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ROYAL GOVERNMENT OF BHUTAN
MINISTRY OF AGRICULTURE AND FORESTS
DEPARTMENT OF FORESTS AND PARK SERVICES
FOREST RESOURCES MANAGEMENT DIVISION
THIMPHU: BHUTAN

"Sustaining Forest Resources for Present and Future Generations"

Management Plan for Rudongla Forest Management Unit

Plan Period: 1st January, 2013 to 31st December, 2023

Written by:
Santosh Katwal, Forestry Officer
Forest Resources Management Division
January 2013

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PART 1

GENERAL DESCRIPTION AND THE CURRENT SITUATION

1. LOCATION, AREA, BACKGROUND AND STATUS

1.1 Location

Bumthang Dzongkhag with an approximate area of 2,667.75Km^2 makes around 7% of the country's total area (LCMP, 2010) and is bordered by Trongsa and Lhuntse Dzongkhag. Around 66.73% of the total area is under forest cover including the scrub forest. The forest is mainly dominated by pure blue pine stands with medium to high crown density. The valleys of Bumthang are glacial and are comparatively wide and U-shaped. About 1.09% of the Dzongkhag's total area is under agriculture, mainly found in the valley of Chumey, Chamkar and southern part of Chhoekhor.

Table 1.1: Land use category of Bumthang Dzongkhag (LCMP)

Land Use Category	Area(ha)	As % of Total Area
Forest	172685	64.73
Agriculture	2920	1.09
Meadows	28330	10.62
Settlements	246	0.09
Others	62594	23.46
Total	**266775**	**100**

1.2 Location of Rudongla Forest Management Unit

Rodungla Forest Management Unit (RFMU) is situated in Tang Geog under Bumthang Dzongkhag. The FMU is bordered by Lhuntse to east and north-east between 90° 41'E to 91°E and 27°30'N to 27°42'N. The traditional route of Bumthang to Lhuntse passes through the FMU. The FMU is bordered to the east and south by Thrumshingla National Park (TNP) and Wangchuck Centennial Park (WCP) in the northen part.

1.3 Area Statement

The total area of Rodungla FMU is 14,686.58 ha. The details of the area statement of RFMU are as under;

Table 1.2 Area statement of RFMU

Area statement	Area (ha)
Total FMU area	19340.94
Area of TNP within RFMU(excluded from FMU)	4479.65
Net area available for FMU	14686.58

Table 1.3 Area Statements by Land use (LCMP, 2010)

Forest Types	Area (ha)	Area (%)
Blue pine forest	1783.71	12.15
Fir forest	2397.30	16.32
Mixed Conifer Forest	8187.90	55.75
Shrubs	1328.55	9.05
Meadows	704.53	4.80
Agriculture	227.96	1.55
Settlements	3.56	0.02
Others	53.06	0.36
Total	**14686.58**	**100**

1.4 Forest Condition

The altitude of FMU ranges from 2,638-4,230 m asl and the major forest type found here are Blue pine and mixed conifers. The mixed conifer forest comprises of Spruce, Hemlock, Blue pine, Juniper, Larix and some broadleaf species like Poplar, Maple, Rhododendron, Oak, etc. Almost 55.75% of area of RFMU is covered by mixed conifers and 12.15% by Blue pine. The Blue pine forests comprises mostly of young stands with medium to high crown density. The upper conifer belt of the FMU is covered by *Abies densa* (Bhutan Fir) which forms a dominant conifer, in altitudes between 2,800 -3,700m. Located mainly in the upper watersheds, fir forests play a very important protection function and are characterized by thick layer of moss with rhododendron and bamboo.

1.5 Legal Status

1.5.1 Ownership

The Forest and Nature Conservation Act 1995 defines *"forest" as "any land and water body, whether or not under vegetative cover, in which no person has acquired a permanent and transferable right of use and occupancy, whether such land is located inside or outside the forest boundary pillars, and includes land registered in a person's name as Tsamdro (grazing land) or Sokshing (wood lot for collection of leaf litter"*. Consequently, all such forests are declared to be Government Reserved Forests (GRF). On this basis, the extent of Reserved Forests within the FMU is about 14,402ha (98.06%) and the human settlement and agriculture land is about 231.52ha (1.58%). On the ground, some farmland boundaries may have encroached on forestland during the course of agricultural expansion. Not withstanding this, however, the lands not registered as private lands are considered legally as GRF**.**

1.5.2 Rights and Privileges

The rights and privileges of the local inhabitants with regard to the use of forest are defined in the FNCA, 1995. The Act allows grazing and collection of firewood, fodder and leaf mould for domestic and farm use, either *free of charge* or upon payment of royalty. *Bona fide* households are entitled to an allotment of construction timber every twenty five years for new construction and five years for house repairs and other maintenance works (Forest & Nature Conservation

Rules, 2006). Trees are marked standing by authorized forest officials for allotment to *bonafide* local users, after all the necessary verifications and payment of corresponding royalty. Hunting is illegal within the forest.

1.5.3 Grazing Rights

The local communities have traditional rights for grazing their cattle in the forest within the FMU. The local cattle from the adjoining villages graze the FMU area besides migratory cattle from other places. The Forest and Nature conservation Act, 1995 has the provision of regulating grazing in GRF.

