraints. If the people are actively involved from the very beginning in the whole FMU establishment process, future conflicts can be avoided. If during the course of this discussion, strong opposition against the establishment

of a FMU comes up, this needs to be considered seriously. The Head of the FRDS should be informed immediately and the matter should be discussed with the Joint Secretary of FSD who then should decide whether to stop the whole Reconnaissance Survey or not.

Anlaysis of problems of local people.

The local people should be encouraged to discuss openly about their problems and should try to rank them. Special attention should be paid to those problems which have a potential interlinkage with forest and land use (e.g. accessibility, forest and agricultural products, water availability, crop damage by wildlife, etc.).

Assessment of the expectations of the local people and possible changes in livelihood and land use.

It is of importance, that the expectations of the local people which are linked with future commercial forest management (ie. road access, job opportunities, etc) are discussed objectively. Exaggerated or unrealistic expectations need to be adjusted at this stage in order to avoid future disappointment and resulting conflicts.

Assessment of present forest resource use.

For the economic assessment it is of importance to know the approximate operable area for commercial forest management. Forest areas, which are intensively used by the local population should be set aside for their local use only (refer to chapter IV a on Forest Function Mapping, Forest Management Planning Code of Bhutan). A rough estimate of the area is sufficient at this stage. Furthermore, information should be collected on types and quantities of forest products, grazing rights (tsamdo) and other forest and land uses.

Information on wildlife and environmental issues.

For the Preliminary Environmental Examination information should be collected on the occurence of protected or rare wildlife species and their respective habitats, rare flora and ecosystems, problems with erosion or water availability and quality, etc..

5.3 SES-Format

The Socio-Economic Study should contain a brief analysis of the socio-economic conditions within the potential FMU area. It consists out of a standardised cover page (see form in Annex 2), where the most essential information is summarized and of an informal and unformated report, which should not exceed two pages. The SES should be prepared by the officer in charge of the RRA and has to be submitted to the Head of the Reconnaissance Survey Section.

6 Reconnaissance Forest Inventory (RFI)

6.1 Introduction

The RFI has been designed in such a way that the preparation of the inventory and the implementation of field work can be carried out for an average FMU in less than two month. The design chosen is a stratified inventory based on randomly distributed cluster samples. For the purpose of the FRI a sampling error of +/- 20% of the average gross volume per ha on 95% confidence level is sufficient. For the identification of the cluster location Geographic Positioning System (GPS) is used, which grants compatibility with the Geographic Information System (GIS) of FRDS. Planning and preparation of a RFI should be done by the Reconnaissance Survey Section of FRDS as only already existing and available information (namely PIS/LUPP maps, SPOT imagery, topo-maps) is required.

This code on the Reconnaisssance Forest Inventory describes the objectives and the inventory design and explains the preparation of a RFI, it´s analysis and the preparation of the RFI-Report. Guidelines for the implementation of the field work are provided in the Recon-naissance Forest Inventory Field Manual.

6.2 Objective

The Reconnaissance Forest Inventory (RFI) is the most crucial component of the Economic Feasibility Study, which forms the basis for decision makers to decide whether it is worthwhile to open a particular potential forest area as a FMU on a commercial basis. In particular, the RFI should provide the following information:

- estimate of average gross volume per diameter class and species/species group;
- area statistics for different forest strata (potential management areas);
- estimate of operable forest management area;
- estimate of exploitable commercial timber volume and potential AAC;
- observations on wildlife, minor forest products, human impacts and biodiversity.

Some of the information are also very useful for the elaboration of the other components of the Reconnaissance Survey: the Socio-Economic Study and the Preliminary Environmental Examination.

In addition, the RFI provides some information for forest management planning, which are in particular:

- sustainable AAC for the entire FMU area;
- preliminary identification of priority areas for forest management for the first planning period of 20 years.

6.3 Description of Inventory Design

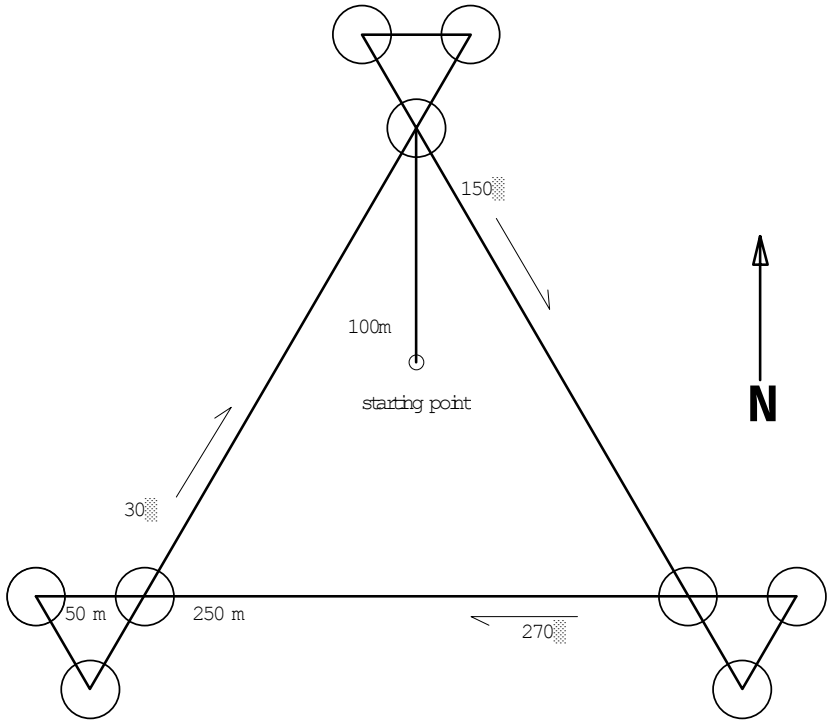
The RFI has been specially designed to fulfill the above mentioned objectives. For these purposes, it is suifficient if the sampling error of the average gross volume per ha does not exceed +/- 20% on 95% confidence level.

The inventory design selected can be described as

stratified inventory based on randomly distributed cluster samples.

The sampling design consists out of satellites (or clusters) of triangular shape with a triangular arrangement of relascope sampling clusters which are randomly distributed according to the size and coefficient of variation (CV%) of each stratum (see Figure 2).

Figure 2: Sampling design



The main triangle is called satellite, the smaller triangles are clusters. Each satellite consists out of three clusters, each cluster consists out of three relascope samples.

A satellite, in this context, is defined as a set of three inventory samples arranged in a triangular shape 250m apart from each other, which are treated as independent inventory samples. The three samples within one cluster are 50 m apart from each other. They are not independent and they are treated as one sample.

Justification

The inventory satellites are randomely distributed within predetermined clusters following a coordinate system. The number of inventory samples within one stratum depends on it´s size. This reduces the number of samples required. Random distribution of samples provides an unbiased estimate of the standard error. To arrange sample plots as satellites (independent samples) reduces the time required to reach the inventory sample location. Cluster sampling reduces the CV% and by this the number of sample plots required. Angle count sampling with the help of a relascope increases the precision of the estimate of the volume, as the probability to be selected as a sample tree is dependent from it´s size (basal area). Furthermore, it has the advantage, that no sample plot has to be surveyed.

Data collection is minimized to those which are really required. These are the following:

for each cluster:

- name of inventory unit
- number of cluster
- name of crew leader
- date
- average altitude
- average slope
- accessibility

for each sample:

- altitude
- slope
- accessibility
- tree species code
- diameter at breast height
- total height total height (only for one sample per cluster)
- signs of human impact
- signs of wildlife

For the purpose of a RFI it would be sufficient to identify only the commercial species. On the other hand, for the Preliminary Environmental Impact Assessment information on biodiversity is required. Therefore, all the different tree species have to be identified according to the species list attached in the "RFI-Field Manual" and in the „Guidelines for Forest Management Inventory Field Work“.

How to measure the individual data is described in detail in the RFI-Field Manual.

6.4 Preparation of Inventory

Before the actual field work can start, some preparatory work has to be done in the office, namely stratification of the forest area within the proposed FMU and the distribution of the inventory samples.

6.4.1 Stratification

Stratification of the operable areas is done based on the RS-base map (refer to chapter 3.2).

Main criteria for stratification are forest type and density class. The total number of different forest strata should not exceed 10. Each forest stratum may consist out of a different number of areas or substrata, which should have at least a size of 50 ha, smaller units have to be allocated to a neighboring stratum of similar crown density. Finally, the individual substratum should be serially numbered starting in the northeast corner of the map. The numbers should consist out of two digits, the first should indicate the type of stratum, the second one the serial number of the area or substratum (i.e.: 1.3 would be the third substratum of stratum 1). The final stratification including numbering should then be transferred to a transparent topo-map scale 1:50.000 with 40 m altitude lines.

After the stratification is completed the areas of the individual substrata have to be calculated. This should be done with the assistance of the GIS-Unit of FRDS.

6.4.2 Distribution of Samples

The total number of samples required depend from the target sampling error (SE%), the confidence level and the coefficient of variation (CV%). For the purpose of a RFI the tolerated SE% for the average gross volume per ha should be +/- 20% at a confidence level of 95%. The distribution of samples within the inventory area has to be done in the following way:

1. calculation of the optimal number of samples per stratum;
2. distribution of samples to the substrata of each stratum;
3. selection of sample location based on random figures;
4. preparation of a inventory base map 1:25.000 and a survey description.

ad 1.) Calculation of the optimal number of samples per stratum

Based on the total area and the CV% of each stratum (see Table 1), the optimal number of samples per stratum has to be calculated according to the formula below.

$$n = t^2 * \left(\sum P_i * CV_i\%\right)^2 / SE\%^2$$

$$n_i = n * (P_i * CV_i\%) / \sum (P_i * CV_i\%)$$

t	t-value on a confidence level of 95% $\approx$ 2
P_i	area weight of stratum i
n	total number of plots
n_i	total number of plots per stratum i
SE%	standard error
$CV_i\%$	coefficient of variation (for total gross volume per ha) for stratum i

Table 1: CV% for different forest types

forest type	CV%
Fir forest	50%
Blue pine	105%
Mixed coniferous	70%
Broadleaf	85%

An example for the calculation of required satellite samples is shown in Table 2 and Table 3 below.

Table 2: Example for the calculation of the required number of sample plots per stratum

Stratum	Area in ha	Area Weight	CV%	No. of Samples
1 fir forest, density > 60%	1825	.250	50	8.2
2 fir forest, density < 60%	242	.033	50	1.1
3 mixed conifer, density > 60%	4020	.552	70	25.4
4 mixed conifer, density < 60%	483	.066	70	3.0
5 broadleaf mixed with conifer	440	.060	85	3.4
6 broadleaf	287	.039	85	2.2
total	7299	1.000	-	43.3

Source: Gogona RFI

As each satellite sample consists of 3 independent samples, the number of samples has to be devided by three and rounded up to the next integer value (see example in Table 3 below). However, the minimum number of satellite samples to be allocated in each stratum should be 2.

Table 3: Example for the calculation of the required number of satellite samples

Stratum	Calculation	No. of satellite samples
1 fir forest, density > 60%	INT(8.2/3)	3
2 fir forest, density < 60%	INT(1.1/3)	2
3 mixed conifer, density > 60%	INT(25.4/3)	9
4 mixed conifer, density < 60%	INT(3/3)	2
5 broadleaf mixed with conifer	INT(3.4/3)	2
6 broadleaf	INT(2.2/3)	2
total		20

Source: Gogona RFI

ad 2.) Distribution of samples to the substrata of each stratum

The distribution of satellite samples among the different substrata (areas) of each stratum is done proportional to area applying the formula below.

