



Bhutan-German Sustainable RNR*-Development Project (BG-SRDP)



*RNR =
Renewable
Natural
Resources

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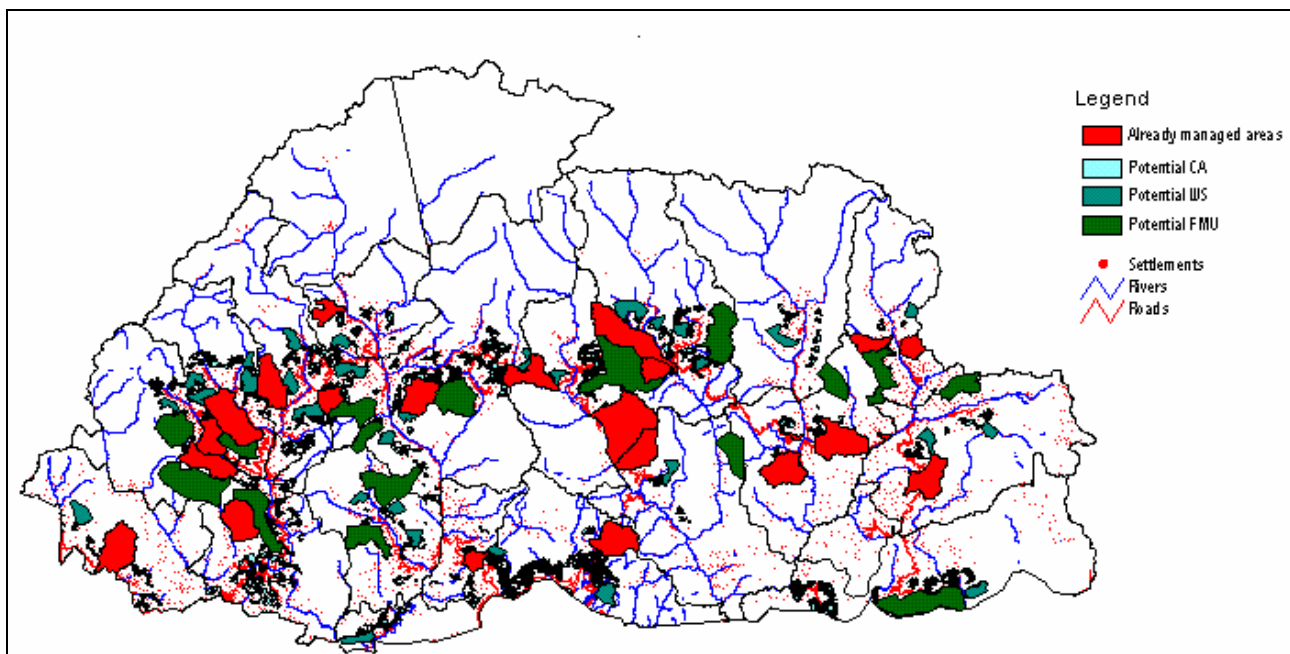
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National Forest Resources Potential Assessment (FRPA) for Bhutan

Part I:

GIS-analysis for the preliminary identification of potential forest areas for commercial timber use



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Abbreviations

BG-SRDP	Bhutan-German Sustainable Renewable Natural Resources Development Project
CA	Cushion Area
CF	Community Forest
DEM	Digital Elevation Model
DFO	District Forest Officer
DoFS	Department of Forest Services
FA	Total Forest Area
FDC	Forest Development Corporation
FMU	Forest Management Unit
FMPL	Forest Management Plan
FNCRB	Forest and Nature Conservation Rules of Bhutan
FRDD	Forest Resources Development Department
FRPA	Forest Resources Potential Assessment
GIS	Geographic Information System
LUPP	Land-use Planning Project
NCD	Nature Conservation Division
NFI	National Forest Inventory
NP	National Park
MOA	Ministry of Agriculture
RGOB	Royal Government of Bhutan
STC	Short-term Consultant, Short-term Consultancy
TA	Technical Advisor
VSO	Volunteer Service Overseas
WS	Working Scheme
WSh	Watershed Conservation
WWMP	Wang Watershed Management Project

Foreword

This report is the first part of the Forest Resources Potential Assessment (FRPA) for Bhutan and contains the results of the GIS-based analysis for the preliminary identification of potential forest areas for commercial timber use.

The reliability of a GIS-based analysis depends on the quality of data which it is based on. There have been some limitations in the use of the satellite based digital elevation model (DEM) with a 90m resolution and the reliability of the LUPP land use data from 1995. Furthermore, the parameters and criteria used for the GIS analysis are estimates derived from present experience in forest management. As such, the area statistics and maps provided herewith should be considered as what they are: a preliminary best estimate of areas which may most likely have a potential for commercial timber production in the near future.

The next step to be conducted now is, to check the areas preliminarily identified as potential forest management units (FMU) and working schemes (WS) in the field on their real economic potential. Only, once this is done, a proper estimate of the commercial timber production capacity of Bhutan's forest resources can be provided, which will be the content of part II of the FRPA-Report.

The GIS-analysis has been conducted by the GIS-Cell of FRDD with support of the Bhutan-German Sustainable RNR Development Project (BG-SRDP). Technical assistance was provided by Sonam Penjore from the Land-use Section of the Planning and Policy Division and Kinga Dheki from the Nature Conservation Division, Ministry of Agriculture. Without their continuous support and trouble shooting it would not have been possible to conduct this GIS-analysis in that short period of time.

At this place it has to be mentioned, that there is an urgent need to provide further technical assistance to the GIS-Cell of FRDD. This refers to upgrading of the hardware, update of the software and further training of the staff in data management, computer and system maintenance and GIS-applications.

1 The Forest Resources Potential Assessment

1.1 Objective and Limitations

It is the objective of the FRPA:

- *to identify and assess the present potential of the forest resources of Bhutan for sustainable commercial timber use with special consideration of technical and economical feasibility; and*
- *to valuate, whether the forests of Bhutan can sustainably supply the country's wood demand."*

The FRPA focuses on the present commercial timber production capacity, it does not identify and assess the overall potential of the forest resources for forest management in the long run. Although this may be desirable, it is simply not possible due to the sources of information available at present.

The FRPA is based on the LUPP land use classification, which specifies forest cover according to forest type and density class, and which is available in digital format. Regeneration and young forests such as the upcoming blue-pine regeneration has not been identified as forest areas, although they may have a very high production capacity in

the far future.¹ Furthermore, not much information is available at present on the production capacity of different sites. As such the FRPA is more exploitation than production oriented and provides only information on the potential commercial timber supply as long as the basic framework condition for forest management are not changed.

The identification of the overall production capacity of the forest resources of Bhutan in the long run needs more thorough investigation on forest condition, age or development stages, regeneration dynamics, site capacity, human interference, etc. This, however, can only be the task of a National Forest Inventory (NFI) which has to be based on intensive field sampling in order to get a better picture on the real forest situation.

Taking into account the pressure on the forest for the supply of the local and commercial timber and firewood demand and for other forest uses such as browsing, shoksing, etc. and, on the other hand, the priceless value of the forest from the environmental point of view, it is strongly recommended to implement a NFI² as soon as possible.

Only with a clear and realistic valuation of the forest condition and the ongoing changes, it is possible to design a forest policy which conserves the forests of Bhutan in order to meet the requirements (i.e. wood supply, nature conservation, environment protection, etc.) of the society as a whole.

1.2 Methodology and Approach

The FRPA has to be seen in the overall context of the 5-level planning approach (see Figure 1) in forest management planning. It is the first planning step and its major objective is to identify forest areas which have a potential for commercial timber use. As such it is a one time planning procedure which may be valid as long as legal, ecological, technical and economic framework conditions are not changed considerably.

The Forest Resources Potential Assessment (FRPA) itself comprises five planning steps as shown in Figure 2.

The first step, the GIS-analysis, provides a preliminary area estimate of forests which may have a potential for commercial timber production and identifies specific areas which may be managed as a FMU or WS in future.

Due to the limitations of GIS-analysis, the economic potential of these identified areas need to be verified in more detail and checked in the field in a second step. Another important aspect of this field check is to verify whether the assumptions and parameters applied in the GIS-analysis are really valid. If not, the GIS analysis needs to be adjusted and redone accordingly.

In a third step, an estimate of the overall commercial timber production capacity of Bhutan's forest resources can be given by combining forest inventory data with the GIS area and forest type statistics.

Step 4 deals with the estimation of the countries' commercial wood demand.

Finally, the FRPA Report will come up with a demand/supply scenario, provide a priority list of FMUs/WSs to be opened and will provide more detailed forest policy recommendations.

The FRPA distinguishes between a technical potential and an economic potential for commercial timber use which are defined as follows:

¹ LUPP has identified the land use classes based on SPOT satellite imagery. Regeneration and young growth coming up on pasture or under very open tree cover of mature trees could not be identified.

² The NFI needs to be designed and tailored specifically to meet these objectives.

Technical Potential:

The technical potential comprises the amount of timber which can be sustainably produced from the legal, technical, ecological and social point of view.

Economic Potential:

The economic potential comprises the amount of timber of the technical potential which can be sustainably produced from the economic point of view taking into account the prevailing economic condition and future development.

While the GIS-analysis identifies the forest areas suitable for commercial production from the technical and economical point of view, it is the task of step 3 to determine the actual volume and products (i.e. timber, firewood) which may be produced in future (AAC forecast).

Figure 1: 5-level planning approach in management planning

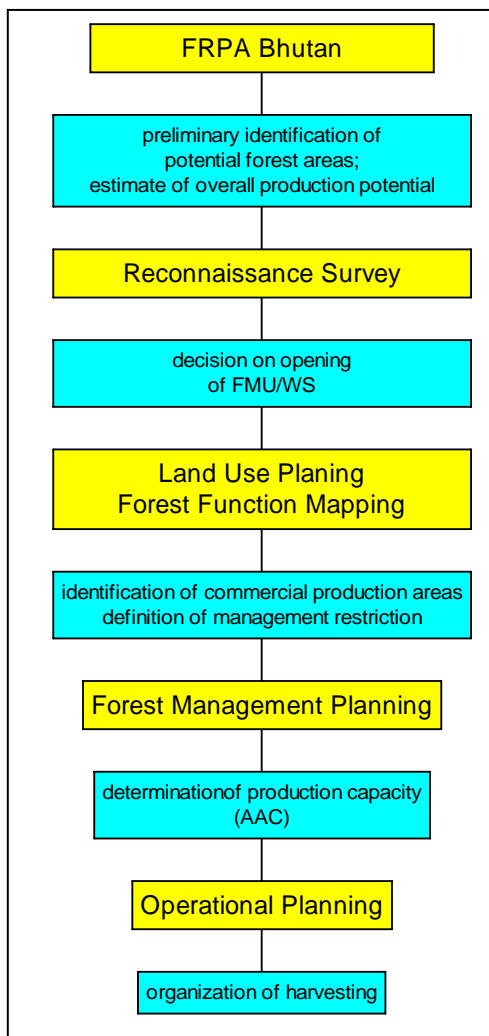
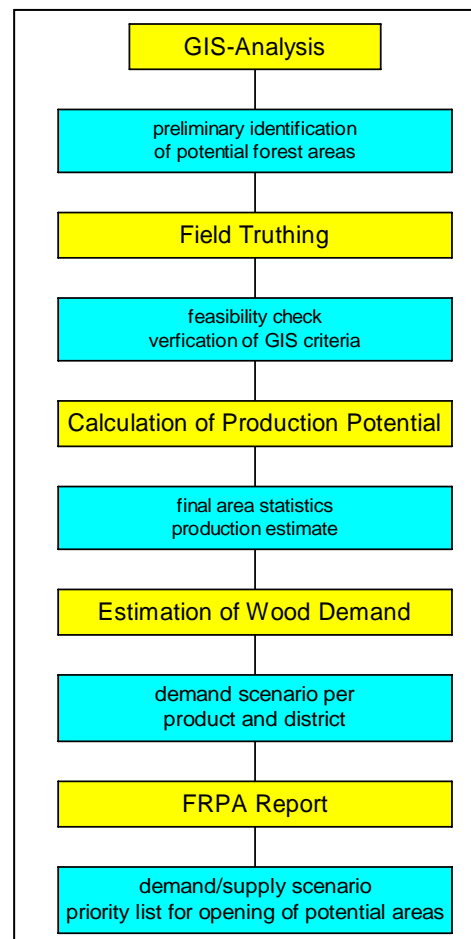


Figure 2: Process of FRPA



2 GIS-Analysis for the Identification of the Technical Potential

2.1 Brief Description of the Approach

The GIS-analysis followed the principle of negative selection, which means, that potential forest management areas are identified by excluding those areas, which definitely have no potential or which are already managed in one or the other way.