1.5.4 Water Rights.

Villagers within the FMU have traditional rights to use perennial or seasonal streams for their local use including irrigation purposes. The Doyungchhu and Drechhu are the main source of water. There are several perennial and seasonal streams and creeks in the FMU that serve as water source for the communities.

1.5.5 Historical Monuments and Monasteries

One of the historical monuments which attract tourists in the valley within the FMU is the Ugyencholing Museum. The history of the place begins with the visit of the famous Tibetan Nyingmapa Saint, Longchen Rabjam to the Tang valley. It is the only structure of its size and history that still exist and used by a family with direct historical links to it. Ugyencholing was never so much a seat of political power but played a vital role as a religious center. Currently, the Museum is connected with road and showcase religious artifact to visitors.

2. PERMANENT SITE FACTORS

2.1 Topography and Slope

The terrain within the FMU is relatively gentle compared to other regions of Bhutan. The valleys are not very deep and are U shaped with lower slopes and flatter areas under cultivation. 10,385.44ha (73.87%) of the total FMU area is below 35% slope and the remaining 4,298.62ha (30.58) is above 35% slope. Most of these steep areas are located along the streams as result of river erosion through geological cycle. The elevation ranges from 2,638m at the lowest valley floor within the FMU to 4,230m. The terrain is also dissected by many small rivulets, mostly flowing east into the main river, Tang Chhu.

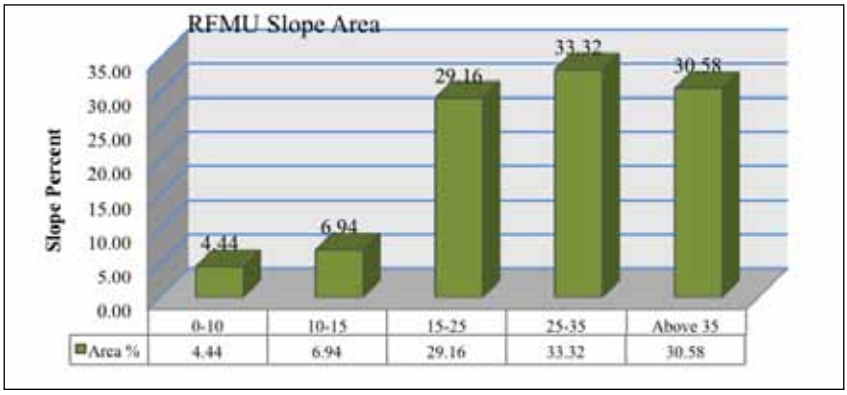

Figure: 2.1 Slope Area of FMU

Climate

Meteorological data has been derived from Station Chamkhar "Class" A, Bumthang, from the Meteorology Section; Department of Hydromet Services, Ministry of Economic Affairs, Thimphu.

2.2.1 Temperature

Table 2.1 Average Monthly Maximum Temperature (^{0}C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	11	14.2	15.7	17.9	19.4	20.9	22	21.7	21	18	14.4	11
2003	10	10.9	13.6	16.6	20.6	22.6	22	21.9	21	18	15.3	12.4
2004	11	12.1	17.4	17.2	19.9	21.3	21	21.6	21	17	13.6	12.1
2005	9.4	12.2	14.5	16.9	17.5	22.1	23	22.8	22	18	15	13.8
2006	14	15.1	15.6	18.3	19.9	21.2	23	23	21	19	15.2	13.2
2007	11	11.1	15.3	18.4	21.2	21.6	22	23.2	20	19	15.1	12.8
2008	11	10.8	15.3	16.7	19.2	21.6	23	22.1	23	20	16.5	13.6
2009	13	14.1	15.4	18.4	19.8	22.7	24	23	23	19	15.4	12.2
2010	14	13.4	16.6	19.2	19.7	21.5	23	22.5	22	19	15.3	13.5
2011	10	14.3	16	18.3	20.6	22.1	22	23.6	23	20	14.5	14.5

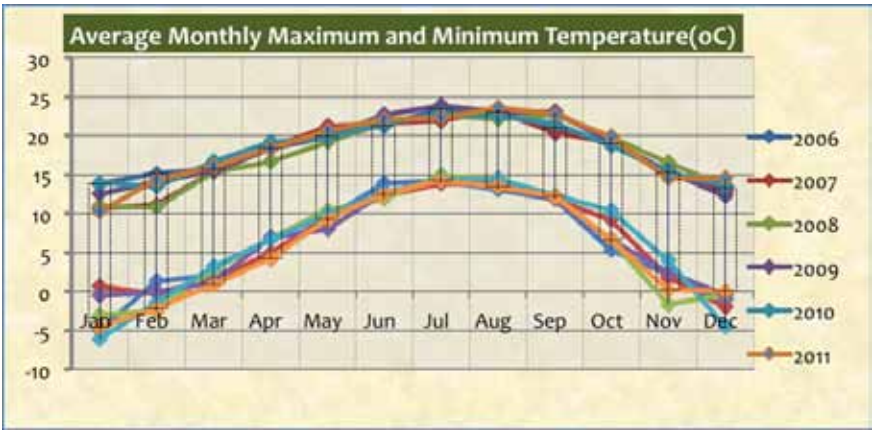

Figure 2.2 Graph Showing the Average Monthly Maximum and Minimum Temperature.