$n_{ji} = n_i * p_j$

n_i number of samples per stratum i
n_{ji} number of samples per substratum j
p_j area weight of substratum j

If there are more substrata within one stratum than satellite samples to be distributed, then the substrata with the highest value should be selected.

Table 4: Example for the selection of substrata for inventory sample allocation

Substratum	**Area in ha**	**Area Weight**	$n_i * p_j$	**No. of Satellites**
total stratum 1	*1825*	*1.000*		*3*
1.1	52	.029	0.087	
1.2	**345**	**.189**	**0.567**	**1**
1.3	48	.026	0.078	
1.4	29	.016	0.048	
1.5	96	.053	0.159	
1.6	79	.043	0.129	
1.7	47	.026	0.078	
1.8	78	.043	0.129	
1.9	130	.071	0.213	
1.10	**207**	**.113**	**0.339**	**1**
1.11	176	.096	0.288-	
1.12	85	.047	0.141	
1.13	123	.067	0.201	
1.14	**277**	**.152**	**0.456**	**1**
1.15	53	.029	0.087	
total stratum 2	*242*	*1.000*		*2*
2.1	**125**	**.517**	**1.034**	**1**
2.2	**77**	**.318**	**0.636**	**1**
2.3	40	.165	0.330	
total stratum 3	*4012*	*1.000*		*9*
3.1	**358**	**.089**	**0.801**	**1**
3.2	**500**	**.124**	**1.116**	**1**
3.3	**548**	**.136**	**1.224**	**1**
3.4	**386**	**.097**	**0.873**	**1**
3.5	**472**	**.117**	**1.053**	**1**
3.6	97	.024	0.216	
3.7	**1126**	**.280**	**2.520**	**3**
3.8	177	.044	0.396	
3.9	38	.010	0.090	
3.10	56	.014	0.126	
3.11	**178**	**.044**	**0.396**	**1**
3.12	84	.021	0.189	
total stratum 4	*483*	*1.000*		*2*
4.1	33	.068	0.136	
4.2	**286**	**.592**	**1.184**	**1**
4.3	**164**	**.340**	**0.680**	**1**
stratum 5	**440**	**1.000**		**2**
stratum 6	**287**	**1.000**		**2**
Total all strata				**20**

Source : Gogona FRI

ad 3.) Selection of sample location based on random figures

The selection of the sample location is done randomly. The following steps have to be carried out, which are described in more detail below:

- overlay coordinate system on the stratification map and link it with standard inventory grid system;
- use random number table (Annex 1) and select random numbers;
- transfer sample location based on randomly selected coordinates to stratification map;
- determine terrestrial coordinates of sample location.

Identify the standard inventory grid location and mark reference points on transparent stratification map. Overlay map on a mm-paper. Then select random numbers with the help of random number table which is attached in (remark: the random figures given in this table ranges from 0-400 which is equal to a distance of 10 km. This should be suitable for most of the potential areas. If the size of the potential FMU is larger a new table should be created using any suitable computer program i.e. EXCEL, LOTUS, etc.).

First select any pair of columns randomly (i.e. with a dice). Then select the first pair of coordinates and transfer them to the mm-paper. The first column indicates the x-, the second column indicates the y-coordinates. Based on the table prepared for the required number of samples per substrata (see also Table 4) the location of the individual samples have to be selected based on the coordinates of the random figure table. To get a good distribution of samples and to make sure that all relascope samples of one inventory satellite are located within the same substratum, only those sample locations should be selected which are

- at least 500 m (or 1 cm on a 1:50.000 map scale) apart from the next sample, and
- at least 250 m (or 0.5 cm on a 1:50.000 map scale) away from the substratum boundary.

If the coordinates selected from the random figure table does not fulfill these criteria, or if the selected coordinates fall outside the selected forest area or into a substrata where all the samples are already allocated, skip it and use the next pair.

If all the satellite samples are distributed to the individual substrata they have to be numbered as follows: AA1 - AA9, AB1-AB9, ... ZA1 - ZA9, starting at the northeast corner of the potential forest area. It is important to do the numbering in that way, otherwise the PLOT-program would not accept the plot number.

Then, for each sample location the terrestrial coordinates have to be specified. This should be done by the GIS-Section (digitize inventory satellite sample location).

Another possibility is to calculate the plot location manually with the help of the 1:50.000 base map. The terrestrial latitude and longitude should be specified in degrees, minutes and fractions of a minute (i.e. 27° 31.06). The manual calculation of the inventory plot location is described in the following:

One minute corresponds in Bhutan approximately to:

latitude: 1852 m
longitude: 1650 m

0.01 minute corresponds then on a map at a scale of 1:50.000 to 0.36 mm (latitude) and 0.33 mm (longitude).

Example: if the sample location is 32 mm east of the 27° 5’ latitude and 16 mm north of 89° 25’ longitude the terrestrial coordinates would then be:

latitude: 27° 05’ + (32/0.36)*0.01’ = 27° 05.89’
longitude: 89° 25’ + (16/0.33)*0.01’ = 89° 25.49’

The location of the different inventory satellites have to be stored in the GPS as waypoints with their reference number.

ad 4.) Preparation of a inventory base map 1:25.000 and a survey description

If all the samples are distributed and numbered, the 1:50.000 stratified base-map has to be enlarged to a scale of 1:25.000 on transparent mylar. This is then the inventory base map which will be used for field survey. From this map a set of at least 3 blueprints should be copied, the original should be kept by the Reconnaissance Survey Section of FRDS.

To facilitate the identification of the sample location in the field a table has to be prepared indicating a description of the sample plot location containing the following information (an example is shown in see Table 5).

Sample No.: i.e. AA10
Substratum: i.e. 3.2
Longitude: i.e. 89° 38.67'
Latitude: i.e. 27° 30.89'
Altitude: i.e. 2740 m
Description: i.e. on steep slope 350m east of deep valley

Table 5: Survey description and location of inventory satellite samples

Satellite	Substrata	Longitude	Latitude	Altitude	Description
AA1	1.2	90° 7.62'	27° 26.04'	3200	south of small valley
AA2	1.10	90° 4.83'	27° 24.72'	3440	
AA3	1.14	90° 6.68'	27° 90.40'	3380	approx. 300 m north of pasture
AA4	2.1	90° 8.24'	27° 24.88'	3700	on steep slope
AA5	2.2	90° 6.90'	27° 90.43'	3640	approx. 600m west of AA3
AA6	3.1	90° 8.33'	27° 25.97'	3600	on steep slope
AA7	3.2	90° 7.03'	27° 24.31'	3030	on gentle slope
AA8	3.3	90° 7.88'	27° 23.61'	3230	
AA9	3.4	90° 5.15'	27° 23.20'	3020	on upper slope of broad valley
AB1	3.5	90° 4.70'	27° 24.28'	3340	
AB2	3.7	90° 5.15'	27° 25.42'	3280	close to small valley
AB3	3.7	90° 4.64'	27° 26.08'	3230	on gentle slope
AB4	3.7	90° 5.46'	27° 26.31'	3150	on gentle slope
AB5	4.1	90° 8.94	27° 26.39'	3570	near Phobjica Prot. Area
AB6	4.2	90° 6.09'	27° 23.97'	3000	
AB7	4.3	90° 3.55'	27° 24.35'	3530	
AB8	5.1	90° 7.48	27° 22.86'	3160	south of small valley
AB9	5.1	90° 8.15'	27° 22.78'	3330	
AC1	6.1	90° 6.81'	27° 22.81'	2910	on gentle western slope
AC2	6.1	90° 6.00'	27° 23.21'	2880	

Source: Gogona RFI

6.5 Field Work

Field work has to be carried out by a specialist RFI-team, which had been trained in the use of GPS and the relascope. The team should consist out of the following members:

1 teamleader
1 assistant
3 helpers
1 camp caretaker (cook)

Beside the ordinary inventory equipment the team has to be equipped with one SILVA GPS-compass (or alternatively a GPS and a hand compass), one Bitterlich Mirror Relascope, an altimeter and a caliper. Guidelines for the implementation of the field work are provided by the RFI-Field Manual.

6.6 Data Analysis

For data analysis the updated version of the PLOT-Program has to be used. The procedure is almost the same as for regular inventories and is described in detail by chapter III b 3 of the Forest Management Planning Code of Bhutan. For analysis of a RFI, the *system variables* have to be set in the PLOT-program as follows:

Relascope Sample: Y
Cluster Sample: Y
Size Major Plot (ha): 0.000
Totals for conifers reported? Y
Site & Stand recorded? Y
- heights recorded? Y
- crown class recorded? N
- timber potential recorded? N
- radial increment recorded? N
- permanent plots recorded? N
- line description recorded? N
- height of codominants reported? N
- new land use codes used? N

Basal Area Factor: 4
Number of plots per cluster: 3
Size Minor Plot (ha): 0.000
Totals for broadleaves reported? Y
Wildlife recorded? Y
- special recorded? N
- log grades recorded? N
Regeneration recorded? N
- bark thickness recorded? N

6.7 Analysis of Results and Preparation of RFI Report

After field work has been completed and data analysis has been carried out, the inventory teamleader has to produce a inventory report which has to provide all the information mentioned in chapter 6.2 Objective. Additionally, some general information on the potential FMU area and detailed information on the forest condition including inventory result tables have to be included. The report should be comprehensive and should concentrate on information relevant for forest management. It will serve as basic information for the Economic Feasibility Study and the Reconnaissance Survey Report.

In the following, the table of content of the inventory report including some keywords is specified. The Reconnaissance Forest Inventory Report for the Potential FMU-Area of Gogona prepared by SCHINDELE and PRABHAT in 1997, should be used as an example.

Table of Content

1 Introduction

- name of inventory teamleader and number of crew members;
- date of inventory implementation;
- applied inventory design;
- number of samples and distribution;
- faced problems (ie: accessibility of plots, support of local population, etc.)

2 General Information

2.1 Soils

- brief description of observations made on soil types, rocky areas, waterlogged sites and swamps, etc.;
- brief valuation of site suitability for forest production.

2.2 Wildlife

- describe your observations on wildlife (species, location, etc.);
- describe problems with animal pest (ie. wild boars)
- analyse inventory data (WILDLIFE.DBF) and specify result as in following example:

Type of Animal	Observation in % of Plots	Protection Status
Musk deer	26%	protected
Sambar deer	52%	
Himalayan black bear	8%	protected
Tiger	5%	protected

2.3 Fauna

- specify most common tree species;
- briefly describe groundflora;
- mention occurence of rare and protected plants.

2.4 Human Impact

- list name of settlements and their location
- describe your observation on human impact, type of observed uses and intervention intensities and spatial distribution;
- analyse inventory data (SITE.DBF) and specify result as in following example:

Type of Use	Observation in % of Plots
commercial wood exploitation	5%
domestic wood extraction	34%
grazing	82%
fire	10%
abandoned shifting cultivation	5%

3 Forest Situation

3.1 Forest Types and Forest Condition

- describe different forest types and their spatial distribution;
- describe forest condition (development stages, damages, diseases, natural disasters, etc.);
- mention your observations made on occurence of natural regeneration.

3.2 Inventory Results

3.2.1 Stratification

- briefly describe objective of stratification,
- specify original stratification (table with name of strata, area, number of samples)
- specify strata combination for data analysis (table with name of strata, area, actual number of samples assessed).