First, all officially protected areas³ (see chapter 2.2.1) and forest areas which are already managed (see chapter 2.5.1) were excluded from further analysis. Then all areas unsuitable for commercial production from the technical, ecological and social point of view were identified and excluded (see chapter 2.2), which are:

- Non forest areas
- Forest shrub
- Areas above 4000 m asl
- Inoperable areas (slope > 45°)
- Road and river buffers
- Local use only areas

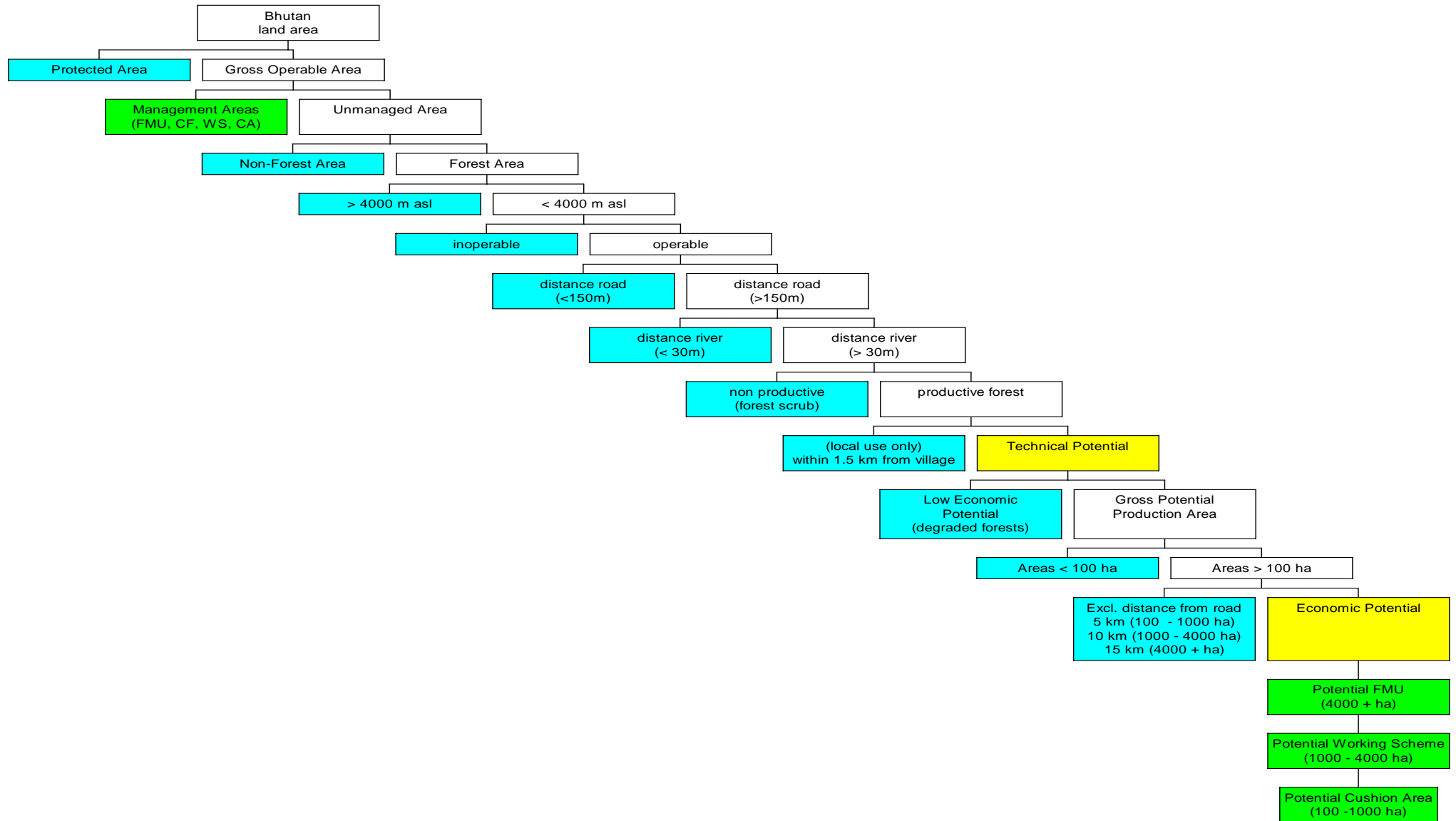
The remaining areas represent the technical potential forest area for commercial timber production. For the identification of the economic potential three criteria were applied: (i) the present forest condition, (ii) the size of the forest area and (iii) its distance to the next road. It was furthermore determined, whether they are located within a biological corridor⁴ or not. The actual process of GIS-analysis is shown in Figure 3.

Most of the required information for the GIS- analysis was already available in digital format. However, the location of the already existing working schemes, cushion areas and larger community forests had to be identified and digitised. Forest type and land use were derived from LUPP land use cover, slope classes were derived from the digital elevation model (DEM) of Bhutan with a 90 m resolution. Unfortunately, the DEM of Bhutan does not cover the whole country, some parts in the east and southwest and another small part in the far east are not covered. It was therefore necessary to calculate slope classes based on contour lines for these areas and to combine them with the slope classes derived from the DEM. The land use and slope data for whole of Bhutan have been very large which caused serious problems (i.e. hard- and software limitations, time required for data processing) and required in some cases, that the GIS-analysis could not follow the logical sequence as shown in Figure 3.

³ A number of areas or watersheds have been identified by a number of different organizations and institutions as critical watersheds, degraded areas, special management areas etc. but they have never been officially approved and in most cases no detailed maps are available. As all preliminarily identified potential FMUs will be checked on economical and ecological feasibility during the second step of the FRPA critical watersheds and other areas in need of protection will be identified at that planning stage, anyway. Smaller areas included within potential FMU for commercial use will be protected during the process of forest function mapping.

⁴ It is not yet decided, whether biological corridors will be declared as protected areas.

Figure 3: GIS-Analysis for the identification of potential forest management areas for commercial use



2.2 Description of Areas Excluded from Technical Potential

Table 1 shows a list of all areas according to their legal character, which were considered as being unsuitable for commercial timber use based on the definition specified above.

Table 1: Forest areas unsuitable for commercial timber use from technical point of view

Legal restrictions (technical, ecological)	Non-legal restrictions (ecological, social)
Classified Protected Areas	Forest areas above 4000 m asl
Steep slopes	Forest scrub
River buffers	Local use areas
Road buffers	

Out of technical reasons, the FRPA-Map: "Technical Potential" shows the technical potential including local use forests (total 812 thousand ha) which is different from the actual technical potential for commercial timber use (total 548 thousand ha) as calculated in Table 4.

2.2.1 Classified Protected Areas

Legal Situation:

According to the *Forest and Nature Conservation Rules of Bhutan 2000 (FNCRB)*, "Protected areas shall mean an area, which has been declared to be a national park, conservation area, wildlife sanctuary, wildlife reserve, nature reserve, strict nature reserve, research forest, critical watershed or other protected areas, in accordance with chapter VI of these rules."

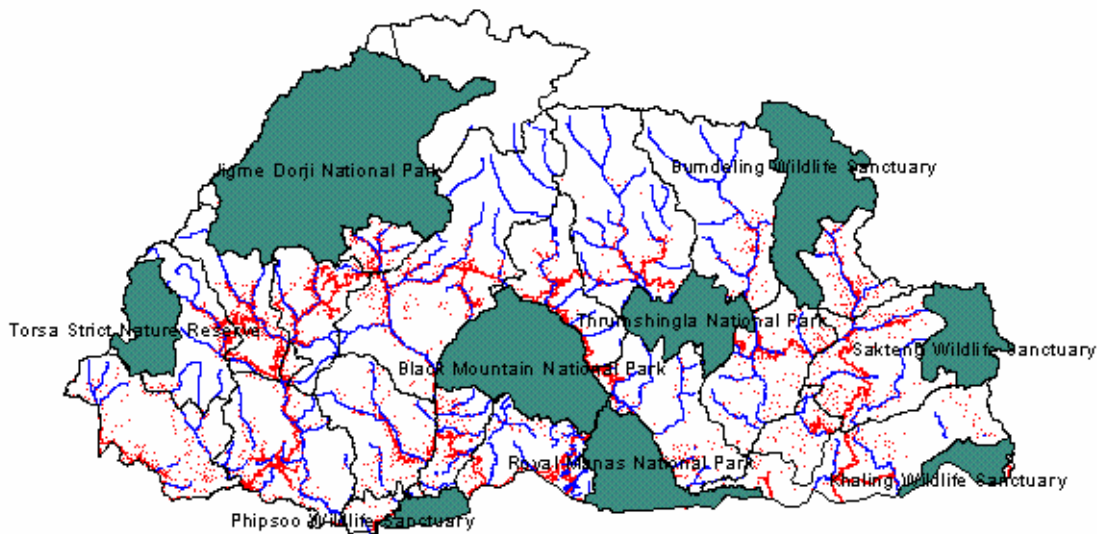
According to chapter 59 of the FNCRB, the Minister shall declare the protected areas from time to time as deemed necessary.

According to chapter 62 (1c) of the FNCRB, commercial logging shall be prohibited except with a written permit or authorization.

Strictly Protected Areas

The Government of Bhutan has officially declared altogether nine areas (see Figure 4) as strictly protected which cover a total land area of about 1,148 thousand ha of which 847 thousand ha are covered with forests. This is equal to 29% of the total forest area of the country.

Figure 4: Strictly protected areas



2.2.1.1 What about Critical Watersheds and Watersheds used for Hydropower?

Critical Watersheds

According to the definition in the FNCRB critical watersheds belong to protected areas. In the master-plan for Forestry Development (RGO/MOA/DOF 1991) a “*first crude macro level identification exercise has been attempted*” for the identification of critical watersheds. Altogether 14 sub-catchments have been identified as most critical, but the proposed operational level assessment on sub-watershed level has never been undertaken, nor have the critical watersheds been officially acknowledged. Most of these preliminarily identified watersheds are located along the southern boundary and overlap with already existing protected areas and biological corridors.

Watersheds and catchments used for hydro-electric power production

There is no specific regulation how far commercial forest management is restricted within water catchments used for hydro-electric power production. At the moment, the Government of Bhutan is working on the preparation of a National Water Policy or Act involving all relevant Ministries (i.e. Ministry of Power, Ministry of Agriculture, etc.). According to the prescriptions for forest function mapping, all water-bodies and streams are buffered and these buffer zones are excluded from logging. Furthermore, sensible water catchment areas are classified as Watershed Conservation (WSh), where e.g. clear felling, etc. is prohibited. As these management restrictions are adequate to ensure proper protection of the water catchment area, there is no need to exclude those areas from future forest management⁵.