Table 2.2 Average Monthly Minimum Temperature (^{0}C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	-6.6	-1.4	1.9	5.1	9.2	14.1	16.3	16.3	14.8	7.4	2.3	-2.8
2003	-5.2	-1.4	2.2	7.5	9.7	13.3	14	14.5	12.8	6.9	3.7	-2.6
2004	-2.6	-2.5	3.9	7	10.7	13.6	14	15	12.6	7.4	0.3	-2.9
2005	-3.2	-1.1	4	6.9	8.6	12.8	14.2	14.5	11.9	7.5	0.4	-6.1
2006	-4.9	1.3	2.1	4.2	9.5	13.9	14.3	13.1	11.9	5.3	2.2	-1.1
2007	0.7	-0.3	1.6	4.9	9.6	12.2	13.9	13.9	11.9	9.2	1.8	-2
2008	-3	-2.6	2.7	6.7	10.4	11.8	14.9	14.5	12.2	6.6	-1.7	-0.5
2009	-0.5	0	1.2	6.9	8	12.6	14.3	13.5	11.8	6.6	2.5	-0.4
2010	-6.1	-1.5	3.2	6.6	9.8	12.6	14.4	14.4	12.3	10.4	4	-4.5
2011	-4.6	-2.3	0.8	4.2	9.2	12.4	14.2	13.4	12.1	6.6	0.1	-

2.2.2 Precipitation:

Table 2.3 Total Monthly Rainfall (mm), Station: Chamkhar "A"

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	0.4	0.3	29.8	40.1	100.4	108.6	158.4	178.4	56.7	31.6	18.5	0	723.2
2003	0	22	16.1	62.4	42	121.1	100.5	38.1	179	9.1	0	7.2	597.5
2004	25.5	0	7	130.4	85.6	156.6	137.5	117.5	63.1	190.8	0	0	914
2005	0	10.3	41.2	66.8	71.2	38.5	96.8	93.9	82.7	147.7	0	0	649.1
2006	0	5.5	43.2	107.5	86.9	78.3	168.2	192.9	57.8	18.1	21.7	0	780.1

2007	2	31	23.1	67.5	44.6	114.6	177.2	123.9	107.3	46.9	0	0	738.1
2008	30.2	4	23.3	54.7	60.7	114.6	149.3	212.2	70.6	90.9	2.2	0	812.7
2009	0	21	42.5	55.4	173.8	39.8	119.8	151.9	42.6	63.9	0.6	0.4	711.7
2010	0	2.4	51.9	103.4	111.1	140.6	209.5	83.7	88.3	49.8	0.1	0	840.8
2011	1.6	19.7	20.6	40.8	83.5	114.3	140.4	165.3	74.7	10.4	8.5	-	679.8

Source: Meteorology Section, Department of Hydromet Services, MoEA, Thimphu, Bhutan.

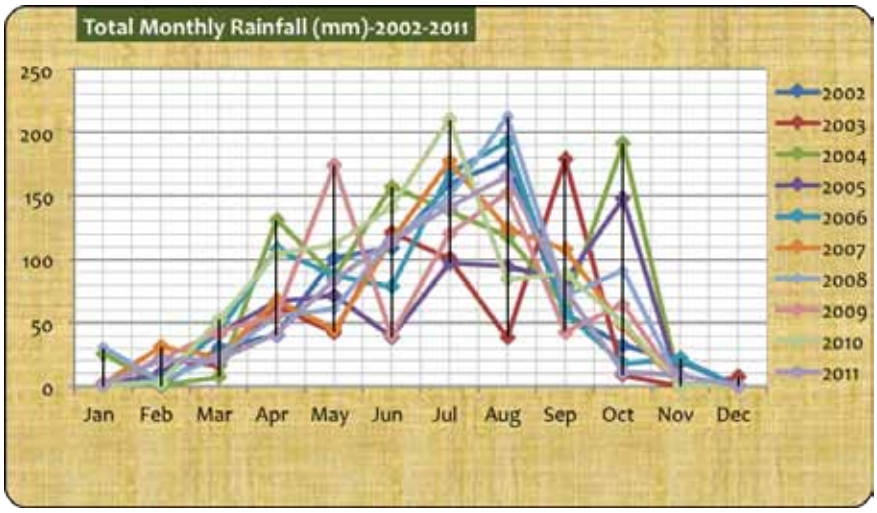

Figure 2.3 Graph Showing Total Monthy Rainfall (mm)