3.2.2 Average Gross Volume per ha

- detailed inventory results should be listed for selected strata in Annex 4.1 of the inventory report
- include Figure 1 (see example below):

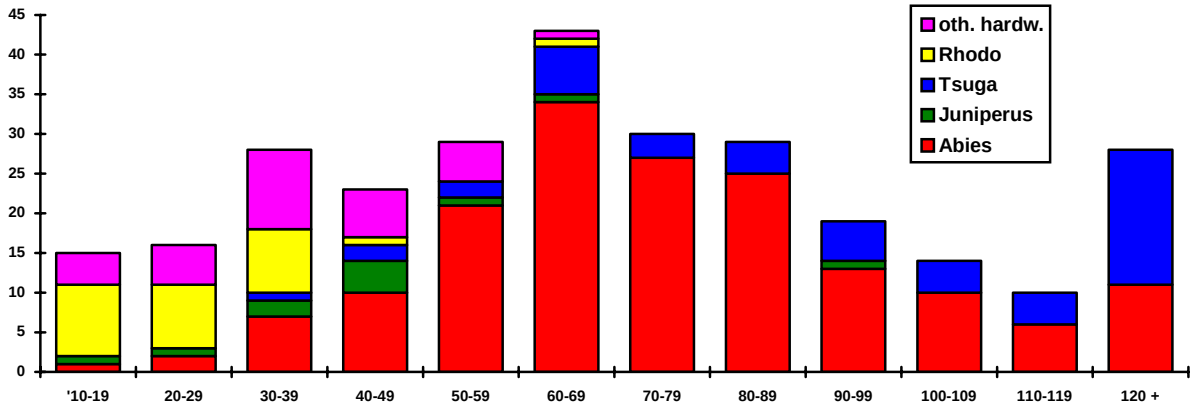


Figure 1: Average gross volume (per ha) per species and diameter class

- specify volume, percentage of conifers/hardwoods, dominating species, total volume above 50 and/or 60 cm dbh, volume of different strata;
- comment on dbh distribution.

3.2.3 Average Basal Area per ha

- detailed inventory results should be listed for selected strata in Annex 4.2 of the inventory report;
- include Figure 2: Average basal area (per ha) per species and diameter class;
- describe diameter distribution of basal area for different species.

3.2.4 Average Number of Trees per ha

- detailed inventory results should be listed for selected strata in Annex 4.3 of the inventory report;
- include Figure 3: Average number of trees (per ha) per species and diameter class;
- describe and valuate tree species and diameter distribution (ie. deviation from typical distribution of natural forests).

4 Operable Area and Areas of Priority for Forest Management

- size of potential forest management area (exclude inoperable and proposed protected areas);
- number and percentage of accessible plots;
- size of accessible area based on GIS-analysis and field experience;
- estimate of percentage of inoperable areas;
- estimate of total operable area for timber production;
- calculation of required size of working area for the next 20 years (plannnig period) based on average rotation and number of rejuvination cuts;
- identification of suitable priority area to start with management (provide sketch map in Annex 5 of inventory report).

5 AAC Estimate

- calculate potential AAC based on usable volume of commercial species. Consider logging waste and, for fir, estimated cull percentage. Use clear cut equivalent and Von Mantels method, or any other suitable AAC calculation method.

7 Preliminary Environmental Examination (PEE)

7.1 Objective

It is the objective of the Preliminary Environmental Examination to:

- valuate the environmental conditions;
- assess the environmental risks of commercial forest management;
- provide a preliminary estimate of protected areas and their location.

7.2 Sources of Information

Information for the PEE is collected during the courses of:

- Pre-RS Field Check;
- Socio-Economic Study (in particular RRA);
- Reconnaissance Forest Inventory;
- Preparation of Reconnaissance Survey, contacts with other institutions (e.g. NCS, NEC, RSPB).

7.3 Environmental Examination

7.3.1 Wildlife

The PEE should provide a list of protected and rare animals which occur in the potential FMU area and should describe their habitat. This information should be derived from the RRA and the results of the RFI. During the preparation of the RS, the environmental organizations, such as NEC, NCS, RSPB, WWF which are contacted, should provide information on wildlife and come up with suggestions, how wildlife habitats should and could be preserved. A proposal for wildlife protection zones and buffers should be indicated on the RS-base map.

7.3.2 Rare Ecosystems and Flora

Information on rare and sensitive eco-systems should be collected from the local people during the course of RRA. This refers in particular to swampy and waterlogged areas and on areas where rare and/or medicinal plants grow. If possible, these areas and ecosystems should be briefly described and their location should be sketched on the RS-base map.

7.3.3 Soil Protection

Steep areas and rugged terrain are endangered by erosion. These areas have already been identified on the slope map and verified by the Pre-RS Field Check and the RFI. Additional information should be collected during the RRA.

7.3.4 Water Catchments

Important catchment areas for drinking water should be identified during the RRA and their location should be roughly sketched on the RS-base map.

7.4 Environmental Risks of Forest Management

The main factors of environmental degradation caused by forest management are road construction, timber harvesting and silvicultural systems. Based on the results of the environmental situation (examination) recommendations should to be given on zones where road construction has low environmental impact and on areas, which should be excluded from road construction by all means, on road alignment standards, and on harvesting and silvicultural systems.

7.5 PEE-Format

The Preliminary Economic Examination should contain a brief description of the environmental conditions within the potential FMU area and an analysis of the environmental risks of forest management. It should include a sketch map indicating proposed protected areas for wildlife, soil and watershed protection and recommendation for forest road construction and harvesting systems. It consists out of one standardised page (see form in Annex 3) with an attached sketch map indicating proposed protected areas and buffers.

The PEE should be prepared by the officer in charge of the RS based on the information obtained from the Pre-RS Field Check, RFI, PRA and from institutions concerned with environmental protection.

8 Economic Feasibility Study (EFS)

8.1 Objective

It is the objective of the Economic Feasibility Study to forecast, whether commercial forest management of the FMU will be financially viable in the long run or not and whether it is worthwhile to open the concerned area as a commercial FMU.

The EFS is the most important component of the RS as it helps to avoid expensive and uneconomic investments in future.

This EFS at the reconnaissance level, needs to be simple without time consuming anaylsis. It will, therefore, not replace a fullfledged economic assessment later on at forest management planning level.

The EFS should be conducted by the Reconnaissance Survey Section in collaboration with FDC and a mangement planning specialist of FRDS.

8.2 Sources of Information

The EFS is based mainly on the results of the RFI as described in the RFI Report. The results of the SES, dzonkhag statistics and basic economic data of FDC provide further information.

Preliminary decision on the harvesting system and a draft road construction and accessibility plan have to be prepared during the EFS, taking into consideration the proposals made by the PEE, in order to allow an estimate of the investment and operational costs.

8.3 Preliminary Road Location and Harvesting Plan

etc. not complete

9 Reconnaissance Survey Report

The final RS-Report is a compilation of the individual reports of the

- Pre-RS Field Check
- Socio-Economic Study
- Reconnaissance Forest Inventory
- Preliminary Environmental Examination
- Economic Feasibilty Study

It should be prepared by the Head of the Reconnnaissance Survey Section of the FSD and submitted for approval to the Head of FRDS.

The table of content including some keywords for the content of the individual chapters are listed below.

1 Brief Summary
- brief description on different activities carried out (when by whom);
- recommendation whether to open FMU or not;
- main constraints and problems;

2 General Information
2.1 Location and Terrain
- names of dzongkhag and geogs;
- boundary alignment and adjoining FMUs, national parks, protected areas, etc.;
- size of potential FMU and approximate size of operable area;
- topographic features such as altitude, slopes, exposition, drainage, watershed;
- accessibility.

2.2 Climate
- brief description of climate (climatic zone, temperature, rain/snowfall, etc.).

2.1 Soils
- brief description on soil types, rocky areas, waterlogged sites and swamps, etc.;
- brief valuation of site suitability for forest production.

2.2 Wildlife
- describe most common wildlife species,
- occurrence and habitat of protected and rare species;
- describe problems with animal pest (ie. wild boars)

2.3 Fauna
- specify most common tree species;
- briefly describe groundflora;
- mention occurence of rare and protected plants.

2.4 Forest Types and Forest Condition
- describe different forest types and their spatial distribution;
- describe forest condition (development stages, damages, diseases, natural disasters, natural regeneration, etc.);

3 Socio-Economic Study
- add SES-Report.

4 Preliminary Environmental Examination

- add PEE-Report

5 Reconnaissance Forest Inventory

- Add chapter 1 and 3.2, 4 and 5 of RFI-Report
-

5.1 Introduction (chapt. 1)
5.2 Inventory Results (chapt. 3.2)
5.3 Operable Area and Areas of Priority for Forest Management (chapt. 4)
5.4 AAC-Estimate (chapt. 5)

6 Economic Feasibility Study

add EFS-Report

Annexes

1 Forest type map
2 Map on protected and inoperable areas, proposed road alignement

Annex 1
Form for Pre-RS-Field Check

ANNEX1.XLS

Annex 2
Cover Page for Socio-Economic Study

ANNEX2.XLS

Annex 3
Format for Preliminary Environmental Examination

ANNEX3.XLS

Annex 4
Random Number Table

Random Number Table (created with EXCEL)

x	y	x	y	x	y	x	y	x	y	x	y
387	117	166	3	135	46	194	275	49	119	133	299
125	95	215	149	16	215	109	117	134	55	264	183
142	270	224	226	159	66	265	193	296	293	228	0
14	110	4	157	28	258	110	121	186	100	115	180
8	69	11	210	168	111	170	290	229	193	134	127
137	175	112	60	159	235	59	0	291	277	80	142
16	61	195	34	115	224	126	183	44	148	118	105
229	59	24	129	289	111	37	67	254	283	220	156
67	281	135	176	209	120	257	187	48	203	286	96
51	189	89	106	292	289	186	113	77	107	164	232
148	270	169	235	130	93	272	164	2	74	61	290
168	170	140	67	176	156	202	92	235	52	39	294
295	59	75	212	36	182	186	298	76	63	226	105
148	210	34	285	113	67	73	223	146	286	244	298
67	60	159	60	207	144	80	38	134	157	13	123
262	48	219	31	29	34	278	86	119	99	41	167
73	233	152	74	121	39	151	172	236	248	140	148
72	266	264	60	105	26	265	166	206	175	40	178
164	274	257	42	127	83	174	182	204	10	242	6
16	253	92	198	288	168	217	254	266	29	57	109
9	20	258	245	165	249	163	189	260	294	249	115
204	168	137	144	127	154	28	208	152	114	161	64
9	183	134	7	238	74	195	269	4	223	245	119
157	142	286	78	257	14	114	131	119	25	243	2
118	145	31	235	242	25	40	187	165	179	222	151
173	132	78	297	173	208	227	32	90	257	97	77
285	34	167	193	119	183	202	267	12	54	176	261
80	151	244	189	147	202	169	98	257	264	24	88
294	91	91	100	15	97	70	59	10	202	192	269
184	102	135	129	293	236	32	290	159	286	65	286
15	269	247	151	231	208	5	24	166	116	269	231
5	65	284	215	114	77	100	173	99	198	165	125
206	73	244	62	162	159	34	180	202	246	45	294
139	229	136	240	271	262	76	39	97	260	272	108
69	183	270	100	87	40	78	89	65	117	209	261
222	2	131	132	110	223	116	218	216	27	157	7
146	299	286	92	219	72	104	13	257	167	233	124
18	298	248	155	96	80	267	52	134	180	294	156
256	175	227	169	92	230	122	67	71	21	41	131
160	109	20	244	25	281	118	258	152	83	121	178
131	17	106	278	152	256	90	244	190	64	98	104
189	201	288	298	174	228	82	112	258	290	68	248
212	156	263	27	46	161	63	54	225	100	62	174
110	2	239	231	78	170	89	232	225	2	257	272
90	79	79	133	158	145	237	191	88	242	137	125
212	248	166	293	7	282	86	106	273	25	232	192
120	238	99	117	230	182	267	112	240	276	161	185
103	2	177	256	95	252	124	124	28	24	263	102
131	146	214	136	10	237	123	48	33	80	198	96
294	209	136	126	179	61	238	4	80	130	157	174
88	177	214	22	298	273	144	117	19	185	202	21
130	283	160	292	141	160	255	250	199	28	104	71