⁵ According to the Department of Power, no maps exist indicating water catchment areas or sub-catchments which should be excluded from forest management

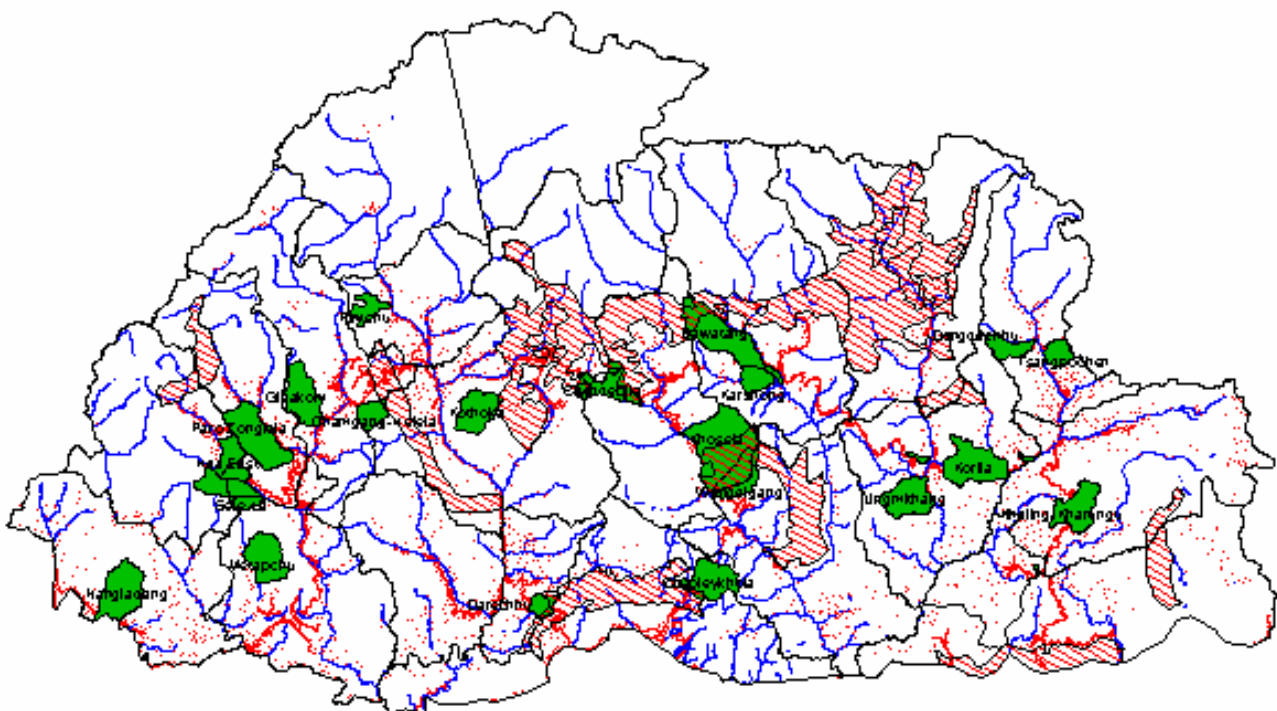
2.2.1.2 *What about Biological Corridors?*

Biological corridors have not been listed as protected areas according to FNCRB. The protection status of Biological Corridors is not clear. According to NCD (undated) it is proposed that “*there is no reason that such corridor should prevent an area of forest being made into a forest management unit (FMU) provided that adequate attention is paid to maintaining genetic corridors across the area during the management plan for that unit.*”

The final decision on the protection status is up to the Minister of Agriculture and may depend on the results of the FRPA. It has to be mentioned at this place, that biological corridors overlap with the forest management units Dawatang, Kothoka, Chamgang-Helela and Wangdigang, and the working schemes Chapleykhola and Darechu

Biological corridors cover a total land area of 383 thousand ha of which 362 thousand ha are covered with forests (or 12% of the total forest cover). The location of the biological corridors and their overlap with already managed areas is shown in the Figure 5 below.

Figure 5: Location of biological corridor and overlap with already managed areas



Remark: If biological corridors would be excluded from commercial timber use than the economic potential forest area would drop from 14.0% to 11.3% of the total forest area (refer also to Table 4).

2.2.2 *Forest Areas above 4000m asl*

According to FRDD no commercial forest management for timber production shall take place on altitudes above 4000m asl. Altogether 219 thousand ha of forest outside of strictly protected or already managed areas are located on altitudes above 4000 m asl mainly in

the northern parts of the country. If these areas are deducted from the already protected or already managed areas then 1,694 thousand ha of forest, which is equal to 57.8% remain.

2.2.3 Inoperable Areas

According to FNCRB 17 (13e) forest areas on slopes > 45° shall be excluded from commercial timber exploitation.

The GIS-analysis of the slope is based on the DEM of Bhutan, which was derived from satellite imagery with a 90m resolution. According to Laumans 1995 "*slope maps generated from DEMs with a relatively low resolution tend to underestimate the steeper slopes considerably*". Field checks and verification based on stereoscopic aerial photos has proven, that areas located above slope classes of 50% (derived from DEM) contain a high percentage of very steep areas and are de facto inoperable⁶.

Therefore, for the preliminary identification of potential forest areas the slope limit was set at 50%. It has to be kept in mind, that a more detailed slope classification will be conducted during the course of forest function mapping for each individual FMU which has passed the reconnaissance survey successfully.

The total operable forest below 4000 m asl (excl. protected and already managed areas) is about 875,000 ha or 29.9 % of the total forest cover.

2.2.4 Road Buffer

According to FNCRB 17 (13e) forest areas shall be exempted from exploitation within 600 feet uphill and 300 feet downhill of any national highway (other than a forest road).

As it was not possible to distinguish between uphill and downhill side of roads, all roads were buffered with a 150m buffer on each side. Altogether, about 18.5 thousand ha of forests were deducted from the operable forest area specified in chapter 2.2.3.

2.2.5 River Buffers

According to FNCRB 17 (13e) forest areas within 100 feet of the bank or edge of any river, stream, watercourse or water source shall be exempted from timber exploitation.

During the GIS-Analysis the rivers were buffered with a 30m buffer each side. This is rather an underestimate, as the riverbeds are not included as well as the entrenchments slope. Also, only the main rivers have been added (note: to identify the real river buffers is subject of forest function mapping).

River buffers are estimated at about 8 thousand ha.

2.2.6 Alpine and Forest Scrub

Alpine and forest scrubs, classified as "FS" by LUPP have no potential for commercial timber use and were excluded.

Within the operable forest area altogether 36.4 thousand ha are alpine and forest scrub. If their area is deducted, then only about 812,400 ha remain available for timber production from the technical point of view.

2.2.7 Local Use only (Village Buffers)

Potential forests within the range of 1.5 km from a settlement has been set aside for local use only, which comprise about 264 thousand ha.

⁶ It has been experienced in the past, during the course of forest management planning, that areas defined as operable production forest operable still contain a considerable percentage (10-30%) of inoperable areas.

Validation:

Due to climatic condition, the timber and firewood per household is quite high in Bhutan. It increases with altitude. Most of the wood demand in rural areas is produced/collected in forest areas close to the settlements. Only a fraction comes from FMUs or commercial wood production (i.e. wood waste, residuals, urban supply). SCHINDELE 1995 estimated the official fuelwood supply⁷ from standing trees for Wangdi-Phodrang, Punaka and Gasa Districts at 0.67 cbm/capita. The rural demand on construction timber produced by local use (outside FMUs) was estimated at about 0.92 cbm/capita⁸. This figure is fairly high and may drop in future with the use of other materials for house construction (e.g. corrugated iron sheets instead of shingleps).

The total amount of timber from standing trees for the rural supply is estimated at 550,000 capita*1.6 cbm/capita = 880,000 cbm standing volume.

Taking into account an average increment of 3 cbm/year (estimate derived from the analysis of several forest inventories throughout Bhutan), then the production capacity is about 264,000 ha * 3cbm/ha = 792,000 cbm per year.

As such, to set aside all forest areas within a 1.5 km buffer zone around settlements seems to be a realistic estimate (remark: rural wood supply also comes from forest areas which have already been excluded from further analysis such as high altitudes, commercially inoperable areas, forest scrubs, etc.).

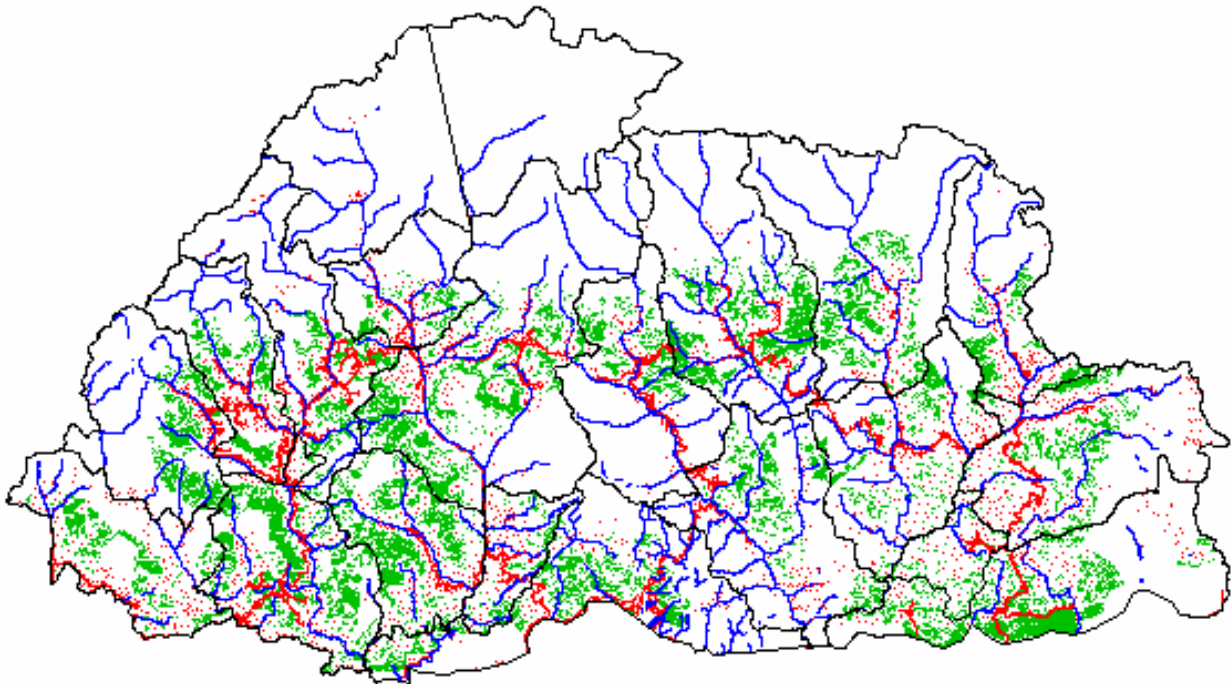
2.3 Technical Potential

If all the above mentioned forest areas are deducted, then altogether about 548 thousand ha of forests, which is equal to 18.7% of the country's forest cover, have an additional potential from the legal, technical, ecological and social point of view (technical potential see definition in 1.2). Figure 6 shows the distribution of these areas:

⁷ Each rural household has the right to obtain 4 trees per year for the production of fuelwood. The trees are marked by the beat officer and are usually selected close to the household location (SCHINDELE, 1995).

⁸ This figure includes the supply of construction timber for the dzong renovation and construction of the NRTI building in Wangdi-Phodrang.

Figure 6: Forest areas having an additional technical potential for commercial timber use



2.4 Description of Areas Excluded from Economic Potential

The economic viability of commercial timber exploitation depends on many variable factors such as: accessibility, quantity and value (price) of timber to be harvested, harvesting system applied, distance to market, etc. As such, the economic potential is no constant value, but depends from the actual economic situation. For the purpose of this analysis the assumption was made, that timber prices may increase in future depending on the high demand in timber.

In absence of reliable information and due to technical constraints, it was simply impossible to consider all economic factors during the GIS-analysis. However, three factors which have the highest impact from the economic point of view could be addressed, which are:

- forest type and condition
- size of forest area
- accessibility or the distance to the next road

In the following chapters the criteria which have been applied for the identification of the economic potential forest areas for commercial timber use are described.

2.4.1 Degraded Forests

SCHINDELE 1995⁹ categorized LUPP forest types according to their potential for commercial forest management into the following three classes:

Table 2: LUPP forest types and their potential for timber use

Class	LUPP land use class
Low potential	FCf1, FCm1, FCb1, FCc1, FCc2, FBc1, FB1
Potential	FCf3, FCm3, FCb2, FBc3, FB3
High potential	FCf2, FCb3, FCc3, FBc2, FCm2

All forests classified as low potential are deducted from the technical potential forest areas.