Figure:2.4 Years Monthly Average Rainfall

2.2.3 Relative Humidity

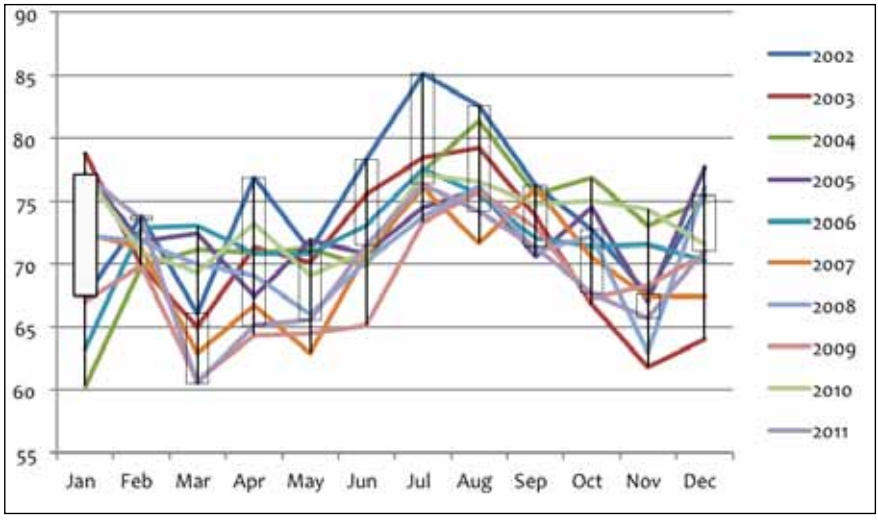

Figure 2.5: Relative Humidity (%) 2002-2010

2.3 Geology and Soil

The soil type is predominantly sandy loam and loamy sand with high topsoil moisture. There are several swampy areas near streams in Ugyencholing, Bezabi and Doyungchhu block. The top soil found in the Blue pine forest ranges from dry, moist to permanently wet type whereas the top soil found in the mixed conifer forest and fir are moist. The humus and litter depth varies in different forest types.

2.4 Hydrology

Rodungla FMU forms the main eastern catchments area for the Tang River. There are numerous small and large streams originating from the FMU which feeds the main river flowing through the valley. Downstream, there is the legendary "Tang mebartso" from where Terton Pema Lingpa retrieved a statue and a treasure chest. According to the verbal narration from the locals, when Terton Pema Lingpa (1450-1525) went to the lake (a water pool along the tang river) to get the treasure revealed in his dream, he was accused by the local ruler of the area that he performed these feats under a trickery scheme. To prove this to the people, Pema Lingpa took a lighted lamp and jumped into the lake and emerged back on the rock with the lamp still burning holding a statue and a treasure chest. The lake then came to be known as the "Mebartso" meaning the burning lake.

3. VARIABLE SITE FACTORS

3.1 Population and Demography

Tang Gewog has 27 hamlets out of which 10 villages fall within Rodungla FMU. Tang Gewog has a total population of about 1,158.

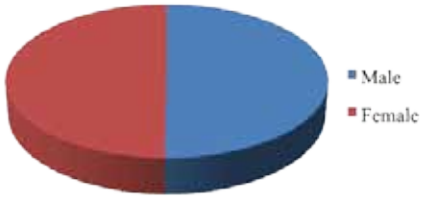

Figure 3.1: Sex Composition

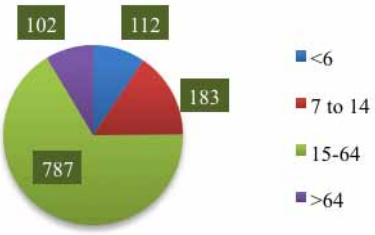

Figure 3.2: Age Groups (Years)

The people are mostly farmers whose main source of income is generated through sale of potatoes supplemented by livestock and livestock products. There are about 85 people working in the government service and only few are involved in business or private sector. The children are either enrolled in schools or in monastic bodies.

Table 3.1 Population According to Village

Village	Population	Village	Population
Benzabi	42	Pangshing	102
Chojam	7	Parlang	64
Chutoe	80	Pemaling	9
Gamling	105	Remuchen	14
Gangjute	47	Sakarmay	16
Jamjang	55	Sarmath	42
Jhoney	10	Shedrak	14
Jog	12	Shobum Gompa	6
Kharab	69	Tarcheling	13
Khoiyar	13	Tasur	106
Kizom	73	Thangras	22
Mesethang	50	Ugyencholing	157
Namkhoi	18	Yarang	19
Naroth	30	Zebrag	11

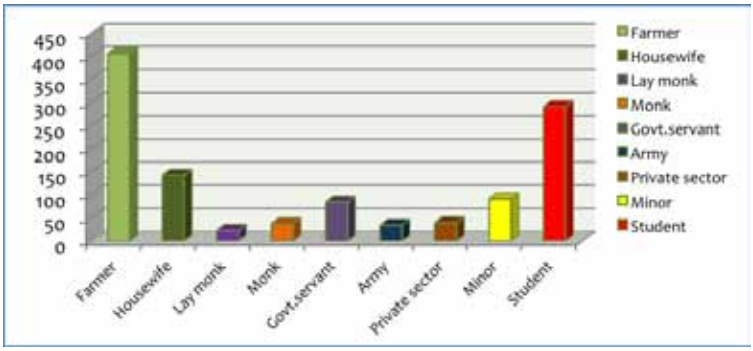

Figure 3.3: Population Profile

Table 3.2: Migrants by Age, Sex, and Year of Migration.

Age	No. of persons	Sex		Year of Migration		
		Male	Female	Before 1985	1985-95	After 1995
1 to 6						
7 to 14	1	1			1	
15 above	168	115	53	27	50	91
Total	169	116	53	27	51	91

3.2 Farming and Agriculture

Agriculture forms the basis of livelihood for the people living within the FMU. They earn their cash income by selling agriculture and livestock products. Potato is an important cash crop for these people and therefore, widely grown. It accounts for more than 70% of their cash income. On an average, a household earns minimum of Nu. 22,000/- a year from the potatoes alone.