Annex 5
RFI Tally Sheet

Dec. 95 **Reconnaissance Forest Inventory: Tally Sheet** recoform.wk1

1 inventory unit
2 cluster number
3 crew leader
4 date
5 average altitude (m)
6 avrage slope (%)
7 accessibility (if all samples = N then N, else Y) (Y) (N)

relascope sample for trees of dbh 10+ cm

sample 1			sample 2			sample 3			
altitude (m)			altitude (m)			altitude (m)			
slope (%)			slope (%)			slope (%)			
accessibility	(Y)	(N)	accessibility	(Y)	(N)	accessibility	(Y)	(N)	

No.	species code	dbh	No.	species code	dbh	No.	species code	dbh	height
1			1			1			
2			2			2			
3			3			3			
4			4			4			
5			5			5			
6			6			6			
7			7			7			
8			8			8			
9			9			9			
10			10			10			
11			11			11			
12			12			12			
13			13			13			
14			14			14			
15			15			15			
16			16			16			
17			17			17			
18			18			18			
19			19			19			
20			20			20			
21			21			21			
22			22			22			
23			23			23			

observation of wildlife

species	code	evidence	code

observation of human impact

commercial wood exploitation	(Y)	(N)
domestic wood extraction	(Y)	(N)
grazing	(Y)	(N)
fire	(Y)	(N)
abandoned shifting cultivation	(Y)	(N)
cardamon cultivation	(Y)	(N)

general remarks

Forest Function Planning and Mapping

Section	Planning and Mapping	IV
Sub-Section	Forest Function Planning and Mapping	a

Keywords	forest function, soil protection, soil conservation, watershed conservation, biodiversity, wildlife protection, social function, road buffer, water course buffer, riparian reserve
Author(s)	Forest Resources Development Section, Thimpu

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Glossary

Chams	Splitted square timbers
Goenba	Monastery
Gney	Religious site
Lhakangs	Monastery
Shingleps	Shingles used for roofing
Shokshing	Area used for collection of leaf litter for used in the field
Tshims	round poles used as rafters for roofing
Tsamdrog	Cattle grazing ground

ACRONYMS

AAC	Annual allowable cut
API-Cell	Aerial Photo Interpretation Section of FRDS
DEM	Digital elevation model
EA	Environmental Assessment
EFS	Economic Feasibility Study
FDC	Forest Development Corporation (former BLC)
FMPL	Forest Management Planning
FMU	Forest Management Unit
FRPA	Forest Resources Potential Assessment
FRDS	Forest Resources Development Section
FSD	Forestry Services Division
GIS	Geographic Information System
GIS-Cell	GIS-Cell of FRDS
GPS	Geographic Positioning System
LUFFP	Land Use and Forest Function Planning
LUPP	Land Use Planning Project
N	Nature Conservation
NB	Biodiversity Protection
NCS	Nature Conservation Section
NWC	Wildlife Conservation
NWP	Wildlife Protection
NEC	National Environment Commission
NTFP	Non Timber Forest Products
PEE	Preliminary Environmental Examination
PRA	Participatory Rural Appraisal
RB	Road Buffer
RFI	Reconnaissance Forest Inventory
RNR	Renewable Natural Resources
RRA	Rapid Rural Appraisal
RS	Reconnaissance Survey
RSPN	Royal Society for the Protection of Nature
SC	Soil Conservation
SES	Socio-Economic Study
SF	Social Forestry
Soc	Social Function
SocL	Social (Local Use Only)
SocLC	Social (Local Cum Commercial Use)
SocRS	Religious Site Protection
SP	Soil Protection
Topo-map	Topographic map with 40m height lines, scale 1:50.000
W	Water and Watershed Conservation
WRR	Riparian Reserve Protection
WSMA	Special Management Areas
WLS	Local Water Supply Protection
WSh	Watershed Conservation
WWF	World Wide Fund for Nature

1 Objective

Forest function mapping is an essential tool for forest management planning. It defines for all the forest areas within the FMU ecological, environmental and social functions and as such allows to balance the some times often diverging interests of commercial logging, local forest use and nature conservation. The forest function map provides the information on the total commercially operable area, identifies which areas have to be reserved for local use and provides the management planner and the implementor with information on management restrictions for particular areas.

2 Administration

The forest function map must be prepared for the entire permanent forest areas (this includes bare land or range lands to be reforested) and is done in a planning step which follows land use planning. The responsibility of forest function planning is with the management planner, who is supported by the GIS-Cell and the API-Cell. The forest function map must be updated and/or revised every 20 years when a new management plan is prepared.

3 Definition and Description of Forest Functions

There are five main groups of functions (see Table 1). Each one includes a number of subfunctions which are differentiated among each other by their influence on forest management (degree of management prescriptions). For the sub-function the term protection is used if commercial use is prohibited, the term conservation - or a more specific phrase - is used, if the function imposes management restrictions on the commercial use. In case a function group contains both protective and conservative functions, then for the function group the term conservation has been selected *(i.e. Soil Conservation, Water and Watershed Conservation, Nature Conservation).*

Table 1: List of different forest function groups and sub-functions

Soil Conservation	Water and Watershed Conservation	Nature Conservation	Social Function	Road Buffer
SP Soil Protection	WRR Riparian Reserve Protection	NWP Wildlife Protection	SocRS Religious Sites Protection	RB Road Buffer
SC Soil Conservation	WLS Local Water Supply Protection	NWC Wildlife Conservation	SocL Social (Local Use Only)	
	WSMA Special Management Areas around Water Courses	NB Biodiversity Protection	SocLC Social (Local cum Commercial Use)	
	WSh Watershed Conservation			

3.1 Soil Conservation

The group “Soil Conservation” is one of the most important functions and it is defined in order to prevent land and snow slides, damages caused by falling stones or rocks, protection of arable land, etc. Also, the protection of the topsoil from erosion is an essential measure in order to maintain the fertility and production capacity of the soil in the long run, which is a pre-condition for sustainable forest management and agriculture.

	Soil Protection (SP)	Soil Conservation (SC)
Definition	Soil Protection includes all areas which are extremely sensitive to soil erosion, land and snow slides. These areas include in particular very steep slopes, rocky and stony areas, water-logged gleys and already eroded areas. Unstable slopes above or near important objects such as villages, settlements, individual houses, roads, agricultural land, etc. are defined for protection reasons as Soil Protection, too.	The function "Soil Conservation" covers all areas which are sensitive to soil erosion, which are, for example, steep slopes, waterlogged areas and exposed sites.
Objective	(1) to prevent damages caused to the environment and infrastructure by land slides, snow slides, falling stones and other physical impacts; (2) to protect the soil from erosion and to sustain soil fertility.	(1) to minimize or prevent negative impacts due to forest resource use in order to protect the soil from erosion and other degradation processes and to sustain soil fertility.
Legal Restrictions	According to § 14 a (iii) of the Forest and Nature Conservation Act (1995*) "no permits shall be issued to fell and to take any timber where the slope is greater then 45 degrees (100%) unless authorized under an approved management plan or by the Head of the Department."*	None.
Identification	Soil erosion depends largely on geology, site conditions (soil type, water regime, etc.) and slope gradient. In general it can be said, the finer the soil texture, the steeper the slope and the higher the water content (saturation) the more sensitive the soil becomes towards erosion and landslides. Unfortunately, up to date soil map does not exist for Bhutan and soil mapping for entire FMU would definitely over stress the human resources of the Forest Services Division. The only parameters which can be comparatively easily assessed are the slope gradient, the land use type and already existing signs of erosion (gullies, rills, land slides, etc.).	
	The following areas shall be classified as Soil Protection: • very steep areas (slope above 100%); • unstable areas and sites prone to landslides and areas with indications of severe erosion.	The following areas shall be classified as Soil Conservation: • steep areas (slopes of 76-100%); • areas with indication of slight to moderate erosion; • exposed sites (ridges, etc.).
Short Description of Management Prescriptions/ Restrictions	Strict Protection! No trees shall be felled or removed for commercial purposes. However, if the area is not prone to landslide limited local use may be permitted. In heavily landslipped areas, even collection of leaf litter shall be restricted. Cattle grazing, in such areas, shall also be regulated or restricted. However the collection of minor forest products such as fruits, nuts, medicinal herb, etc. shall be permitted. In case the forest is in such a bad condition that its protective function is no longer valid, silvicultural operations required to restore functionality of the forest cover have to be planned and implemented. Already severely eroded areas which are poorly stocked should be reforested as soon as possible.	Only management restrictions! Forest harvesting operations shall minimize disturbances to understorey vegetation and damage to residual trees. Silvicultural systems shall focus on natural regeneration, with enrich-ment planting only where necessary. Deep rooting and site adapted species shall be promoted on unstable sites. Rejuvenation periods should be rather long (at least 60-100 years) in order to promote an uneven-aged and multistory structure of the stand. Clear cuts shall be strictly prohibited. Low impact local forest use shall be permitted, however grazing pressure in rejuvenation stands shall be kept to a minimum. Silvicultural improvement measures (i.e. enrichment planting, tending) shall be planned and implemented in poorly or inadequately stocked areas.

3.2 Water and Watershed Conservation

Water is one of the most valuable natural resources and clean potable water is an indispensable asset for the human population. The protection of water resources therefore gains highest priority in resources management. The function "Water and Watershed Conservation" focuses on the conservation of the cleanliness of the groundwater and surface water bodies and the maintenance of a continuous water supply. According to the objective of the function and the imposed management prescriptions/restriction different sub-functions are defined.

<table>
<tr><th></th><th>Riparian Reserve Protection (WRR)</th><th>Special Management Areas (WSMA)</th></tr>
<tr><td><u>Definition</u></td><td colspan="2">Riparian areas occur along the banks of rivers and streams, and around the perimeter of lakes and wetlands. They include the water body itself, areas subject to periodic inundation and flooding, areas with high water tables and immediate adjacent uplands. Streamside vegetation stabilizes stream banks, regulates stream temperatures through shading, and supplies a continual source of coarse woody debris to stabilize stream channels and diversify aquatic habitat. The majority of fish food organisms come from overhanging trees and shrubs, while the nutrients from organic materials that fall or wash into the stream are the basis of aquatic ecosystem productivity.