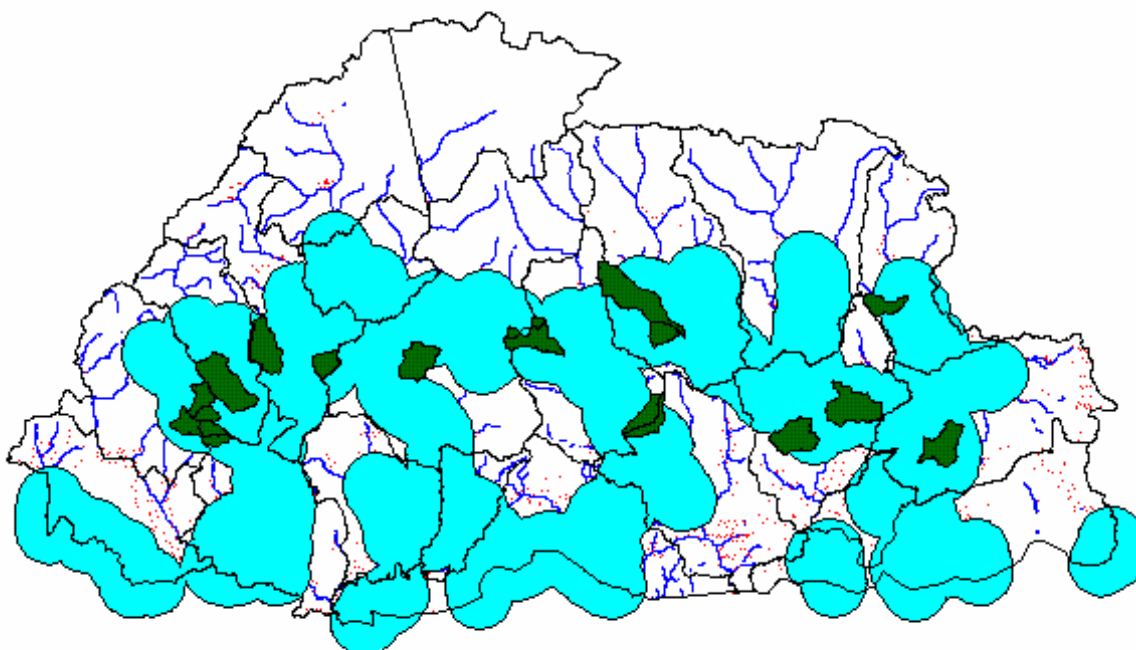
2.4.2 Minimum Size of Forest Area

Isolated forest patches having a size of less than 100 ha are – under present condition, using cable crane for logging - considered as being too small for commercial logging. For larger forest blocks the minimum size depends on the distance to the next road (refer to chapter 2.4.3).

2.4.3 Maximum Distance from Road

The maximum distance from the next forest road depends on the size of the potential forest area. GIS-analysis has shown, that all existing FMUs are located within a horizontal distance of 10 km to a road (refer to Figure 7).

Figure 7: Location of existing FMUs within 10km road buffer



⁹ This was done by linking forest management inventory which have been conducted within FMUs throughout the country with LUPP land use classes.

Taking into account future economic development (i.e. rise in timber price) only forest areas are considered having an additional economic potential which fulfil the criteria specified in the table below:

Table 3: Maximum distance from next road

Type of Potential Area	Size	Maxim distance from road
FMU	4000+ ha	15 km
Working Scheme	1000 – 4000 ha	10 km
Cushion Area	100 – 1000 ha	5 km

Altogether 16 potential forest management units and 31 working schemes were identified (refer to chapter 2.5.1).

2.5 Economic Potential

If all the areas described above are deducted from the additional technical potential, than altogether about 240 thousand ha of forests remain which have an economic potential for commercial forest management in addition to those areas already managed, which is equal to 8.2 % of the total forest cover (refer to Table 4).

If the 159 thousand ha of forest management areas are added then the total economic potential forest area for commercial use is about 410 thousand ha or 14% of the total forest cover. This includes biological corridors. Table 5 and Table 6 below show the distribution of the economic potential according to management status.

Table 4: Identification of the area having an additional economic potential

Type of Area	Forest Area (ha)	Remaining Forest Area	
		(ha)	in % of total
Total Forest Area	2,929,085	2,929,085	100.0
- Strictly protected areas	-846,054	2,083,031	71.1
- Areas already managed	-169,991	1,913,040	65.3
- Forest area > 4000 masl	-218,738	1,694,302	57.8
- Inoperable areas	-819,055	875,247	29.9
- Road buffer	-18,482	856,765	29.3
- River buffer	-8,013	848,752	29.0
- Alpine and forest shrub	-36,381	812,371	27.7
- Forest reserved for local use	-264,779	547,592	18.7
Additional Technical Potential		547,592	18.7
- Degraded forests	-32,356	515,236	17.6
- Forest areas > 15 km from road	-69,479	445,757	15.2
- Small forest patches < 100 ha	-59,196	386,561	13.2
- Forest areas < 4000 ha and > 10 km from road	-70,187	316,374	10.8
- Forest areas < 1000 ha and > 5 km from road	-76,801	239,573	8.2
Additional Economic Potential		239,573	8.2

Table 5: Economic potential areas (including biological corridors)

Potential areas	Total Area	Forest Area	% of total FA
	(ha)	(ha)	(%)
Areas already managed for commercial timber use	197,996	169,991	5.8
Preliminary identified FMUs	158,842	110,776	3.8
Preliminary identified Working Schemes	58,536	43,165	1.5
Areas < 1000 ha	85,632	85,631	2.9
Total Economic Potential Forest Areas	501,006	409,564	14.0

Table 6: Economic potential areas (excluding biological corridors)

Potential areas	Total Area	Forest Area	% of total FA
	(ha)	(ha)	(%)
Areas already managed for commercial timber use	176,679	158,936	5.4
Preliminary identified FMUs	120,326	82,138	2.8
Preliminary identified Working Schemes	37,652	34,020	1.2
Areas < 1000 ha	54,439	54,439	1.9
Total Economic Potential Forest Areas	389,096	329,533	11.3

2.5.1 Areas Already Under Forest Management

FRDD distinguishes the following four categories of forests according to management status:

- Cushion Areas (CA)
- Working Schemes (WS)
- Forest Management Units (FMU)
- Community Forest (CF)

2.5.1.1 Working Schemes and Cushion Areas

For working schemes and cushion areas neither a clear definition nor elaborated management concept exists. Working schemes are usually larger and managed over a longer period of time, or are located within areas previously identified as a FMU, but which have never been managed as FMU. Cushion areas are quite small and harvested within a period of less than one year. Both are managed based on a type of harvesting plan which is set-up for a period of one to three years. Forest management is not sustainable within one particular cushion area or working scheme. It is of urgent importance to develop a management system which regulates sustainability in the long run within a group of CAs or Ws, which are preferable located within one district, otherwise these areas will be over-utilised. Also management responsibilities need to be clearly defined.

At the moment the following working schemes and cushion areas are under operation:

Table 7: List of existing working schemes

Name of working scheme	Dzongkhag	Total area	Total Area without NPs	Forest Area without NP	Operable Working scheme area
		(ha)	(ha)	(ha)	(ha)
Rimchu	Punakha	4455	500	492	212
Chapley Kola	Sarpang	10913	2848	1695	532
Darechhu	Tsirang	3273	3273	2509	696
Tsangpochen	Trashiyangtse	4134	4134	3911	502
Tsamang	Monggar	677	677	641	651
Total		23452	11432	9248	2593

The total area of the existing five working scheme is 23,4 thousand ha. However, Rimchu is located within the multiple use zone of Jigme Dorji NP and Chapley Kola within the multiple use zones of Royal Manas NP and Black Mountain NP. As, according to FCCRB, no commercial timber exploitation is permitted in protected areas, the manageable area is reduced to 11.4 thousand ha of which 9.2 thousand ha are actually covered by forests. The operable working scheme area (i.e. area for which a "harvesting plan" has been prepared) is altogether 2,593 ha.

Table 8: List of existing cushion areas

Name	Dzongkhag	Total area	Operable Forest Area
		(ha)	(ha)
Jogidara	Samtse	9	9
Lamitar		126	75
Bhoteykharka - 3		38	30
Bhoteykharka - 4		15	12
Bhoteykharka - 5		27	21
Kalapani		250	250
Dipujhora		105	60
Total		570	457

There are altogether 7 cushion areas, all are located in Samtse Dzongkhag. Their total area is 570 ha, of which 457 ha are defined as operable forest area. Beside Kalapani, all cushion areas are smaller than 100 ha.

2.5.1.2 *Forest Management Units*

Forest management units are large forest areas and generally cover whole watersheds. They are managed permanently on a self-sustainable basis. There are altogether 14 FMUs currently under operation covering a total land area of 138.5 thousand ha and a forest area of 120.3 thousand ha (4.1% of total forest cover). Three FMUs are in the planning stage. According to the various management plans the total operable forest area is 113.1 thousand ha. A list of the already existing FMUs and those which are currently in the planning stage is provided by Table 9 below.

Table 9: List of existing and already planned FMUs

Name	Dzongkhag	Total area (ha)	Forest area (ha)	Operable (ha)
Karshong	Bumthang	4693	3876	3047
Dawathang	Bumthang	17529	14191	9232
Haa East	Haa	7122	6231	5882
Sele La	Haa	9695	8837	6125
Korila	Monggar	13832	11734	8109
Lingmithang	Monggar	10566	9879	5686
Paro-Zonglela	Paro	16151	13894	12319
Chamgang-Helela	Thimpu	4696	4611	4440
Gidakom	Thimpu	10948	9488	7836
Khaling-Kharungula	Trashigang	10057	7463	4721
Chendebji	Trongsa	9704	8332	7823
Khotokha	Wangdue	9377	8673	8548
Wangdigang	Zhemgang	9333	8384	2450
Dongdechhu	Trashiyangtse	4813	4742	2612
Subtotal established FMUs		138516	120334	88830
<i>Nangladang*</i>	<i>Samtse</i>	<i>13314</i>	<i>10459</i>	<i>9427</i>
<i>Metapchhu*</i>	<i>Chhukha</i>	<i>10535</i>	<i>9596</i>	<i>8567</i>
<i>Khosela*</i>	<i>Tronsa</i>	<i>23309</i>	<i>19576</i>	<i>6319</i>
Subtotal FMU planning stage		47158	39631	24313
Total FMUs		185674	159965	113143

2.5.1.3 *Community Forests*

There are altogether nine officially approved community forests in Bhutan and another two (i.e. Dawakha, Jilegang) are in the planning stage (source: Forestry Extension Division, DoFS). Only three of them are located within existing natural forests (see Table 10). The total area of natural forest managed as CF is 580 ha. Yakpugang is located within Korila FMU. All other CFs are plantations which vary in size from 0.4 ha to 8.0 ha and are of no relevance for the FPRA.