Rice is also grown in these valleys. Apart from potatoes, the farmers also grow varieties of vegetable and fruits. The people of Tang concentrates more on livestock rearing due availability of large open temperate pasture and livestock products, especially cheese, butter and eggs are important for their sustenance.

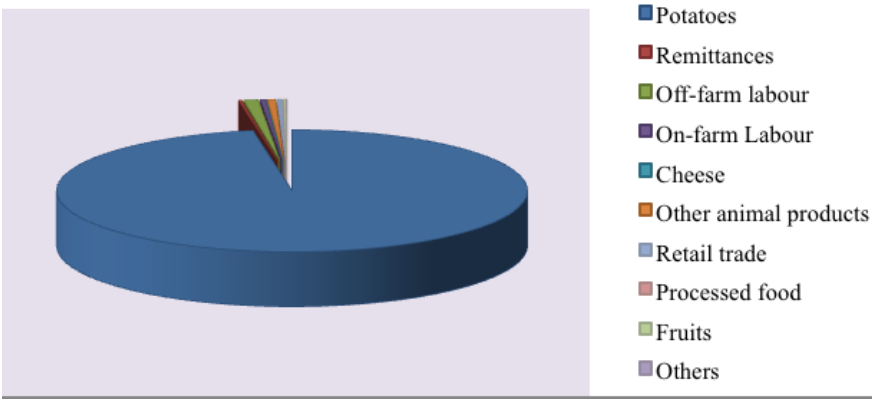

Figure 3.4: Sources Income

Animal husbandry

Livestock are treated mainly as a source of dietary supplements especially for cheese, butter and eggs. Only the excess products are sold which accounts for 5% of their total income. The villages own 2,452 cattles, 284 poultry, 59 sheep and 127 yaks. It is evident from the lesser number of other livestocks that the importance is placed on the animals which are capable of providing some form of produce.

Livestock pressure is concentrated more on Gamling, Ugyencholing, Chutey, Kharab and Tasur, as these villages have very large number of cattles (which could be attributed to existence of comparatively larger number of households and availability of open grazing pasture. On an average, there are twelve cattle per household.

Table 3.3: Livestock Products

Livestock Products	Year					
	2005	2006	2007	2008	2009	2010
Fresh Milk (L)	80171	228614	243929	77344	208058	538140
Butter (Kg)	4687	9451.4	10096	4392	8635.5	16034
Fresh Cheese(Kg)	52817	77534	78944	17655	76610	83268
Eggs(No)	13205	25838	24705	0	0	0
Beef (Kg)[1]	22650	21600	12850	25934	23765	18872
Pork (Kg)[2]	200	200	360	400	620	0

RNR-EC Tang Geog)

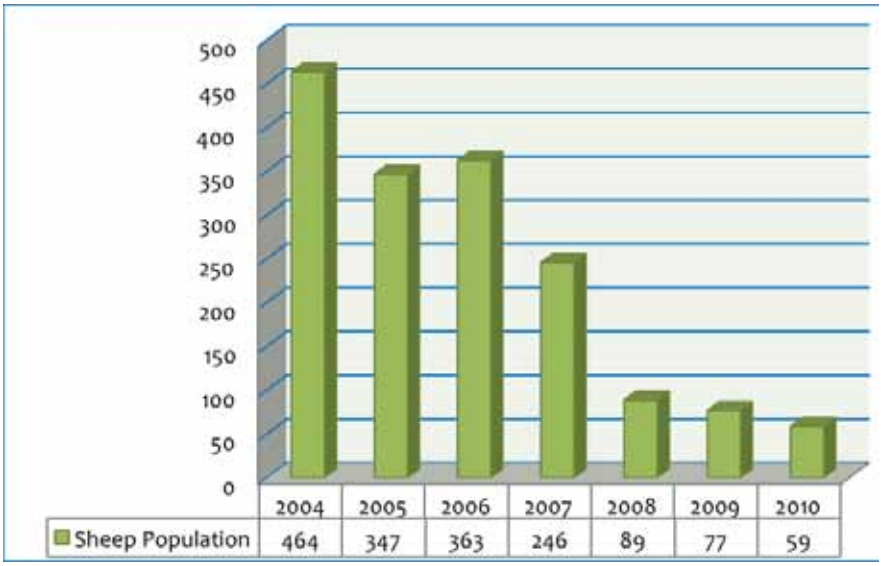

Figure 3.5 Sheep Population in Tang

Total sheep population for the year 2010 was 59 with a total of 26 kg of wool was produced during the period (Livestock census, 2010, Tang)

3.3 Traditional Use of Forests

Ever since the settlement has taken place in and around the FMU, the people have been using the forest for their livelihood. The bond between these people and forest is very strong, they use the forest to; construct their houses, collect firewood, fodder, graze their animals, fruits and vegetables, leaf litters, make farm implements, fencing materials, medicinal plants etc.