Riparian areas often contain the highest plant and animal diversity, and some of the highest valued non-timber forest resources in the forest landscape. They provide critical habitats, home ranges and travel corridors for many mammal and bird species, and maintain ecologically-important vertical and horizontal linkages throughout the forest landscape.</td></tr>
<tr><td><u>Objective</u></td><td colspan="2">(1) to minimize or prevent negative impacts due to forest resource use on stream channel stability, water quality, and aquatic ecosystem productivity and diversity;
(2) to protect and sustain plant diversity associated with riparian areas; and
(3) to allow sustainable and environmentally-sound forest uses consistent with objective (1) & (2) above.</td></tr>
<tr><td><u>Legal Restrictions</u></td><td colspan="2">According to § 14 a (ii) of the Forest and Nature Conservation Act (1995) "no permits shall be issued to fell and take timber within 100 feet (30 m) of the bank or edge of any river, stream, water course and or water source.</td></tr>
<tr><td rowspan="2"><u>Identification</u></td><td colspan="2">Stream courses in mountainous landscapes vary considerably in gradient, cross section, flow, stability and ecological importance. To ensure adequate protection the characteristics of the water courses have to be taken into account.</td></tr>
<tr><td>The Riparian Reserve includes the stream bed and extends to the top of the entrenchment slope. Along alluvial and semi-alluvial rivers and streams the width of the Riparian Reserve is 30 m.</td><td>The size of the Special Management Area extends to the specified distance from the top of the stream bed.

Large non-alluvial rivers: 100 m
Alluvial and semi-alluvial rivers and steams: to edge of active flood plain</td></tr>
<tr><td><u>Short Description of Management Prescriptions</u></td><td>Strict Protection!

Within buffer zones (riparian reserves) along streams, small rivers and perennials, it is not allowed to carry out any forestry operation except those required to improve the forest condition and to restore its original natural condition. Such rehabilitation activities are: reforestation of cleared sites, beating up, tending, weeding and, if necessary from the silvicultural viewpoint in order to increase stability, thinning. All those activities have to focus on the establishment of multi-structured, uneven-aged mixed forests and they have to be carried out manually only. The use of machines is strictly prohibited. Local use is limited to the collection of NTFP. Cattle grazing and leaf litter collection are not be allowed. The establishment of infrastructure like logging roads, establishment of log ponds, housing, sawmill and other utilization units, camp-sites, log landings etc. is strictly prohibited within these areas. (Note: Removal of trees shall be considered on epidemic out-break & silvicultural reasons.)</td><td>Only management restrictions!

Forest harvesting operations within the special management zones and 20 m from the top of the entrenchment slopes should minimize disturbance to understorey vegetation and damage to residual trees. Silvicultural systems should focus on natural regeneration, with enrichment planting wherever necessary. Clear cutting is prohibited. Woody debris, occurring in the site, should be maintained and no weeding or burning or slash disposal should take place. The conversion of natural forests into plantations is prohibited. Low impact forest use is permitted, however high cattle densities are to be discouraged.</td></tr>
</table>

	Local Water Supply Protection (WLS)	Watershed Conservation (WSh)
Definition	Buffer zones have to be defined for all areas in the immediate vicinity of water resources used for the local water supply and includes the water-body itself and swampy or waterlogged catchment areas.	Watershed conservation. Forests cover the upper catchment areas of water courses on steep slopes and poorly drained or permanently waterlogged areas.
Objective	(1) to prevent negative impacts due to forest resource use on water quality and stream channel stability	(1) to maintain the cleanliness of ground and surface water (water quality); (2) to prevent surface run-off of precipitation and to sustain continuos water supply; and (3) to allow sustainable and environmentally-sound forest uses consistent with objective (1) & (2) above.
Legal Restrictions	According to section 14a (ii) of Forest and Nature Conservation Act (1995) "*no permits shall be issued to fell and take timber within 100 feet (30 m) of the bank or edge of any river, stream, water course and or water source*."	None!
Identification	The buffer zone consists out of the Riparian Reserve (WRR) and an additional 30 m wide protection zone along the outer edge of the Riparian Reserve. Swampy or waterlogged areas feeding the respective water resource will have to be included.	Water conservation measures are necessary on steep areas (> 25% slope). Also upper catch-ment areas and poorly drained or waterlogged sites, moist areas and swamps, and all other sites serving as water retention or water feeding bodies, should be classified as Watershed Conservation areas.
Short Description ofManagement Prescriptions/ Restrictions	Strict Protection! No commercial operations shall take place within WLS buffers. Low impact local use shall be permitted, but intensive cattle grazing has to be restricted for hygienic reasons. The establish-ment of infrastructure, such as, logging camps, log landings and forest roads, is prohibited. Note: Removal of trees shall be considered in the following cases: 1. Epidemic out-break. 2. On silvicultural reasons.	Only management restrictions! Water quality can be affected through the fast decomposition of raw humus layers, the application of chemicals or fertilizers, the wash out of the topsoil and increased surface run-off of precipitation and intensive forest pasture. To sustain and maintain continuous water supply the water infiltration rate should be kept as high as possible. Forest harvesting operations within Watershed Conservation areas should minimize disturbance to understorey vegetation and damage to residual trees. Silvicultural systems should focus on natural regeneration, with enrichment planting only where necessary. Clear cuts and the conversion of natural forests into plantations shall be prohibited. Multi-structured, uneven-aged forests with a high percentage of deep-rooting tree species fulfill the requirements of water conservation in the best way. Local forest use is permitted, however, high cattle densities have to be avoided. The use of heavy machinery, application of chemicals, dumping of waste (i.e. old oil) and the establishment of logging camps, sawmills, etc. are prohibited.

3.3 Social Functions

The local population living in and around the FMU largely depend on the forest as a resource for construction timber, firewood and fence posts. They also use the area for collection of NTFP and as cattle grazing ground. To avoid conflicts with commercial logging, the forest area used by the local people must be identified and, if required, a portion of the forest has to be set aside for their exclusive use. It is of greatest importance, that the identification of the areas used by the local people and the decision on "social functions" is made in a participatory way. Therefore, the identification of social functions is subject of the PRA. There is one problem in defining and mapping social functions, they are not consistent and they depend largely from social framework. Therefore, when mapping the social forest functions, future trends and developments need to be appraised.

<table>
<tr><th></th><th>Social (SocL)
(Local Use Only)</th><th>Social (SocLC)
(Local cum Commercial Use)</th></tr>
<tr><td><u>Definition</u></td><td>Forest areas which are, and have been, traditionally used intensively by the local population and which are an integrated and indispensable component of their subsistence should be set aside for Local Use Only.</td><td>Forest areas which are used by the local population for the collection of wood (shingleps) and NTFP should be defined as Social (Local cum Commercial Use) forests.</td></tr>
<tr><td><u>Objective</u></td><td>(1) to provide the local population with sufficient forest products for their subsistence needs in a sustainable way; and
(2) to exclude forest areas from commercial logging, where the commercial use of the forest is in contradiction with objective (1).</td><td>(1) to provide the local population with sufficient forest products in a sustainable way; and
(2) to allow sustainable commercial forest use by FDC in a way that it is consistent with objective (1) above.</td></tr>
<tr><td><u>Legal Restrictions</u></td><td>None!
Remark: if Social (Local Use Only) use is defined as a separate community forest reserves, then the "Social Forestry Rules" and the "Community Forestry Guidelines for Bhutan" provide the legal basis.</td><td>None!</td></tr>
<tr><td><u>Identification</u></td><td colspan="2">The definition and mapping of social functions is done during the PRA after the decision has been taken to open a FMU. The procedures for identifying the individual functions will be prescribed in the PRA manual. Criteria for the identification are:
• vicinity to settlement or village;
• accessibility;
• forest type and condition (can the area provide the required product in a sustainable way?);
• site capability (production potential);
• traditional use and user (any registered rights?);
• visibility of boundaries (natural features);
• prospective of future social development (i.e. population growth, market structures)
• other functions.</td></tr>
<tr><td><u>Short Description of Management Prescriptions/ Restrictions</u></td><td>No commercial exploitation!

Note: Removal of trees shall be considered in the following cases:
1. Epidemic out-break.
2. On silvicultural reasons.</td><td>There is no standard management restrictions for "Commercial cum Local Use".
The prescriptions/restriction for commercial forest depends largely from the type of local use. For example: if the forest area is traditionally used for shinglep production, enough "shinglep"-trees have to be excluded from commercial logging. These will have to be marked by the Beat Officer during tree marking. Another example: thinning of blue pine could be done by the people for the production of tshims, poles, fence posts, etc., the final logging could be done for commercial purpose only or it could be linked with local use (i.e. shingleps).
The various management restrictions to be imposedl have to be <u>jointly determined by the management planner and the local population during the PRA</u> for different forest areas and have to be specified in the stand or compartment book.</td></tr>
</table>

Social Function (Soc) (Religious Sites)	
Religion plays an important role in Bhutan. Through out the country, monasteries, gneys, meditation houses and other religious objects are distributed and many of them are located in forested areas. To respect the sanctity of these holy places and in order, not to disturb people in their religious practice, no forestry operations should take place in the immediate vicinity of religious sites.	
	Religious (SocRS) Site Protection
Definition	Religious sites are lhakhangs/goenbas and gneys and all other places used by people to practice religion.
Objective	(1) not to disturb people in their religious practice and to respect the sanctity of these places.
Legal Restrictions	None!
Identification	Most of the monasteries and religious sites have already been localized on topographic maps or LUPP land use working maps. During the process of RRA and PRA all religious sites which should be buffered will have to be jointly identified and mapped and the size of the buffer zone should be determined. The minimum buffer around a religious site is a circle of 100 m in diameter.
Short Description of Management Prescriptions/ Restrictions	Strict protection! Buffer zones around religious sites will have to be exempted from commercial logging. However, silvicultural improvement measures such as planting, weeding, tending and thinning should be planned and implemented if the religious site is located on a Soil Protection area and if the implementation of these measures are required for protecting these objects Only the local forest uses should be permitted which do not disturb the sanctity of the place. Note: Removal of trees shall be considered in the following cases: 1. Epidemic out-break. 2. On silvicultural reasons.

3.4 Nature Conservation

According to the objective of nature conservation two different types of functions are distinguished:

- Conservation of wildlife and wildlife habitats (in particular rare or endangered species).
- Protection of areas rich in biodiversity and/or of high ecological value.

	Wildlife Protection (NWP)	Wildlife Conservation (NWC)
Definition	This function includes all habitats and other areas where rare or endangered mammals and birds occur and where the protection of these animals gains highest priority.	All forests areas rich in species variety and number of wildlife, in particular, mammals and birds.
Objective	(1) to conserve the habitat of protected wild animals and corridors for their movement; and (2) to prevent the protected animals from human disturbance.	(1) to minimize or prevent negative impacts due to forest resource use on wildlife habitats and to minimize disturbances due to human impacts.
Legal Restrictions	According to § 22 (a) of the Forest and Nature Conservation Act of 1995 altogether 23 wild animals are totally protected in Bhutan (see Annex 3).	None!
Identification	The determination of wildlife protection and conservation areas hould be done during EA exercise, which should be carried out in close consultation with NCS, NEC, WWF and RSPN. Useful information can be derived from the RFI and RRA/PRA. Criteria for the identification are: type and number of wildlife species and protection status, actual vegetation and habitat condition, habitat size, and degree of disturbance. Of course these criteria depend largely from the type of wildlife which should be conserved or protected. Details on habitat requirements of various protected animals can be derived from ASTE (1994).	
	All areas where protected wildlife species occur and wildlife corridors. According to Aste (1994) a wildlife corridor is defined as "*a linear two-dimensional element that connects two or more patches of wildlife habitat*". If possible wildlife corridors should be aligned in more or less undisturbed areas and areas unsuitable for commercial management which are for example: steep slopes, ridges (i.e. SP or SC), gullies or canyons (i.e. WRR), etc..	All areas rich of wildlife, both in species and in number. Especially breeding areas, watering places, etc..
Short Description of Management Prescriptions/ Restrictions	Strict protected! Within wildlife refuge areas and corridors commercerial logging is strictly prohibited. Local forest use is only permitted if the habitat quality and structure is not significantly changed (i.e. single tree felling for shinglep production) and disturbance to the protected animals is not long lasting and kept to a minimum. Road construction within wildlife refuge areas and corridors. should be avoided as much as possible Note: Removal of trees shall be considered in the following cases: 1. Epidemic out-break. 2. On silvicultural reasons.	Only management restrictions! Forest operations within Wildlife Conservation zones should minimize disturbance to undertorey vegetation, in particular bamboo, and to residual trees. Fruit and fodder trees for wild animals have to be excluded from exploitation. Small pasture areas or gaps have to be left open and should not be reforested. Logging operations should leave behind some undisturbed forest patches irregulrly distributed within a coup. At least one snag tree per ha of a big diameter has to be left in order to provide arboreous living animals with tree cavities. The opening of the forest has to be limited in size to a gap with a maximum diameter of one tree length. The remaining canopy density has to be at least 50% and the maximum standing volume to be removed is 30%.