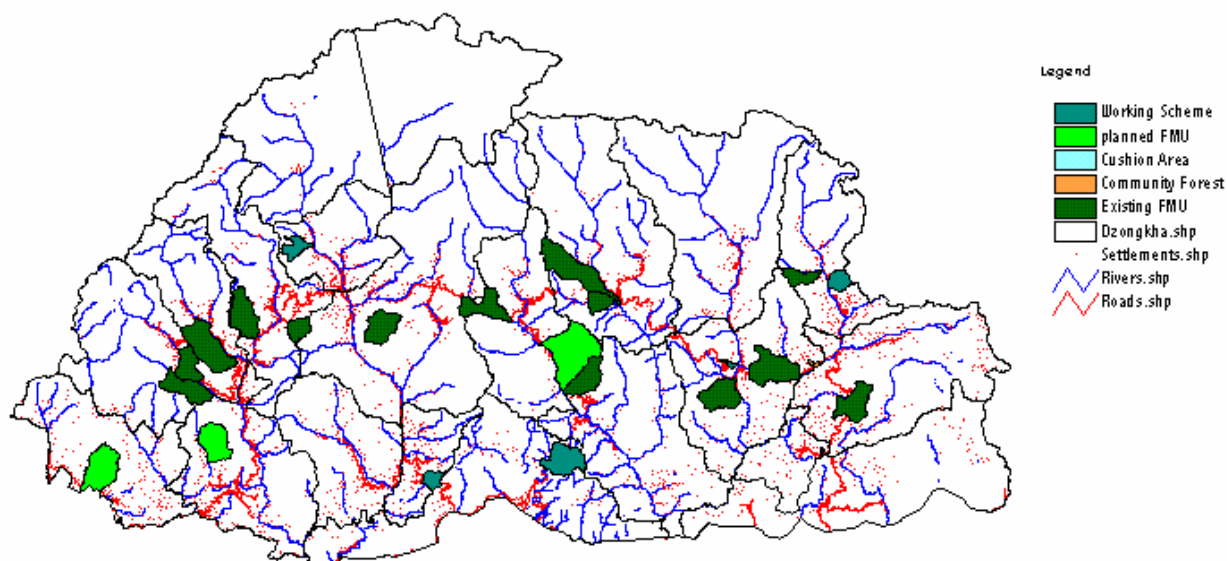
Table 10: Existing natural forests managed as a community forest

Name	Dzongkhag	Total area (ha)	Total area without FMU (ha)
Yakpugang	Mongar	260	0
Dezam	Mongar	300	300
Gayzor	Pemagatshel	20	20
Total CF		580	320

Figure 8 below shows the location and distribution of all areas¹⁰ which are already under forest management.

¹⁰ Very small cushion areas and community forests assigned for reforestation are not included.

Figure 8: Location and type of already managed forest areas



The total forest area which is already managed for timber use is altogether about 170 thousand ha or 5.8 % of the total forest cover (see Table 11).

Table 11: Compilation of areas already managed

Areas already managed	Total Area	Forest Area	% of total FA
	(ha)	(ha)	(%)
Existing FMU ^{*1}	138,516	120,334	4.1
FMU under Preparation	47,158	39,632	1.4
Community Forests ^{*2}	320	320	0.0
Working Schemes	11,432	9,248	0.3
Cushion Areas	570	457	0.0
Total Area under Forest Management	197,996	169,991	5.8

^{*1}: excluding areas located in NPs

^{*2}: excluding areas located in FMUs

2.5.2 Additional Potential Areas

The areas identified as having an additional economic potential were classified according to size as described in chapter 2.4.3 specified in Table 3.

Figure 9 shows the distribution of the potential forest areas for commercial timber use.

Figure 9: Location of potential forest areas for commercial timber use

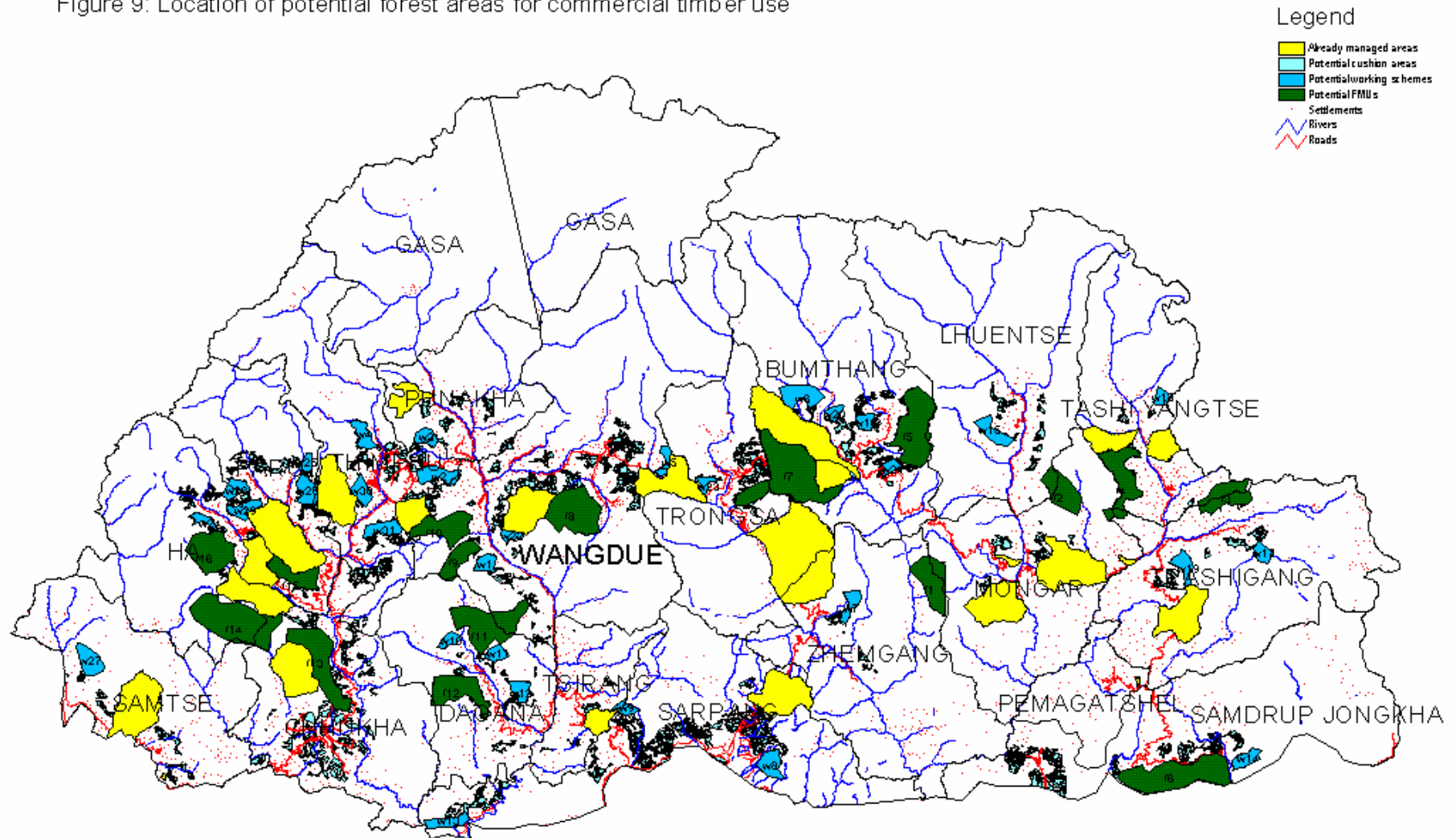


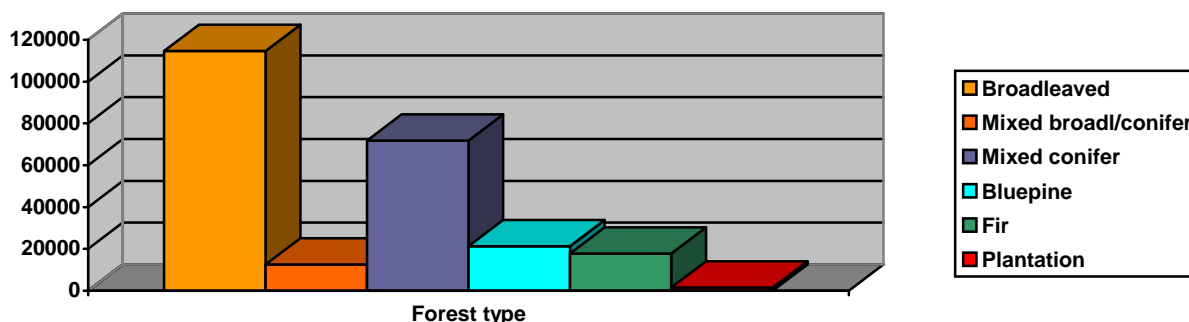
Table 12: Additionally potential forest areas according to district

District	FMU			WS			Cushion Area		Total		
	non pot.	pot.	total	non pot.	pot.	total	pot.	total	non pot.	pot.	total
BUMTHANG	10310	19659	29969	2424	5088	7512	5449	5449	12734	30197	42930
CHHUKHA	2487	11404	13891				11035	11035	2487	22439	24926
DAGANA	6304	9674	15978	765	3812	4577	1910	1910	7069	15395	22464
HA	7630	14110	21740	817	2237	3054	2550	2550	8447	18897	27344
LHUENTSE	879	1260	2139	636	1863	2499	2092	2092	1515	5215	6730
MONGAR	1837	4269	6106				2205	2205	1837	6474	8311
PARO	1112	3627	4739	1460	3906	5366	3812	3812	2572	11346	13917
PUNAKHA				223	947	1170	2504	2504	223	3451	3674
SAMDRUP JONGKHA	2106	13041	15147	227	1769	1996	7754	7754	2333	22563	24896
SAMTSE	107	219	326	985	2120	3105	2626	2626	1092	4965	6057
SARPANG				1411	4584	5995	13882	13882	1411	18466	19877
TASHI YANGTSE	2564	7581	10145	386	765	1151	822	822	2950	9168	12118
THIMPHU				3158	7560	10718	8348	8348	3163	15903	19066
TRASHIGANG	513	3290	3803	1315	2276	3591	2425	2425	1828	7991	9819
TRONGSA	797	2443	3240	367	1099	1466	3512	3512	1164	7055	8219
TSIRANG				53	250	302	829	829	53	1078	1131
WANGDUE	8559	17174	25733	852	3245	4097	13082	13082	9407	33506	42912
ZHEMGANG	2859	3025	5884	293	1644	1937	796	796	3152	5466	8618
Total	48066	110776	158842	15371	43165	58536	85632	85632	63436	239574	303010

The districts having the highest ratio of additional potential areas are Wangdue, Bumthang, Chhukha and Samdrup Jongkha. The distribution of potential FMUs, working schemes and cushion areas within the districts is described further below. The distribution according to LUPP land-use forest types and according to management type and district is attached in Annex 4.

48% of the potential forest areas are stocked with broadleaved forests, 5% with mixed broadleaved/conifer forests and 47% with conifer forest. The distribution varies according to ecological zones from district to district. The figure below shows the distribution of the potential forest area according to forest type.

Figure 10: Distribution of forest types within additional potential areas



2.5.2.1 Potential Working Schemes

Altogether 31 potential working schemes were identified with a total area of about 58.5 thousand ha, of which 43.1 thousand ha have a potential for commercial timber use.

Especially in the west (i.e. Thimpu, Paro and Wangdue) there is a high number of potential working schemes, but also in the far eastern district of Bhumtang. Working schemes also overlap in some cases district boundaries. The distribution of potential working schemes according to districts is shown in Table 13.

Table 13: Potential working schemes according to district

District	No. of WS	High Potential (ha)	Potential (ha)	Total Potential (ha)	Non Potential (ha)	Total Area (ha)
BUMTHANG	6,16,20,21	3026	2062	5088	2424	7512
DAGANA	10,11,12	1262	2550	3812	765	4577
HA	24,26,29	1636	601	2237	817	3054
LHUENTSE	15	989	873	1863	636	2499
PARO	25,26,28,29	2949	956	3906	1460	5366
PUNAKHA	3	1	946	947	223	1170
SAMDRUP JONGKHA	14	1026	742	1769	227	1996
SAMTSE	27	965	1155	2120	985	3105
SARPANG	8,9,13	1225	3359	4584	1411	5995
TASHI YANGTSE	18	402	362	765	386	1151
THIMPHU	2,3,4,28,30,31	4497	3063	7560	3158	10718
TRASHIGANG	17,19	1240	1036	2276	1315	3591
TRONGSA	15,23	433	666	1099	367	1466
TSIRANG	9	7	243	250	53	302
WANGDUE	1,2,5,22	853	2392	3245	852	4097
ZHEMGANG	7	17	1627	1644	293	1937
Total		20532	22634	43165	15370	58536

25% of the working scheme area has no potential for commercial use, this includes forest set aside for local use, open and degraded forests and agricultural areas. Of the remaining potential areas 49% are over-mature forests which should have high priority for harvesting (see Table 14). The distribution of the forest areas according to LUPP land-use classes is attached in Annex 4.