Table 3.4: Migration pattern of cattle

Village	HHs who migrate cattle	No of cattle migrating	Final Destination			Village through which the herds migrate until they reach final destination	Month of start of migration	Month when herds return to village	No of taken days taken to reach final destination	Reason for migration
			Dzongkhag	Geog	Village					
Jamshong	1	33	Mongar	Silangbi	Rengaithang	Ura, Sengor, Silangbi	End Oct	End April	30	Traditional Practice
Bebzur	2	47	Mongar	Silangbi	Rengaithang	Ura, Sengor, Silangbi	End Oct	End April	32	Traditional Practice
Bebzur	2	52	Zhemgang	Shingkhar	Shingkhar	Ura, Shingkhar	End Oct	End April	32	Traditional Practice

3.4 Grazing

The information about pattern of grazing, number of cattle and grazing land were mostly acquired from semi structured interviews and most of the information was collected during series field visits. Grazing is evident in most areas of the FMU and is going to be one of the main pressures in the FMU. The heaviest grazing pressure is in the forest areas close to the settlements, despite the availability of pastures and grazing grounds for the animals. Local cattle graze during the summer months and the migratory herds during winter months enter the FMU. However, grazing at current rate will have little impact on soil and water quality, but uncontrolled grazing could lead to poor regeneration and soil compaction in the near future.

The nomads mostly practices migratory grazing. The effect on forest regeneration as a result of selective browsing both by resident and migratory cattle can lead to severe impairment of regeneration capacity of the forest in the long term. Future management prescriptions and options should take into account the dynamic and the appropriate regulation of cattle grazing in the forest.

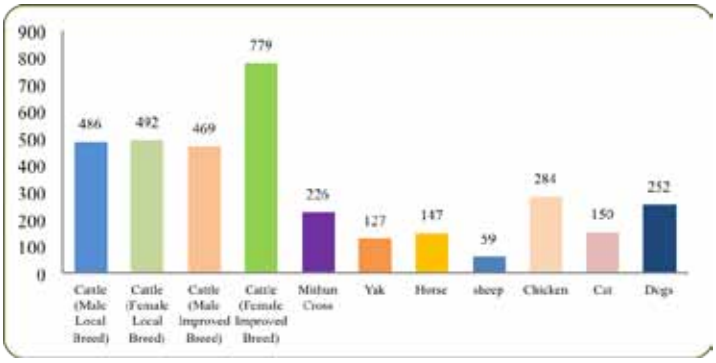

Figure 3.6: Livestock Census, 2010, RNR-EC Tang

The improved breeds have almost replaced the local less productive cattle. People in Tang prefer to raise few productive animals rather than herds of local cattle. This has also greatly reduced pressure on forests and enhanced income of the people.

3.5 Forest Fires

Despite stringent legislation and public awareness programmes, forest fire has persisted as a major environmental problem in Bhutan. 23 (1993-2010) forest fire has been recorded in Bumthang Dozongkhag alone affecting about 2,085.20ha of pristine forests. While forest fire has both positive and negative effect on the ecology of the forest but in Bhutan the negative effect of the fire is more common due to its frequency. The cause of forest fire is both natural and anthropogenic. Majority of our population depends on agricultural farming, burning of debris in the field is a regular routine for the farmers and forest fire spreading from such burning is very common. The natural cause of forest fire in Bhutan is very negligible; almost 90% of forest fire in Bhutan is manmade.

Although fire is an annual phenomenon in the central region, especially in the bluepine areas, it is has been observed that part of the FMU was affected by forest fire in the past. Though it is not a severe problem for mixed conifer, the risk of forest fire in blue pine forest which is found in young stand in Doyungchhu and Ugyenchholing blocks are expected to increase in the near future. Strict vigilance should be in place to prevent forest fire and the local people should be educated on fire safety, fire risk mitigation measures based on proper Fire Science.

3.6 Pest and Diseases

There is no history of bark bettle (*Ips schmutzenhoferii*) in the FMU and no signs and symptoms have been observed during field visits. Fir die-back phenomena like in western Bhutan were not found in the FMU. In some areas leafy Misletoe has affected the blue pine stands. The Guidelines for control and prevention of Bark Beetle and Darf Misletoe are available in FRMD and should be strictly followed.

3.7 Non-Wood Forest Product (NWFPs)

Wide range of Non-Wood Forest Products (NWFPs) for food, fiber, shelter medicine, household implements, handicrafts and several other purposes are being used by the rural Bhutanese. Forest Nature Conservation Rules, 2006 provide legal basis for their use and management of forest resources by local communities. Non Wood Forest Produce contributes to the live-hood and sustenance of many rural communities in Bhutan. Local people usually collect various NWFPs, such as medicines, fodder, leaf litter, high value mushrooms, edible fruits, nuts, shoots and flowers, incense plants, plants for dye and bamboos from the forest for their bonafide uses. There are many other plant species found within the FMU which

are used as NWFPs, whose various properties are valued by the locals and are put into use. Some of the important NWFPs found in RFMU are listed in the following table.