	Biodiversity Protection (NB)
Definition*	Biodiversity can be defined as the diversity of plants, animals and other living organisms in all their forms and level of organization, including genes, species, ecosystems and the evolutionary and functional processes that link them. Biodiversity does not entail merely the preservation of a few rare, endangered or interesting species, but rather the protection and conservation of the diversity of species, genetic materials, biophysical processes and ecosystem structures that together determine biological productivity and stability. The diversity of a given ecosystem is defined by the following three components: • **Composition:** Ecosystems are composed of organisms, species, groups of interacting species, genetic diversity within species, the remains of dead organisms, and various inorganic compounds; • **Structure:** Ecosystem structure arises from the patterns in which the basic building blocks of composition occur. There are two types of structure: physical structure or spatial pattern (i.e. canopy layer, patchiness in distribution of species, etc.) and social structure (relationship of individuals, species, group of species to each other and to the ecosystem as a whole). • **Function:** Function refers to the actions or interrelationships between components of composition and structure.
Objective	• to preserve rare and extra-ordinary rich ecosystems and ecological niches and to protect them from human interference in order to conserve the biological diversity within the concerned FMU.
Legal Restrictions	Legal Restrictions According to § 22 of Forest and Nature Conservation Act of 1995 the following plants are totally protected (see Annex 3).
Identification	The following areas should be allocated to forest function "Biodiversity Protection" (NB). • ecosystems rich in biological diversity (in particular flora and non-vertebrate animals such as reptiles, insects, amphibians); • rare ecosystems (i.e. swamp forests, gallery forests, alpine shrubs); • ecosystems and areas with a high percentage of protected flora; and • forest areas which should be conserved because of their extra-ordinary composition or structure. NB-areas are generally smaller than Wildlife Conservation areas and may range between 1 and 100 (or more) hectares.
Short Description of Management Restrictions	Strict protection! Commercial and local forest use are strictly prohibited. This refers also to the collection of NTFP and other minor forest products. If possible, these areas should be exempted from grazing. No road construction within NB areas.

3.5 Road Buffer

Road Buffer (RB)	
Definition	A road buffer is the zone along a road where the implementation of forest activities may have direct negative impact on the road itself or on the security of the traffic.
Objective	to protect the road from rock fall, land and snow slides, surface runoff of precipitation and erosion and to safeguard traffic.
Legal Restrictions	According to § 14 a (i) of the Forest and Nature Conservation Act (1995) "*no permit to fell or to take any timber within 600 feet (200 m) uphill and 300 feet (100 m) downhill should be issued along motorable roads except for forest roads*."
Identification	The need of determining a road buffer depends mainly on the type of road (i.e. motorable road, forest road etc.) and the terrain. The size of the buffer zone required depends on the terrain stability as specified below: Type of road — Unstable terrain — Stable terrain Motorable public road — 200 m uphill — 200 m uphill 100 m downhill — 100 m downhill Main factors influencing terrain stability are steepness, drainage, soil and site type, stoniness and geology. Features indicating unstable terrain are: steep slopes, poor drainage or waterlogged areas, clayish soil texture, high stoniness and fragile geologic formations. The distance specified is the real distance from the edge of the road (not the horizontal distance!)
Short Description of Management Prescriptions/ Restrictions	Commercial logging within road buffer zones is prohibited, including felling and removal of trees for local use. However, trees which are a source of danger for the road, or the traffic on it, will have to be felled as soon as possible. This refers namely to dead or decayed trees, or exposed single trees which may break or fall during storms or heavy winds. The collection of NTFP such as fruits, medicinal herb, mushrooms etc. for the local use may be permitted. However collection of dead wood and fallen branches for firewood will be permitted. Note: Removal of trees shall be considered in the following cases: 1. Epidemic out-break. 2. On silvicultural reasons

4 Effects of Forest Function on Forest Management

For each forest function management prescriptions/restrictions are defined which must be observed during implementation. For each stand the management restrictions have to be recorded in the stand or compartment book.

In many cases forest functions overlap, especially those which depend on the same parameter (i.e. slope) which are in particular SP/SC and WSh. On the other hand overlap of functions should be done intentionally, in order to maximize the production forest area and to make optimal use of the forest potential. This applies, for example, for NWP/NWC with SP and SC. In case several functions are classified for one particular forest area, then all prescribed management prescriptions/restrictions have to be considered. In Table 2, the forest functions are ranked according to their impact on commercial forest management.

There are also cases in which forest functions exclude each other which are: SC and SP, NWC and NWP, WRR/WLS and WSMA. Also, SocLC (Local cum Commercial Use) cannot be defined in areas already classified with one of the following functions: NB, SP, WRR, NWP, WLS, SocRS, RB, and SocL.

Table 2: Impact of forest function on commercial forest management and local use

Rank	Code	Function	Restriction on Commercial Use	Restriction on Local Use
1	NB	Biodiversity Protection	no commercial use	no local use
2	SP	Soil Protection	no commercial use	no tree felling; no tsamdo; no shoksing
3	WRR	Riparian Reserve Protection	no commercial use	only collection of NTFP; no tsamdo; no shoksing
4	RB	Road Buffer	no commercial use	no tree felling
5	NWP	Wildlife Protection	no commercial use	restriction to activities that do not change habitat quality and disturb wildlife
6	WLS	Local Water Supply Protection	no commercial use	low impact use only; no cattle grazing
7	SocRS	Religious Site Protection	no commercial use	only uses which do not disturb sanctity of place
8	SocL	Social (Local Use Only)	no commercial use	no restriction
9	SC	Soil Conservation	no clear cutting; no conversion into plantation; extension of rejuvenation periods	low impact local use; no intensive cattle grazing
10	WSMA	Special Management Area around Water Courses	no clear cutting; no conversion into plantation; minimize disturbance to understorey vegetation	low impact local use; no intensive cattle grazing
11	WSh	Watershed Conservation	no clear cutting; no conversion into plantation; minimize disturbance to understorey vegetation	no intensive cattle grazing
12	NWC	Wildlife Conservation	no clear cutting; no conversion into plantation; leave snags; leave some undisturbed patches; minimize disturbance to understorey vegetation (bamboo)	local use should minimize disturbance to wildlife
13	SocLC	Social (Local cum Commercial Use)	depends on type of local use; has to be individually determined from case to case	no restriction
14		Production	no restriction	no restriction

Based on their impact on commercial forest management the forest functions are further classified into the following three categories (see Table 3).

Table 3: Forest function classification

Class 1 Protected Areas	Class 2 No Commercial Use	Class 3 Limited Production (commercial use restricted)
Biodiversity Protection Soil Protection Riparian Reserve Protection Road Buffer Wildlife Protection Local Water Supply Protection Religious Site Protection	Social (Local Use Only)	Soil Conservation Special Management Area around Water Courses Watershed Conservation Wildlife Conservation Social (Local cum Commercial Use)

All areas which have no defined function are considered as production forests without any particular management restriction except:

1. those imposed by the Forest and Nature Conservation Act 1995 and relevant rules issued by FSD from time to time.
2. management prescriptions/restrictions which cannot be mapped, such as:
    - 10 m buffer along small streams (as WRR);
    - 10 m along the top of the entrenchment slope of small streams with boulders or bed-rocks channel substrate (as WSMA);
    - 20 m along the top of the entrenchment slope of small streams with fine textured channel substrate (as WSMA); and
    - 30 m wide buffer uphill along temporary forest roads (logging roads) in unstable terrain (as RB).

5 Preparation of Forest Function Map

5.1 Specification of Forest Function Map

The standard scale of the Forest Function Map is 1:25.000. As attachment to the Management Plan itself the Forest Function Map has to be reduced to such a scale that it can fit on a A3 size paper. For the purpose of standwise planning, excerpts of the Forest Function Map should be enlarged at a scale of 1:10.000.

Beside the forest function itself the map must contain the following information (see example of the Forest Function Map of Kothoka in Annex 1):

- forest/non-forest areas
- villages, settlements, schools, campsites, sawmills, etc. with respective annotation
- roads, mule treks, footpathes
- streams, rivers and other drainage
- 40 m contour lines

Forest functions must be determined for all areas which have been defined as permanent forest areas by the participatory land use planning. However, particulars such as, black neck crane roosting or feeding places should be indicated on the map, too.

For all functions within one group the same colour is used. However, to distinguish among protective and conservative functions different patterns are applied. Additionally, the annotation of the following functions must be printed on the function map (WLS, WSMA, NB) to distinguish them from the other functions of the same group. The colour code of the GIS-Cell`s HP-plotter for the different functions is specified in Table 4.

Table 4: Colour code for forest functions for HP Plotter (GIS-Section)

Function Type	No Commercial Use			Limited Commercial Use		
Soil Conservation	Soil Protection	SP	9	Soil Conservation	SC	79
Water Conservation	Riparian Reserve Protection	WRR	77	Special Management Areas	WSMA	13
	Local Water Supply Protection	WLS	77	Watershed Conservation	WSh	13
Nature Conservation	Wildlife Protection	NWP	59	Wildlife Conservation	NWC	19
	Biodiversity Protection	NB	59			
Social Functions	Local Use Only	SocL	88	Local cum Commercial Use	SocLC	80
	Religious Site Protection	SocRS	88			
Road Buffer	Road Buffer	RB	69			

5.2 Mapping Procedure and Sources of Information

The forest function map must be prepared by the GIS-Cell of FRDS. As it need to be updated whenever a new plan is being prepared, the GIS- data of the function must be saved and stored permanently. One back-up set of the data has to be handed over for saafety reasons to the Forest Management Planning Section of FRDS.

Figure 1 shows the process of map preparation and the sources of information used.

The forest function map is prepared in three steps:

1. Preparation of *preliminary forest function map*
2. Preparation of *final forest function map (draft)*
3. Preparation of *final forest function map*

The preliminary forest function map is prepared in the offic based on the analysis of already existing information collected by:

- GIS-analysis,
- aerial photo interpretation,
- information collected by the Reconnaissance Survey,
- Participatory Rural Appraisal, and
- the Environmental Assessment.