There is a high number of forests which qualify as potential cushion areas (i.e. potential forest patches with a size 100 ha - 1000 ha). Many of those are located within the vicinity of existing or potential FMUs or working schemes. Their total potential area is altogether 85.6 thousand ha. The highest number of potential cushion areas is found in the districts of Sarpang, Wangdue, Chhukha and Thimphu (the distribution of cushion areas according to districts can be derived from Table 12).

Table 14: Potential working schemes according to potential areas

No. of WS	High Potential (ha)	Potential (ha)	Total Potential (ha)	Non Potential (ha)	Total Area (ha)
1	0	1408	1408	316	1724
2	571	1714	2285	844	3129
3	1	1222	1223	413	1636
4	1419	194	1613	523	2136
5	1078		1078	303	1381
6	2059	569	2627	1401	4029
7	17	1627	1644	293	1937
8	339	1737	2076	783	2859
9	111	825	936	190	1127
10	478	590	1068	227	1295
11	526	758	1284	207	1491
12	258	1202	1460	331	1791
13	782	1040	1822	490	2312
14	1026	742	1769	227	1996
15	989	873	1863	636	2499
16	14	950	964	464	1428
17	851	216	1067	450	1518
18	402	362	765	386	1151
19	389	820	1209	864	2073
20	176	543	719	329	1048
21	778		778	229	1007
22	59	742	801	324	1125
23	149	666	816	253	1069
24	261	590	850	293	1143
25	388	376	764	244	1008
26	1232	3	1235	623	1858
27	965	1155	2120	985	3105
28	1729	392	2121	640	2762
29	1296	225	1521	552	2073
30	1157	198	1355	901	2256
31	1031	893	1924	648	2572
Total	20532	22634	43165	15371	58536

2.5.2.2 Potential Forest Management Units

Altogether 16 areas > 4000 ha were classified as potential FMUs with a total area of about 158.8 thousand ha and a forest area of about 110.8 thousand ha which is equal to 3.8 % of the total forest area. Most of the identified FMUs are located within two or more dzongkhags. Bumthang has the highest ratio of potential forest followed by Wangdue, Haa and Samdrup Jongkhar. The distribution of the potential FMUS according to districts is shown in Table 15.

Table 15: Potential FMU according to district

District	No. of FMU	High Potential (ha)	Potential (ha)	Total Potential (ha)	Non Potential (ha)	Total Area (ha)
BUMTHANG	5,7	15377	4282	19659	10310	29969
CHHUKHA	12,13,14	3937	7467	11404	2487	13891
DAGANA	9,11,12	6243	3431	9674	6304	15978
HA	14,15,16	10243	3867	14110	7630	21740
LHUENTSE	2,5	429	831	1260	879	2139
MONGAR	1,2,4	2407	1862	4269	1837	6106
PARO	15	2956	672	3628	1112	4739
PUNAKHA						
SAMDRUP JONGKHA	6	5730	7311	13041	2106	15147
SAMTSE	14	0	219	219	107	326
TASHI YANGTSE	3,4	5522	2059	7581	2564	10145
THIMPHU						
TRASHIGANG	3,4	1690	1599	3289	513	3803
TRONGSA	7	630	1813	2443	797	3240
WANGDUE	8,9,10,11	8567	8607	17174	8559	25733
ZHEMGANG	1	1330	1695	3025	2859	5884
FMU Total		65061	45715	110776	48066	158842

Table 16: Potential FMUs according to potential areas

No. of FMU	High Potential (ha)	Potential (ha)	Total Potential (ha)	Non Potential (ha)	Total Area (ha)
1	2138	1697	3835	3386	7221
2	1383	2569	3952	1961	5914
3	2224	2668	4892	1241	6133
4	5426	1008	6433	1948	8382
5	7383	2581	9965	2637	12601
6	5730	7311	13041	2126	15166
7	8832	3618	12451	8567	21018
8	3749	2444	6193	4936	11129
9	1449	2123	3572	717	4289
10	1545	3290	4835	2124	6959
11	4179	2229	6408	5541	11949
12	3914	1977	5891	1584	7475
13	2290	6749	9039	1747	10786
14	6369	4764	11132	5346	16478
15	2959	672	3630	1120	4751
16	5492	16	5508	3085	8593
Total	65061	45715	110776	48066	158842

30% of the FMU area has no potential for commercial use, this includes forest set aside for local use, open and degraded forests and agricultural areas. Of the remaining potential areas 60% are over-mature forests which should have high priority for harvesting (see Table 16). The distribution of the forest areas according to LUPP land-use classes is attached in Annex 4.

2.5.3 Compilation of Economic Potential According to District

The distribution of potential areas according to districts vary considerably. There are neither existing nor potential FMUs in Punakha, Sarpang and Tsirang districts. Lhuentse shares potential FMUs with Mongar (FMU No. 2) and Bhumtang (FMU No. 7) District. Also the potential forest area of Zhemgang district is quite small.

The highest ratio of forest areas having a economic potential for commercial timber use is located in Bhumtang (12%), Wangdue (12%), Chhukha (9%) and Ha (9%) district.

Table 17: Total economic potential areas (excluding CFs) according to district

District	FMU			WS			Cushion Area			Total		
	exist. ¹	pot.	total	exist. ²	pot.	total	exist.	pot.	total	exist..	pot.	total
BUMTHANG	18067	19659	37726		5088	5088		5449	5449	18067	30197	48264
CHHUKHA	9596	11404	21000					11035	11035	9596	22439	32035
DAGANA		9674	9674		3812	3812		1910	1910		15395	15395
HA	15068	14110	29178		2237	2237		2550	2550	15068	18897	33965
LHUEMSE		1260	1260		1863	1863		2092	2092		5215	5215
MONGAR	21631	4269	25900	641		641		2205	2205	22272	6474	28746
PARO	13894	3627	17521		3906	3906		3812	3812	13894	11346	25240
PUNAKHA				492	947	1439		2504	2504	492	3451	3943
SAMDRUP JONGKHA		13041	13041		1769	1769		7754	7754		22563	22563
SAMTSE	10459	219	10678		2120	2120	457	2626	3083	10916	4965	15881
SARPANG				1695	4584	6279		13882	13882	1695	18466	20161
TASHI YANGTSE	4742	7581	12323	3911	765	4676		822	822	8653	9168	17821
THIMPHU	14099	8	14107		7560	7560		8348	8348	14099	15915	30014
TRASHIGANG	7463	3290	10753		2276	2276		2425	2425	7463	7991	15454
TRONGSA	27908	2443	30351		1099	1099		3512	3512	27908	7055	34963
TSIRANG				2509	250	2759		829	829	2509	1078	3587
WANGDUE	8673	17166	25839		3245	3245		13082	13082	8673	33493	42166
ZHEMGANG	8384	3025	11409		1644	1644		796	796	8384	5466	13850
Total	159984	110776	270760	9248	43165	52413	457	85632	85632	169689	239574	409263

¹: forest area

²: forest area without national park

2.6 Conclusion

Including already managed areas altogether only 410 thousand ha or 14% of the total forest cover may have a potential for commercial timber use. This includes biological corridors. If they are excluded only 329.5 thousand ha or 11.3% of the total forest area remain.¹¹

It has to be kept in mind, that this figure represents the upper ceiling, as some of the identified areas will not qualify as potential based on the field check. Also, the criteria applied for the calculation of the economic potential are based on the assumption that timber prices will raise in future according to increasing demand.

¹¹ Whether this is sufficient to supply the country's timber demand in the long run, can only be answered once the FRPA is completed.

To mobilise as much of the potential areas as possible for commercial timber use, the following actions need to be taken (remark: more detailed conclusions will be given in the final FRPA-Report):

1. Biological corridors shall not be exempted from commercial timber use. Instead, those areas shall be mapped as wildlife conservation areas during the process of forest function mapping and adequate management prescriptions (i.e. no large clear fellings, no conversion into plantations or agricultural land) shall be defined.
2. The economic conditions for commercial forest management shall be supported by the forest policy, e.g. by increase of timber prices, reduction of royalties/taxes for timber production in remote places and areas of poor accessibility, etc.
3. Management systems need to be developed as soon as possible for the sustainable management of working schemes and cushion areas.
4. Management responsibilities need to be clearly specified, especially for working schemes and cushion areas, where FDC is not present all the time. For example: protection, tending and thinning contracts with the local people may be a solution to ensure proper regeneration of harvested areas.
5. To open additional FMUs close to areas having high timber demand in order to release pressure (i.e. over-utilization) on existing FMUs
6. A considerable percentage of the potential areas is covered with broadleaved forests. To mobilise this potential a sustainable silvicultural system for broadleaved forest management needs to be developed including adapted harvesting technology.

2.7 Required Follow-UP

To complete the FRPA the following 4 steps need to be undertaken:

1. Field check (pre-reconnaissance survey) of potential FMUs and WSs
2. Calculation of production capacity
3. Estimation of timber demand according to districts
4. Preparation of final FRPA Report including demand/supply scenario

Once all the additional identified FMUs and WSs have been checked on feasibility for commercial timber use, a more realistic estimate of the economic potential areas is available. Based on the distribution of forest types, an estimate of the production potential according to products can be provided by using already existing inventory data¹².

The estimation of the present and future wood demand according to districts shall be conducted as soon as possible. Only once the production capacity of the forests and the wood demand is known, then the question can be answered, whether the forests of Bhutan can sustainably supply the wood demand of the country. Based on the demand/supply scenario per district a priority list for opening of additional forest areas (i.e. potential FMUs, WSs) can be prepared and more specific recommendation for forest policy action can be made, which will be main subject of the final FRPA-Report.

2.8 Pre-Reconnaissance Field Check

The pre-reconnaissance field check is an initial scoping visit with the objective

- *to determine whether the preliminary identified potential FMU or WS has a real economic potential for commercial timber use;*

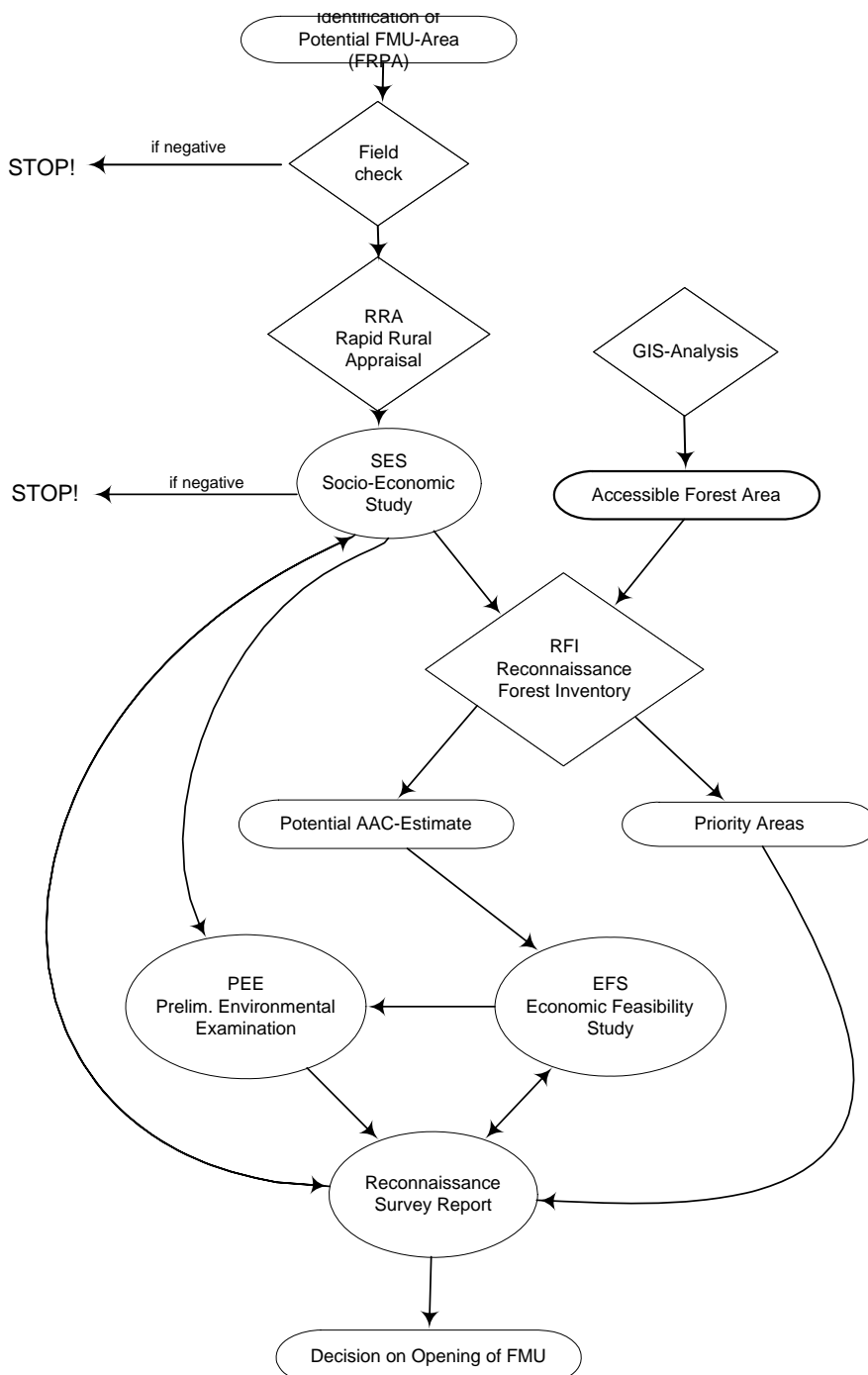
¹² For this purpose the excel based program "FRPACALC.XLS" can be used, which was developed by SCHINDELE in 1996.