Table 3.5: Important NWPFs Found in RFMU

Botanical Name	Habit	Parts Used
Medicinal Plants		
Pseudoginseng	Shrub	tuber
Picorrhiza kurroa	Shrub	tuber/root
Artimisia spp	Shrub	leaf
Cannabis sativa	Shrub	leaf
Edible Mushrooms		
Auricular auricula	saphrophyte	whole tissue
Plerotus cornucopiae	-do-	-do-
Plerotus oestreatus	-do-	-do-
Plerotus salmoneo	-do-	-do-
Ramaris spp	-do-	-do-
Tremela fuciformis	-do-	-do-
Lichen spp	-do-	-do-
Edible Fruits		
Sorbus tibetica	Tree	fruit
Docynia indica	Tree	fruit
Rosa webbiana	prickly shrub	fruit
Rubus ellipticus	prickly shrub	berry
Incense	Shrub	Whole plant
Daphne spp	Shrub	wood chips
Artimesia spp	Shrub	whole plant
Berberis spp	Shrub	whole plant
Elsholtzia spp	shrub	Leaf
Gaultheria spp	shrub	Leaf
Rhododendron spp	Medium tree	leaf anf bark
Dye		
Berberis spp	shrub	Root
Elsholtzia fruticosa	Shrub	leaf & bark
Quercus griffithi	Tree	leaves
Rubia mangith	Vine	stem
Rhus wallichi	Tree	fruit
Symplocus paniculata	Tree	leaves
Lycopodium spp	Moss	whole plant

Fibre		
Cannabis sativa	shrub	bark
Daphne spp	shrub	bark
Girardinia spp	shrub	bark
Rubia cordifolia	Vine	stem

4. ECOLOGY

The geographical diversity combined with equally diverse climatic conditions and a biogeographic record adds to the Bhuran's wide range of biodiversity and ecosystems. Royal Government has always placed preservation of its rich natural heritage in top priority in all developmental activities. Therefore, this has to be considered in the forest management, and underpin all forestry activities. No forestry activities within the FMU should compromise biodiversity or Ecological functionality.

4.1 Floral Association

There is no detailed classification of the vegetation in Bhutan. However, with minor variations, the works of Champion and Seth (1968) on the classification of forests in India, which include Himalayas, could be applied to many of the forest types in Bhutan.

The Blue Pine forests within the FMU occur between 1800m to 3000m and are dominant in this belt. It is also found in mixed conifer forest and mixed with broadleaves. Mixed conifer forests are dominated by *Tsuga dumosa*, *Pinus wallichiana*, *Larix griffithiana*, *Picea spinulosa*, *Abies densa* and *Taxus baccata*. Several Rhododendrons (e.g *Rhododendron hodgsonii, R. barbatum, R. campylocarpum, R. campanulatum, R. fulgens, R. thomsonii)* grow profusely in the understory, along with *Viburnum spp., Symplocos spp., Lonicera spp., Betula utilis, Acer spp., Sorbus spp., Juniperus indica, and J. recurva*. This contributes to the overall diversity of the mixed conifer zone and many species of annual herbs and medicinal plants occur in these forests. Fir forest in the FMU is located mainly in the upper watersheds and play vital protection function. A thick layer of moss with rhododendron, bamboo, other shrubs and herbs forms characteristic undergrowth.

Table 4.1: Vegetation Layer

Vegetation Layer	Characteristic species
Upper Canopy	Spruce (*Picea spinulosa*), Hemlock (*Tsuga dumosa*), Fir (*Abies densa*), Blue pine (*Pinus wallichiana*)
Middle Canopy	Juniper (*Juniperus recurva*), *Rhododendron spp*, Oak (*Quercus semecarpifolia*), *Acer cambellii*, *Betula sp*, *Populus ciliata*, and other species.

Shrubs	The dominant shrubs are *Rosa laevigata*, *Berberis spp*, *Rubus ellipticus, Eleagnus parviflora, etc.*
Ground Cover	*Aconitum sp., Thalictrum foliolosum, Potentilla spp., viola spp., Senecio spp., Aster albescense, Cotoneaster sp. Rumex hastatus, Causinia thomsonii, Gerenium wallichianum* and pteridophytes which are excellent soil binders (*Adiantum sp., Pteris sp. Pteridium sp., Asplenium sp*).

Table 4.2: List of ImportantPlant Species Found in the FMU

Scientific Name	Commom Name	Habit	Scientific Name	Commom Name	Habit
Abies densa	Fir	Trees	***Taxus baccata***	Himalayan yew	-do-
Acer caudatum	Maple	-do-	***Tsuga dumosa***	Hemlock	-do-
Betula utilis	Himalayan Birch	-do-	***Anaphylus spp***		Herbs
Docynia indica	Tong	-do-	***Euphorbia griffithii***	Griffith's Spurge	-do-
Lidera hyterophyla		-do-	***Lycopodium esculenta***		-do-
Mallus baccata	Crab Appple	-do-	***Potentilla peduncularis***	Potentilla	-do-
Picea spinulosa	Spruce	-do-	***Rubia mangith***	Manjith	-do-
Prunus cornuta	Himalayan Bird Cherry	-do-	***Rumex nepaliensis***		-do-
Quercus semicarpifolia	Oak	-do-	***Trifolium repens***	Clover	Scrub
Salix tetrasperma	Willow	-do-	***Crotoneaster spp***		-do-
Sorus tibetica		-do-	***Daphne spp***	Daphne	-do-
Symplocus paniculata		-do-	***Rhododendron kesangii***	Rhododendron	-do-
Taxus baccata	Himalayan yew	-do-	***Rhododendron keysii***	Rhododendron	-do-
Tsuga dumosa	Hemlock	-do-	***Rhododendron trifolium***	Rhododendron	-do-
Anaphylus spp		Herbs	***Rosa moschata***	Wild Rose	-do-

4.2 Fauna

FMU is very rich in Wild fauna. Wildlife evidences were recorded by the inventory team in the year 2005. Even during the socio-economic survey, the status of wildlife was discussed in detail. Some of the animals and birds were directly spotted during the transect walk and some through indirect evidences.