Additional aerial photo interpretation and GIS-analysis will be necessary later on (see also Table 4*).* It will be important that during the planning process *(i.e. during PRA and EA exercise)* the proposed location of the nature conservation areas, and the delineation (including defining) of the social functions are jointly agreed upon by the followings:

- Forest Management Planner,
- Local population,
- The Forest Management Unit Incharge,
- Nature Conservation Section of Forestry Services Division and
- Forestry Development Corporation, in a participatory way.

Figure 1: Process of preparation of forest function map

The preliminary forest function map has then to be taken to the field for intensive field truthing, *in particular*: (i) Soil Conservation and (ii) Water and Watershed Conservation Area, and, if necessary, it has to be corrected accordingly and this map is then called *"Final Forest Function Map (draft)".* In case, more specific information are derived during compartment or standwise planning, these information must also be incorporated. This corrected, updated map is then the *"Final Forest Function Map".*

Table 4: Sources of information for the identification of the various forest functions

Source of Information	Type of Information	Related Forest Function
GIS-Analysis and Inventory Data Analysis	slope classes; settlements, infrastructure, etc.; human impact; occurrence of wildlife;	soil conservation; social functions; nature conservation;
Aerial Photo Interpretation	forest and land use types; wildlife habitats, biodiversity; rocks, erosion, roads, infrastructure; riparian zones and alluvial sites;	nature conservation; soil conservation; social functions; road buffers; water and watershed conservation;
Participatory Rural Appraisal (PRA)	localization and spatial distribution of local forest uses; quantification of local demand on different forest uses and estimation of sustainable production area; identification of social functions; identification of religious sites and holy places; identification of sources for local water supply; verification of preliminary forest function map (wildlife, biodiversity, corridors, buffers);	social functions; nature conservation; water and watershed conservation;
Environmental Assessment (EA)	verification and final determination of nature conservation areas, critical sites, inoperable areas; definition of management restrictions, etc.;	nature conservation; soil conservation; water and watershed conservation;
Field Truthing	verification of inoperable areas (steep slopes, rocks, erosion) and critical sites; verification of alluvial sites and stream classification; verification of land use classification; suitability of wildlife corridors;	soil conservation; water and watershed conservation; nature conservation; road buffers;
Standwise Planning	identification of rare ecosystems, habitats and sites (swampy and waterlogged areas) small in size or not identifiable on aerial photos; smaller size inoperable areas;	nature conservation (biodiversity, ecology, wildlife); soil conservation;
Contacts with relevant institutions	wildlife and biodiversity, social aspects, etc.;	all type of functions

The timely sequence of the individual working steps for the identification of the different functions s specified in the table below.

Table 5: Timely sequence of working steps for identification of different forest functions

Seq.	Working Step	Responsible Unit	Output	To be verified by
1	Preparation of GIS-Base Map.	GIS-Cell	Base Map	
2	Slope analysis.	GIS-Cell	Base Map	
3	Identification of standardized buffers for WRR, RB.	GIS-Cell	Prel. FFM	field truthing
4	Preliminary identification of WSMA.	GIS-Cell	Prel. FFM	API, field truthing
5	Analysis of inventory data for the preliminary identification of NWP, NWC, SocL and SocLC.	GIS-Cell	Prel. FFM	PRA, EA
6	Preliminary identification of SC and SP based on GIS slope analysis and aerial photo verification.	API-Cell	Prel. FFM	EA, field truthing
7	Delineation of entrenchment slopes for WRR identification.	API-Cell	Prel. FFM	EA, field truthing
8	Identify non-alluvial rivers for standardized WSMA, for alluvial and semi-alluvial streams identify WSMA.	API-Cell	Prel. FFM	GIS, EA, field truthing
9	Define WSh based on GIS slope analysis and include swamps and upper catchment areas.	API-Cell	Prel. FFM	EA, field truthing
10	Identify permanent forest areas.	PRA-Unit	Land Use Map	
11	Identify SocL, SocLC, SocRS.	PRA-Unit	FFM	
12	Identify water resources used for WLS.	PRA-Unit	Prel. FFM	standwise planning planner
13	Collect information on wildlife, biodiversity and inaccessible areas.	PRA-Unit	Prel. FFM	EA
14	Identify NWP and NWC, use information prepared by GIS-Cell and PRA-Unit.	EA	FFM	
15	Determine SP, SC, WSMA, WRR, WSh.	Field truthing	FFM	
16	Categorize roads and define RB.	Field truthing	Prel. FFM	GIS, field truthing
17	Identify buffer zone for WLS.	Standwise planning	FFM	
18	Map unstable areas as SP or SC which have not been identified so far.	Standwise planning	FFM	
19	Map drainage not yet identified and specify WRR.	Standwise planning	FFM	
20	Identify NB.	Standwise planning	FFM	

5.2.1 GIS Analysis and Inventory Data Interpretation

The GIS-Cell has to prepare a GIS-Base Map, at a scale 1:25.000 in the following manner:

1. Identify and digitize outer boundary of FMU.
2. Digitize 40 m contour lines, (where topographic map sheets are available). If maps are not available, use the satellite derived DEM with approximately 90 m resolution.
3. Categorize the following slope classes: (i) 26-50%, (ii) 51-75%, (iii)76-100%, (iv) > 100 %.
4. Digitize forest type boundaries *(aerial photo interpretation)* and specify the annotations.
5. Digitize additional information on infrastructure, religious sites, etc. (aerial photo interpretation).
6. Prepare GIS-Base Map containing the following information:
    - infrastructure such as: villages, settlements, roads, footpaths, etc. *(source of information: topo-sheets and LUPP maps);*
    - location of religious sites *(source of information: topo-sheets and LUPP maps);*
    - drainage; *(source : topo map)*
    - 40 metres contour lines; *(source: topo map)*
    - forest type and land use boundaries including annotation.
7. prepare an additional GIS-Base Map which contains the above specified information and show additionally the different slope classes in different light pattern or colours.

Of the above-mentioned GIS-base maps at least 5 copies each have to be produced and handed over to the forest management planner.The planning, identification and field truthing of the different forest functions have to be carried out by different supporting units of Forest Resources Development Section (see also Table 5). The detailed planning procedures are specified in the subsequent chapters.

The GIS-Cell has to prepare the Preliminary Forest Function Map, to digitize the final boundaries and to incorporate GPS-field measurement of i.e. roads, religious sites, etc. in the map.

Based on the information provided from aerial photo interpretation and field truthing, the GIS-Cell has to define the standardized buffer along

- roads (Road Buffer: RB)
- alluvial and semi-alluvial rivers (Riparian Reserve Protection: WRR)
- non-alluvial rivers (Special Management Areas: WSMA)

In cases, where a forest management inventory for the whole area has been carried out recently, the GIS-Cell, in collaboration with the Forest Inventory Cell, has to analyze the data for the preliminary identification of wildlife conservation areas (NWP, NWC) and of the social functions *(SocLC)* and *(SocL)*. This needs to be done before the EA and the PRA are carried out. The process of data analysis is described below.

Wildlife Protection (NWP)

1. Based on the wildlife data of the forest inventory, the location of the plots need to be identified where endangered species occur. This is done in the following way:
    - Sort WILDLIFE.DBF of the inventory data according to *Animal* and print out *Plotnr* for all protected species.
    - Prepare a GIS-layer (ANIMAL) and print out on 1:25.000 map the location of the plots using different colours for different species.
2. Furthermore, forest inventory information on human impact (should be minor) and/or the occurrence of bamboo *(an important habitat feature for red panda, bears and other protected*

animals) is used to locate suitable habitat areas. This is done by analyzing the SITE.DBF in the following way:

- select all records of SITE.DBF with *Bambocov* > 1
- prepare GIS-layer (BAMBO) of plot location
- then select all records which fulfill the following criteria, *i.e*. *Grazing* = N and *Comwext* = N and *Domwext* = N and *Abandcult* = N and *Cardamon* = N and (v) prepare GIS-layer (HUMAN) of plot location.

3. The combination of GIS-layer ANIMAL, BAMBO and HUMAN will show all areas which should be preliminarily identified Wildlife Protection areas*.*

Wildlife Conservation (NWC)

Based on the wildlife data, of the forest inventory, the location of the plots has to be identified where wildlife observations were made. This is to be done in the following way:

- sort WILDLIFE.DBF of the inventory data according to *Animal*
- print out *Plotnr* for all species except wild boar (*Animal* = BOAR)
- prepare a GIS-layer (ANIMAL2) and (iv) print out the location of the plots on 1:25.000 scale map.

Social Functions: (SocL and SocLC)

Based on the site data of the forest inventory the location of the plots has to be identified where local use was reported. This is to be done in the following way:

- select all *Plotnr*. in SITE.DBF for which *Grazing* = Y and *Comwext* = Y and *Domwext* = Y and *Abandcult* = Y and *Cardamon* = Y
- prepare a GIS-layer (HUMAN)
- print out the location of the plots on a 1:25.000 map scale.

5.2.2 API Aerial Photo Interpretation

Aerial photo interpretation is one of the most important means for forest function mapping. It has to provide detail information on *land use,* different *forest types* and on the *present infrastructure*. The use of stereoscopic pairs of aerial photos also allows the identification of *steep slopes*, *gorges*, *valleys* and the *classification of rivers*. Aerial photo interpretation has to be done at two stages:

- standardized interpretation of the whole Forest Management Unit, in the office, by the API-Cell of FRDS;
- identification of boundaries and forest functions in the field during PRA, standwise planning and field truthing by the responsible management planner.

Beside the specified functions below, aerial photo interpretation has to provide, in particular, information on the location of Religious Sites *(SocRS) and* information required for identification of Biodiversity Protection areas *(NB).*

5.2.2.1 Soil Protection (SP)

On the GIS-Base Map the FMU-area has already been classified into different slope categories. The accepted limit of slope, for any forestry operations, has been specified under section 14 (a) iii, of Forest and Nature Conservation Act of 1995, which says "*no permit shall be issued under this chapter to fell and take any timber ....on any place where the slope is greater than 45 degrees (100%) unless authorized under an approved management plan or by the Head of the Department*". Therefore, all areas with slope > 100% have to be put under soil protection.

However, slope maps derived from DEMs with comparatively low resolution tend to underestimate the steeper slopes considerably. Therefore, for the preliminary identification of soil protection areas, all areas having a slope of > 75% on the map should be earmarked.

The following steps shall be followed for determining the soil protection areas on the map:

- With the help of aerial photo interpretation, all areas of slope classes > 75% should be checked using the stereoscope.
- Identify actual Soil Protection area boundary, based on aerial photos and topographic map information *(do not use GIS-boundaries).*
- If there are doubts, whether an area should be classified as SP or not, then the area, in question, has to be marked for field verification (field truthing).
- Mark all areas near/around objects such as villages, settlements, individual houses, roads of slope class 51-75% *(GIS-Base Map)* for field check on stability.
- Indicate all SP areas on preliminary forest function map for field truthing.

5.2.2.2 Soil Conservation (SC)

In general, all areas belonging to slope classes 76-100%, as observed in the field, should be classified as Soil Conservation (SC). Because of the underestimation of the slope based on GIS-derived DEMs, (refer to chapter 5.2.2.1) all areas within DEM slope class 51-75% should be earmarked for Soil Conservation.

The following steps should be followed for determining the Soil Conservation areas on map:

- With the help of aerial photo interpretation, all areas of slope class 51-75% should be checked using the stereoscope.
- Identify actual Soil Conservation area boundary, based on aerial photos and topographic maps information *(do not use GIS-boundaries).*
- Identify exposed sites *(i.e. mountain ridges).*
- If there are some doubts, whether an area should be classified as SC or not, the area in question should be marked on map for field verification *(field truthing).*
- Indicate all SC areas on preliminary forest function map for field truthing.