- to provide sufficient information to allow potential FMU and WS sites to be ranked from the best to the lowest potential, and
- to provide a more realistic estimate of the overall economic potential forest area.

The pre-reconnaissance field check shall be implemented for all preliminary identified FMUs and working schemes at the same time within the next few month.

For FMUs and working schemes which passes the field check a more detailed reconnaissance survey shall be conducted one year before the area is planned to be opened for commercial timber use. For more details on the reconnaissance survey refer to SCHINDELE (1998) and Figure 11.

Figure 11: Components and process of reconnaissance survey



The pre-reconnaissance field check is designed to be rapid and provide mainly descriptive information based on the analysis of existing information and ocular estimates. It comprises three steps:

1. preparatory office work before setting out into the field
2. the pre-reconnaissance field check or scooping visit itself
3. analysis of results and update of base maps

2.8.1 Preparatory Office Work

It shall be the task of FRDD to prepare and provide all the required working documents for the field check which are for each FMU/WS:

- Excerpt of topographic map with 40m contour lines (scale 1:50,000)
- Excerpt of PIS map at scale 1:50,000
- aerial photos/satellite imagery
- FMU/WS base map
- field forms (check list)

FMU/WS-base map (1:50,000):

First of all, the proposed boundary shall be adjusted according to topographic features¹³. If possible FMUs shall cover a whole (sub-)watershed.

The base map shall contain the following information:

- proposed boundary of FMU/WS
- all LUPP forest types
- slope classes 50-60% and >60% as different shading
- contour lines
- rivers, roads and settlements
- administrative boundaries

To facilitate field checking, the LUPP land-use classes shall be compared with PIS information. In case of serious discrepancies¹⁴, verification of the forest type and forest type boundaries shall be done by using recent satellite imagery or aerial photos. If the forest type cannot be clearly identified, this shall be indicated on the map and must be checked in the field.

Altogether 4 copies of the base map shall be prepared.

Before implementation of the field check it shall be ensured, that the area concerned is not included or under plan to be included under some other conflicting form of management (e.g. watershed used for hydro-electric power production, etc.). For this purpose a map indicating all potential FMUs and working schemes shall be distributed to all agencies involved in land-use planning and decision making and they shall be asked for their opinion/consent.

¹³ Remark: Due to time constraints and the number of FMUs/WSs this could not be done to the extent required during the GIS-Analysis.

¹⁴ Experiences made during previous 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.

2.8.2 The Pre-Reconnaissance Field Check

This step is very important. Compared with the GIS analysis, a short field visit may provide a quite different view of the proposed FMU/WS 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. Also, local people should be informed at that stage, that the government has the intention to check whether this area is suitable to be managed on a commercial basis.

First, all potential FMUs shall be checked, then the potential working schemes. The actual field check is based on visual assessment, observations and discussion with local people and may take approximately two to three days (not including travel). The responsibility of the field check lies with the DFO, for potential FMUs, FRDD needs to be involved.

The field check comprises the following four steps and shall follow the prescriptions of the check list (see Annex 5):

1) Discussion with local people (information collection)

The local people should be informed about the intention of the government to open the area concerned for commercial forest management. The positive and negative effects on their livelihood and the environment shall be discussed openly and it should be investigated, whether there are any serious constraints or opposition against opening of the area for commercial use. The expectations and perceptions of the local community shall be noted.

Information shall be collected on the present local use of the forest resources and the areas intensively used shall be identified on the base map according to the specific use (i.e. shoksing, shinglep production, local use for timber/firewood, tsamdrol, etc.). Also information shall be collected on the occurrence of rare wildlife and the location of their habitats.

The boundary of the FMU/WS shall be discussed and a local name shall be jointly given to the FMU/WS.

The base map shall be verified together with the local people to minimize effort for field truthing.

2) Field check (Verification and update of base map)

Due to time constraints, it is simply impossible to check the whole forest area. Map verification has, therefore, to be based on collecting as much as possible information from the local people (see step 1) and by walking transect lines and comparing field observation with information derived from PIS-, topographic and base map.

The outer boundary of the FMU/WS shall be reviewed and, if necessary adjusted. The LUPP forest types and boundaries shall be checked as indicated on the base map and corrected accordingly, using LUPPs land use classification system (refer to Annex 4). In addition, the various development stages of the forest (i.e. young, mature, over-mature) shall be indicated. The general health condition of the forest and the situation of natural regeneration (i.e. effect of browsing) shall be described.

Areas of slope class 50-60% shall be checked and the approximate boundary of future protection zones shall be indicated. An estimate of the percentage of inoperable areas within the operable areas shall be given.

All settlements and roads which are not yet indicated on the map need to be mapped, if possible by using GPS readings.

3) Planning

All areas which should be exempted from commercial timber use such as wetlands, wildlife habitats, critical watershed areas, etc. shall be mapped.

The condition of existing roads and their suitability for timber transportation shall be described.

On the base map, a potential lay-out of the main access road from the next public motorable road to the FMU/WS concerned shall be planned and a brief description of the terrain condition and the implications for road construction shall be provided.

4) Recommendation

Finally, the head of checking team shall give his personal opinion concerning the suitability of the area for commercial use and justify it.

2.8.3 Analysis of Results and Update of Base Maps

The final decision whether the FMU/WS has a potential for commercial timber use is done in the office based on the information derived from the check list.

First, the updated base-maps have to be digitised by the GIS-Cell of FRDD. Based on the updated forest type classification, the production capacity can be estimated by using already existing inventory data. Then a simple cost-benefit analysis shall be conducted taking into account the specific cost for road construction (to be derived from the results of the field check) and other key economic values.

Based on the result of the cost benefit analysis, the recommendation of the field staff and the opinion of the local people, the decision can be made, whether the FMU/WS concerned shall be considered as a potential area and earmarked for a reconnaissance survey later on.

Literature reviewed:

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- JAFTA; 1999: Forest Register 1999.
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- JAFTA; 1999: Activity report of wide area tropical forest resources survey. The Kingdom of Bhutan.
- JORDAN, G.; 2002: Cost benefit analysis for new FMUs: the basics of analysis and constraints identified
- LAUMANS, P.; 1995: Selection of Potential Forest Management Areas in Eastern Bhutan based on GIS Techniques. Third Forestry Development Project, RGOB/MOA/FSD.
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- RGOB/MOA; 2000: Forest and Nature Conservation Rules of Bhutan, 2000. Volume I.
- SCHINDELE, W.; 1995 (a): Forest Resources Management in Punakha and Wangdue-Phodrang District. Mission Report on Forest Resources Assessment and Forest Management within the Scope of the Bhutan-German Integrated Forest Management Project. BG-IFMP, Working Paper No. 4.
- SCHINDELE, W.; 1995 (b): Forest Resources Potential Assessment for Gasa, Punakha and Wangdue-Phodrang Districts. Mission Report on Forest Resources Assessment and Forest Management within the Scope of the Bhutan-German Integrated Forest Management Project. BG-IFMP, Working Paper No. 5.
- SCHINDELE, W.; 1998: 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; BG-SRDP
- SCHINDELE, W., DHITAL, D.B.; 1997: Forest Function Planning and Mapping. Guidelines for the Preparation of a Forest Function Map and Definition of Management Restrictions. BG-SRDP, Working Paper No. 11.

List of themes required for GIS-Analysis (FRPA)

Shape-Files	Arc-Files	Content	Procedure
	<i>Alti1000m</i>	100m altitude lines	Already available
	<i>Bhd-bnd</i>	Outer boundary of Bhutan	Already available
	<i>Bhu_dem</i>	Bhutan DEM	Already available
<i>Biocorridor.shp</i>	<i>Corr3</i>	Biological corridors	Already available
	<i>Cf</i>	Community Forests	digitized
	<i>Contours</i>	Contour lines 200m	
<i>Cushion.shp</i>	<i>Cush_are</i>	Cushion areas	digitized
<i>Dzongkha.shp</i>	<i>Dzongkha</i>	Dzongka boundaries	Already available
<i>Fmuexist.shp</i>	<i>Existfmu</i>	Existing FMUs	Already available
<i>Fmu_prep.shp</i>	<i>Fmu_prep</i>	FMUs under preparation	Already available
	<i>Landuse3</i>	Landuse for whole of Bhutan	Already available
<i>Landuse.shp</i>	<i>Land50</i>	Landuse for working maps	Already available
	<i>Park</i>	Protected areas	Already available
<i>Roads.shp</i>	<i>Rd</i>	Roads	From rd
<i>Rivers.shp</i>	<i>River</i>	Rivers	From rv
<i>Settlements.shp</i>	<i>Settlement</i>	Settlements	From settle
	<i>WS</i>	Working schemes	Digitized

Themes prepared for GIS-Analysis (FRPA)

Theme (shape files)	Content	Based on themes	Action
<i>non_prot</i>	Unprotected areas	<ul style="list-style-type: none"> <i>Bhd_bnd</i> <i>park</i> 	Convert to shape-file GW ^{*1} : union <i>Bhd_bnd</i> + <i>park</i> Query: delete protected area
<i>union9</i>	Managed areas	<ul style="list-style-type: none"> <i>Existfmu</i> <i>Fmu_prep</i> <i>Cush_are</i> <i>WS</i> <i>CF</i> 	Convert to shape-file GW: union <i>Existfmu</i> + <i>Fmu_prep</i> + <i>Cush_are</i> + <i>WS</i> + <i>CF</i>
<i>unm_area</i>	Un-managed areas	<ul style="list-style-type: none"> <i>union9</i> <i>non_prot</i> 	GW: union <i>union9</i> + <i>non_prot</i> Query: delete unmanaged areas
<i>forestcov</i>	Forest cover for whole of Bhutan	<ul style="list-style-type: none"> <i>landuse</i> 	Query <i>landuse</i> : delete non-forested area
<i>unmareab4000</i>	Unmanaged areas below 4000 m asl	<ul style="list-style-type: none"> <i>unm_area</i> <i>Alti1000m</i> 	Query <i>Alti1000m</i> : delete areas above 4000m, create temp file GW: clip <i>unm_area</i> with temp file
<i>unmforb4000</i>	Unmanaged forest areas below 4000 m	<ul style="list-style-type: none"> <i>unmareab4000</i> <i>landuse</i> 	Query <i>landuse3</i> : delete all non forested areas Edit: add field potential, assign potential class to land use type GW: clip <i>unmareab4000</i> with <i>landuse</i>
<i>Slope50</i>	Slopes below 50%	<ul style="list-style-type: none"> <i>Bhu_dem</i> <i>Contours</i> 	Create <i>slope50</i> grid based on <i>Bhu_dem</i> Create slope temp files for missing areas based on contour lines. Convert to grid: Map query for all temp files: identify areas below 50% Convert all map query files into shape files GW: Union all shape files into <i>slope50</i> Edit <i>slope50</i> : merge polygons
<i>operable forest</i>	Operable forest areas below 4000m	<ul style="list-style-type: none"> <i>unmforb4000</i> <i>slope50</i> 	GW: clip <i>slope50</i> on <i>unmforb4000</i>

Annex 2: Themes prepared and required for GIS-Analysis

	asl and 50% slope		
<i>roadbuff150m</i>	Road buffer of 150m each side of road	<ul style="list-style-type: none"> <i>road</i> 	Create buffer
<i>operable forest without rdbuff</i>	Operable forest areas without 150m strip along roads	<ul style="list-style-type: none"> <i>operable forest</i> <i>roadbuff150m</i> 	GW: union <i>operable forest</i> + <i>roadbuff150m</i> Query: select all areas outside road-buffer and save as new shape file
<i>river buffer</i>	30m buffer each side along river	<ul style="list-style-type: none"> <i>river</i> 	Was done in ARCINFO
<i>operable forest without river buffer</i>	Operable forests excluding river buffers	<ul style="list-style-type: none"> <i>river buffer</i> <i>operable forest without rdbuffer</i> 	GW: union <i>river buffer</i> with <i>operable forest without rdbuffer</i> Query: select all areas outside river-buffer and save as new shape file
<i>operable forest without shrub</i>	Operable forest area excluding shrub "FS"	<ul style="list-style-type: none"> <i>operable forest without river buffer</i> 	Query: delete all records with field symb ="FS" Save as new shape file
<i>potential forest</i>	Operable forest area without degraded forests and shrub	<ul style="list-style-type: none"> <i>operable forest without shrub</i> 	Query: delete all records with field potential ="no potential" or "low potential"
<i>road buffer 15km</i>	Areas within 15km each side of road	<ul style="list-style-type: none"> <i>road</i> 	Create 15km buffer
<i>potential forest within 15km of road</i>	Potential forest area within 15km horizontal range from an existing motorable road	<ul style="list-style-type: none"> <i>road buffer 15km</i> <i>potential forest</i> 	GW: clip <i>road buffer 15km</i> on <i>potential forest</i>
<i>village buffer 1</i>	Areas within 1.5 km of village centre	<ul style="list-style-type: none"> <i>settlement</i> 	Create buffer of 1500 m
<i>potential forest commercial</i>		<ul style="list-style-type: none"> <i>village buffer 1</i> <i>potential forest within 15km from road</i> 	GW: union <i>village buffer 1</i> + <i>potential forest within 15 km of road</i> Query: select areas within village buffer and delete record. Save as new shape file
<i>potential forest commercial large</i>	All potential areas which are large enough to be used commercially	<ul style="list-style-type: none"> <i>potential forest commercial</i> 	Edit: <i>potential forest commercial</i> , manual deletion of small forest patches.
<i>potential fmus</i>	Potential forest areas with a total size > 4000 ha	<ul style="list-style-type: none"> <i>potential forest commercial large</i> 	New theme: manual identification and drawing of polygons
<i>road buffer 10 km</i>	Areas within 10 km each side of road	<ul style="list-style-type: none"> <i>road</i> 	Create 10 km buffer
<i>road buffer 5km</i>	Areas within 5km each side of road	<ul style="list-style-type: none"> <i>road</i> 	Create 5 km buffer
<i>pot_forest_10km</i>	Potential forest excl. areas < 4000 ha outside 10 km road buffer	<ul style="list-style-type: none"> <i>potential fmus</i> <i>road buffer 10 km</i> <i>potential forest commercial large</i> 	GW: union <i>potential fmu</i> + <i>road buffer 10 km</i> Create temp theme: <i>Union</i> GW: clip <i>Union</i> with <i>potential forest commercial large</i> Query: delete all areas outside 10 km
<i>potential_workschemes</i>	Potential forest areas with a total size 1000 - 4000 ha	<ul style="list-style-type: none"> <i>potential forest commercial large</i> 	New theme: manual identification and drawing of polygons
<i>pot_forest_5km</i>	Potential forest excl. areas < 1000 ha outside 5 km road buffer	<ul style="list-style-type: none"> <i>potential FMU</i> <i>potential_workschemes</i> <i>road buffer 5 km</i> 	GW: merge <i>potential FMU</i> + <i>potential_workschemes</i> + <i>road buffer 5 km</i> Save as temp file <i>merge1</i> GW: clip <i>merge1</i> and <i>pot_forest_10km</i>
All themes		<ul style="list-style-type: none"> 	Calculate areas: Edit shape file, mark field area, Use calculator: type: Shape .ReturnArea, save edits

*1 GW: GeoProcessing Wizard under menu "View", only active if "geoprocessing" is activated in menu "File/extensions"

LUPP Land-use classification

Forest Type

FB Broadleaved Forest
FBc Mixed broadleaved/conifer forest
FC Conifer Forest
FCm Mixed conifer forests
FCb Bluepine Forest
FCc Chirpine Forest
FCf Fir forest
FS Forest Scrub

Density classes:

1: 10-40% canopy
2: 40-80% canopy
3: > 80% canopy

Examples

FBc3: closed mixed broadleaved/conifer forest with canopy closure > 80%
FCf1: open fir forest with canopy closure < 40%

Annex 4: Additional potential areas according to LUPP land-use classification

Forest Types within potential areas according to districts

District	Potential forest type													non. pot.	Total
	FB2	FB3	FBc2	FBc3	FCb2	FCb3	FCf 2	FCf2	FCf3	FCm2	FCm3	FPb	FPc		
BUMTHANG					5048			5786	292	14953	4117			12699	42895
CHHUKHA	2302	7928	1961	1440	2717	110		1551		1941	2312	70	105	2487	24926
DAGANA	4473	6949	2866		19					1088				7069	22464
HA		585	85	2068	50		565	1554	110	11742	2138		0	8447	27344
LHUENTSE	1318	2847	196					177		139	538			1515	6730
MONGAR	456	2913	107	36				398		1699	865			1837	8311
PARO			25	0	3097	426		2095		5288	414			2572	13917
PUNAKHA		3325								125				223	3674
SAMDRUP JONGKHA	9542	12883										138		2333	24896
SAMTSE	2435	2311		219						0				1092	6057
SARPANG	7793	9563										1110		1411	19877
TASHI YANGTSE	671	2831	1046	114	99			853	62	3481	11			2950	12118
THIMPHU	200	2362			3740	1130		1216		6208	1060			3171	19086
TRASHIGANG	870	3962	150		141			1022		1630	216			1828	9819
TRONGSA	793	3528	265	19				112	16	1226	1087		9	1164	8219
TSIRANG	185	894												53	1131
WANGDUE	3824	12301	1003	509	3034	1636		1161	786	6484	2601		153	9399	42892
ZHEMGANG	794	3868	388							416				3152	8618
no data														35	35
Total	35655	79049	8092	4405	17946	3302	565	15926	1266	56420	15361	1318	268	63436	303010

Forest types within potential cushion areas and working schemes

Management Type	No.	Potential forest type													Non. pot.	Total
		FB2	FB3	FBc2	FBc3	FCb2	FCb3	FCf 2	FCf2	FCf3	FCm2	FCm3	FPb	FPc		
Cushion area		17478	35808	727	694	8038	2018	49	3087	699	11464	4441	862	268		85632
Working scheme	1		1408												316	1724
	2	4	1683			31					567				844	3129
	3		1222								1				413	1636
	4					194	472				947				523	2136
	5			207							870				303	1381
	6					51			617		1442	517			1401	4029
	7	11	1627	7											293	1937
	8	16	1737											323	783	2859
	9	111	825												190	1127
	10	414	571	65		19									227	1295
	11	526	758												207	1491
	12	182	1202	75											331	1791
	13	782	1040												490	2312
	14	1026	742												227	1996
	15	786	873	110					23		71				636	2499
	16										14	950			464	1428
	17								91		760	216			450	1518
	18	42	301						360	61					386	1151
	19	219	820						170						864	2073
	20					543					176				329	1048
	21								202		576				229	1007
	22	59	580		163										324	1125
	23	149	666								0				253	1069
	24					11			54		206	579			293	1143
	25					376					388				244	1008
	26					3					1232				623	1858
	27	965	1155												985	3105
	28					392					1729				640	2762
	29					24	291		211		795	201			552	2073
	30					158			840		317	40			901	2256
	31					893			35		997				648	2572
Total working scheme		5292	17211	463	163	2696	762	2603	61	11088	2503	323		15371	58536	

Forest types within potential FMUs

Management Type	No.	Potential forest type											Non Pot.	Total	
		FB2	FB3	FBc2	FBc3	FCb2	FCb3	FCf 2	FCf2	FCf3	FCm2	FCm3			FPb
FMU	1	533	1697	391							1213			3386	7221
	2	422	1235	85	35						876	1299		1961	5914
	3		2668	124					557		1542			1241	6133
	4	577	739	1026	115	141			1058	1	2765	11		1948	8382
	5					314			1933		5450	2267		2637	12601
	6	5597	7311										133	2126	15166
	7	483	804			1452			2397	307	5953	1055		8567	21018
	8	701	559			1885	522				2526			4936	11129
	9	95	2034							89	1354			717	4289
	10		2371	627		87					918	832		2124	6959
	11	3297	2229	867							15			5541	11949
	12	1181	1977	1760							973			1584	7475
	13	0	1822	1303	418	2645			637		351	1865		1747	10786
	14		585	719	2981				750	110	4900	1088		5346	16478
	15					672			1771		1187			1120	4751
	16					16		516	1132		3844			3085	8593
Total		12886	26031	6902	3548	7212	522	516	10235	507	33868	8417	133	48066	158842

Checklist

FMU WS No.....
Districts:.....
Name of officer:..... Date:.....

Discussion with local people

1. Names of settlements/persons contacted:.....
.....
2. Proposed Name for FMU/WS:.....
3. Boundary accepted? If not, indicate on map.....
4. Peoples expectations:.....
5. Peoples perceptions:.....
6. Strong opposition: yes no , if yes explain:.....
.....
7. Describe local use and indicate on base map:.....
.....
.....
8. Describe rare wildlife, location of habitat, indicate on map:.....
.....
.....
9. Verify base map: indicate changes on base map
- check forest types, inoperable areas, protection zones, etc.
- are all settlements on map?
- are all roads on map?
- identify development stages of forest

Field Truthing

10. Check forest types as indicated on base map
11. Identify development stages of forest (indicative)
12. Check and determine protection areas (especially slope class 50-60%)
13. Health condition: normal bad , if bad describe.....
.....
14. Natural Regeneration: normal bad , if bad explain.....
.....
15. Describe terrain condition:.....
.....
.....
16. Estimate % of inoperable area: : 0-10% : 10-20% : 20-30%
17. Map settlements and roads not indicated on map with GPS

Checklist

Planning

18. Indicate areas in need of protection and justify:.....
.....
.....
19. Plan lay-out for main access road, indicate terrain condition of different transects on map (i.e. easy terrain: dashed line, normal terrain: line, difficult terrain: bold line)
20. Describe and justify lay out (i.e. combined forest/farm to market road):.....
.....
.....
21. Describe problems and terrain implications for road construction:.....
.....
.....

Recommendation

- 22: Area has potential: yes no
- 23: Give your personal opinion:

Date:.....

.....

Signature of resp. officer