5.2.2.3 Riparian Reserve Protection (WRR)

These areas occur along the banks of the rivers and streams and also around the perimeters of the lakes and wetlands. The following steps have to be followed for determining the areas for Riparian Reserve Protection:

- Identify alluvial, semi-alluvial rivers and streams and mark them on preliminary forest function map. The GIS-Cell should be requested to allocate a 30m wide buffer on each side of such rivers or streams.
- Should there be problems in classifying these rivers/streams in the office, then they have to be marked for field truthing later on in the field.
- For entrenched rivers and streams, identify WRR boundary along the top of the entrenchment slope.
- Transfer boundaries defined on aerial photos to the preliminary forest function map *(use Bausch & Lomb Zoom-Transferscope).*

5.2.2.4 Special Management Areas (WSMA)

Special Management Areas are areas along rivers and streams. They also include the perimeters of the lakes and wetlands. The following steps have to be followed for determining the areas for special management:

- Identify large non-alluvial rivers and mark them on preliminary forest function map. The GIS Cell should be requested for allocating a 100 m wide buffer on each side of such rivers.
- Should there be problems in classifying these rivers/streams in the office, they have to be marked for field truthing, later on in the field.
- For alluvial, semi-alluvial rivers and streams, identify the edge of the active flood-plain as function boundary *(if there are doubts, mark for field truthing).*
- Transfer the defined boundaries, which were marked on aerial photos, to the preliminary forest function map.

5.2.2.5 Watershed Conservation (WSh)

In general, all areas above 25% slope, as observed in the field, should be classified as Watershed Conservation Areas. It has to be mentioned, that in this slope category the underestimation of the slope determined by GIS-derived DEMs (refer to chapter 5.2.2.1) is minor and can be neglected (Remark: LUPP generally refers to GIS-derived slope classes). Therefore all forests on DEM slope class > 25% should be earmarked for Watershed Conservation. The following steps have to be followed for determining the areas for Watershed Conservation:

- Generalize polygons boundary, of all areas, with slope > 25 %.
- Determine upper catchment areas.
- Try to identify swamp forests on aerial photographs and mark them for verification in the field.

5.2.3 Participatory Rural Appraisal (PRA)

During PRA, the social functions and the buffer zones for the protection of water-bodies used for the local water supply (WLS) have to be defined and identified. This has to be done in co-ordination with the responsible forest management planner. If required, the boundaries should be surveyed in the field with the help of GPS. The detailed procedures for identifying and defining the individual functions are described in the chapter on PRA. However, a point of caution, the information derived from GIS-analysis and inventory data interpretation should be used (for verification) during the PRA exercise. In addition to the above, information on *wildlife*, *biodiversity* and *inaccessible areas* should also be collected.

Furthermore, one of the most important results of the PRA is the identification of the permanent forest area; only for this, forest functions have to be identified.

5.2.3.1 Social (SocL) (Local Use Only)

See chapter on PRA.

5.2.3.2 Social (SocLC) (Local and Commercial Use)

See chapter on PRA.

5.2.3.3 Religious Site Protection (SocRS)

See chapter on PRA.

Remarks:

Some of the religious sites may, already, have been indicated on the GIS-Base Map prepared by the GIS-Cell. The GIS-Base Map, so prepared, must be thoroughly checked on completeness and the individual religious sites need to be checked for buffering during the PRA. In case, if a 100 m buffer around a religious site is not considered as adequate, then the buffer zone has to be determined jointly by involving all concerned parties. Furthermore, if the

location of a religious site could not be determined from topo-/LUPP-maps or aerial photo interpretation, it´s location has to be identified using GPS.

5.2.3.4 Local Water Supply Protection (WLS)

See chapter on PRA.

The water sources used for local water supply have to be identified during the PRA. The mapping of the required buffer zone must be done during standwise planning (see chapter 5.2.6).

5.2.4 Environmental Assessment (EA)

Functions like SP, SC, WRR, WSMA and WSh are usually identified by aerial photo interpretation and can be easily mapped. However, the final identification of Nature Conservation areas needs to be co-ordinated with NEC, NCS, and RSPN during EA exercise.

The preliminary identification of Nature Conservation areas is done based on forest inventory data and information obtained from PRA (see chapters 5.2.1 and 5.2.3).

5.2.4.1 Wildlife Protection (NWP)

The information on wildlife derived from GIS-analysis and inventory data interpretation (see chapter 5.2.1) should be used and the preliminary identification process is continued by the management planner as follows:

- Incorporate and/or verify information on wildlife obtained from the PRA.
- Exclude areas close to settlements or in the vicinity of roads and footpaths, frequently used.
- As far as possible, NWP-areas (refuge areas and corridors) should be linked with areas having already other protective functions *(i.e. Soil Conservation, Riparian Reserves).*
- Link all the above mentioned information and mark polygons (generalize and if possible follow natural boundaries).
- Where necessary, carry out field truthing for the final boundary definition.

5.2.4.2 Wildlife Conservation (NWC)

By using the information on wildlife derived from GIS-analysis and inventory data interpretation (see chapter 5.2.1) continue the preliminary identification process as follows:

- Incorporate and/or verify information on wildlife obtained from the PRA.
- Identify forest areas on GIS-Base Map, that are used as wildlife habitats, *(i.e. mature and overmature fir forests).*
- Exclude areas close to settlements or in the vicinity of roads and footpaths which are frequently used and areas which are easily accessible. Consider other functions, in particular "Soil Conservation" and "Water and Watershed Conservation" and try to combine them with "Wildlife Conservation" zones.
- Link all above mentioned information and mark polygons *(generalize and if possible follow natural boundaries).*
- Where necessary, carry out field truthing for the final boundary definition.

5.2.5 Field Truthing and GPS-Measurement

After having completed the preliminary forest function map, field truthing needs to be carried out to check the boundaries of the different functions. Special attention should be paid to verify and authenticate those boundaries that were marked on the preliminary forest function map for field verification. Field truthing and authentication is mainly necessary for the final definition of soil conservation *(SP, SC)* areas and the water conservation areas *(WSMA and WRR)*.

The following procedure and points may be considered. viz.:

Soil Protection (SP)

Verify all areas in doubt *(i.e. the areas which have been marked for field check on preliminary forest function map)* in the field, in particular:

- Check steep areas (GIS-based soil class 51-75%) near/around or behind objects such as villages, settlements, individual houses, roads, etc. on stability.
- Check actual slope in the field and if necessary check soil type with a soil auger. If the soil type is gley or pseudo-gley or if top soil texture is composed of clay or silty clay include even areas below 75% slope, as observed in the field.

Soil Conservation (SC)

Verify and check all areas in doubt *(areas which have been marked for field check on Preliminary Forest Function Map)* in the field.

Special Management Areas along Water Courses (WSMA)

Check the marked river on Preliminary Forest Function Map whether it is non-alluvial and verify boundaries of WSMA along alluvial and semi-alluvial rivers and streams (see chapter 5.2.2.4).

Riparian Reserve Protection (WRR)

Check the marked rivers on Preliminary Forest Function Map whether they are alluvial or semi-alluvial (see chapter 5.2.2.3).

Watershed Conservation (WSh)

Carry out field truthing of swampy areas (see chapter 5.2.2.5).

5.2.5.1 Road Buffer Protection (RB)

Mapping the roads can be done, in most cases, based on GIS-Analysis and aerial photo interpretation, but the road classification and valuation of terrain stability has to be done during field truthing. The following procedures have tol be adopted for road mapping and classification:

- Identify and map all roads within FMU area.
- Mark all permanent forest road and logging roads aligned in unstable terrain *(above 50% slope)* using GIS-Base Map (with slope classes).
- Survey the roads not identified so far on the GIS-Base Map with the means of GPS.
- Classify the roads (i.e. motorable public road, permanent forest road or logging road).
- Check stability of the terrain along permanent forest and logging roads on slopes below 50%.
- Decide on width of buffer zone (see chapter 3.5) and indicate it on preliminary forest function map.

5.2.6 Refinement of Function Map during Standwise Planning

Standwise planning is carried out only within that part of the FMU-area in which activities are planned within the planning period. Therefore, the functions that have to be identified and mapped during the course of standwise planning can only be identified for these areas.

During standwise planning, the following information has to be carefully observed and, as far as possible, mapped. This will help to improve and to update the forest function map.

- All swampy and waterlogged areas, feeding the water courses for local water supply, have tobe identified and mapped as WLS.

- Steep and/or unstable areas, area prone to landslides, and also, areas showing indications of erosion as well as imperfectly drained or temporarily waterlogged areas on steep slopes (>50%) which have not been identified yet, as soil conservation areas (SP or SC), have to be mapped, too. This should be done with the help of aerial photos and/or GPS readings.
- Also, all water courses have to be checked. In case, if perennials and small streams are identified, which have not yet been indicated on the preliminary function map, they need also be mapped and the corresponding Riparian Reserve Protection (WRR) has tol be determined.

5.2.6.1 Biodiversity Protection (NB)

Areas which should be protected because of their richness in biodiverity or the occurrence of rare and protected plants can only be identified in the field during standwise planning. During the course of PRA, the local population may provide some information on the location of rare or fragile ecosystems, such as swamp forests. After identification in the field, the mapping can be done with the help of aerial photos and/or GPS readings.

Annex 1

List of Protected Animals and Plants

List of Totally Protected Wild Animals (Source: RGOB, 1995)

No.	**Common Name**	**Scientific Name**
1.	Asian Elephant	Elephas maximus
2.	Clouded Leopard	Neofelis nebulosa
3.	Golden Langur	Presbytis geei
4.	Musk Deer	Moschus chrysogaster
5.	Pangolin	Manis crassicaudata
6.	Pigmy Hog	Sus sylvanicus
7.	Snow Leopard	Panthera uncia
8.	Takin	Budorcas taxicolor
9.	Tiger	Panthera tigris
10.	Wild Buffalo	Bubalus bubalis
11.	Black-Necked Crane	Grus nigricollis
12.	Monal Pheasant	Lophophorus impejenus
13.	Peacock Pheasant	Polyplectron bicalcaratum
14.	Raven	Corvus corax
15.	Rufus-Necked Hornbill	Aceros nepalensis
16.	Golden Mahseer	Tor tor
17.	Spotted Deer	Axis axis
18.	Gaur	Bos gaurus
19.	Leopard	Panthera pardus
20.	Leopard Cat	Felis bengalensis
21.	Himalayan Black Bear	Selenarctos thibetanus
22.	Red Panda	Ailurus fulgens
23.	Serow	Capriocornis sumatraensis

List of Totally Protected Plants (Source RGOB, 1995)

No.	**Local Name**	**Common Name**	**Scientific Name**
1.	Agar/agaru	Eagle Wood/Indian Aloe Wood	Aquilaria malaccensis
2.	Yaetsa-guenboop	Chinese caterpillar	Cordyceps sinensis
3.	Pang-gen metog		Gentiana crassuloides
4.		Snow down lily	Lloydia yunnanensis
5.	Tsher-ngeon	Blue poppy	Meconopsis grandis
6.	Kirang-shing	Yew	Taxus baccata
7.	Bhreeng-gee-ra-dza	Ginseng	Panax pseudo-ginseng

Annex 2

Forest Function Map of Kothoka Forest Management Unit
(Scale 1:50.000)