Table 4.3: Wild Animals Recorded in FMU

Common Name	Scientific Name
Barking deer	*Muntiacus muntjak*
Himalayan Black Beer	*Selenarctos thibetanus*
Himalayan yellow throated marten	*Martes flavigula*
Jungle cat	*Felis chaus*
Leopard	*Panthera pardus*
Monkey	*Rhesus spp*
Musk deer	*Moschhus chrysogaster*
Pine marten	*Martes martes*
Sambar deer	*Cervus unicolor*
Three stripped palm squirrel	*Funambulus palmarum*
Wild dog	*Cuon alpines*
Wild pig	*Sus scrofa*
Wolf	*Canis lupus*

Avifauna

The first list of birds was prepared during the preliminary visit of FRMD team to the forest management unit during the month of September, 2011. Therefore, most of the visitors of other seasons and migrant birds could have been missed out.

Table 4.4: lists Common birds in the FMU

Common Name	Scientific Name	IUCN Status
Beautiful rosefinch	*Carpodacus poicherrimus*	Least Concern
Black billed magpie	*Pica Pica*	Least concern
Black throated tit	*Aegithalos concinnus*	Least concern
Blue whistling thrush	*Myophonus caeruleus*	Least Concern
Carrion crow	*Corvus corone*	Least Concern
Chest nut crowned laughing thrush	*Garrulax erythrocephalus*	Least Concern
Green backed tit	*Parus monticolus*	Least concern
Hen harrier	*Circus cyaneus*	Least Concern
Hodgson's redstart	*Phoenicurus hodgsonii*	Least Concern
Oriental turtle dove	*Streptopelia orientalis*	Least Concern

Pied Kingfisher	*Ceryl rudis*	Least concern
Red billed chough	*Phyrrhocorax Phyrrocorax*	Least concern
Rufous breasted accentor	*Prunella strophiata*	Least concern
Rufous vented tit	*Parus rubidiventris*	Least Concern
Russet Sparrow	*Passer rutilans*	Least concern
Snow pigeon	*Columba leoconota*	Least Concern
Spotted nut cracker	*Nucifraga caryocatactes*	Least Concern
White capped water redstart	*Chaimarromis leococephalus*	Least Concern
White collared black bird	*Turdus ablocinctus*	Least Concern
White throated redstart	*Phoenicurus schisticeps*	Least Concern
White wagtail	*Moticilla alba*	Least concern
Winter wren	*Troglodytes troglodytes*	Least Concern
Yellow billed blue magpie	*Urocissa erythroryncha*	Least Concern

5. SOCIO-ECONOMICS

5.1 Sources of Income and expenditure

The people living within the FMU are mostly subsistence farmers. Since the valley is accessible by Tang-wobthang feeder road the potatoes are mainly sold in the vegetable markets of Thimphu and Phuntsholing. However, there are huge concerns of the local residents as the crops are frequently destroyed by wild Pigs and as a consequence there is ever rising human wildldife conflict. The FNCA, of 1995 and FNCR, 2006 prohibits hunting, taking, removing, destroying, poisoning or injuring any wildlife, whether listed in Schedule I or not. The Act does allow killing of animals that are not included in the schedule I list, only if was found necessary to, prevent destruction of his property, livestock, or crops and further proven that the wild animal in the category has been killed in his own agricultural field.

Most of the house hold income are used in food and clothing. People within the FMU also recognizes the importance of education, therefore, they perceive that the expenditure for educating their children has increased over the past few years.

6. FOREST USES

6.1 Fuel wood

All the people living within the FMU collect fuel wood from the nearby forests. The fuel wood equivalent to 8M^3/282 cft is provided free of royalty as per the entitlement prescribed in the FNCR, 2006. However, the amount exceeding the one prescribed in the rule is charged 50% of the royalty applicable for the rural house construction. It is also understood that a large volume of firewood such as dry wood, lops and tops are collected informally without being recorded.

6.2 Timber

Besides its use as firewood, the allotted rural subsidized timber is used for construction of new houses, repair, renovation and extension of rural houses. Timber is also widely used in other rural construction such as shed for livestock, potato storehouse, farm guard shed/watch tower, toilet and machinery sheds. Timber is also allotted to the rural communities for wooden water channel, water tank, agricultural implements including, domestic furniture, flag poles and fencing poles.

6.3 Wood Based Industries

There are around 31 forest based industries in Bumthang Dzongkhag (Statistical Yearbook of Bhutan, 2007). The majority of the wood based industry in the Dzongkhag are small sawmills.

7. CURRENT TIMBER DEMAND AND SUPPLY

7.1 FMUs under implementation in Bumthang Dzongkhag

There are two FMUs, Kharshong and Dawathang under implementation in the Dzongkhag with the total annual allowable cut of 5,035.00m^3 and 12,186.00m^3 respectively for the year 2012. In addition, total AAC of 3772.53m^3 and 7099.20m^3 respectively is fixed from Zangling and Uruk Working Scheme for the year 2012.

7.2 Supply of Rural Timber in Tang Geog (2006-2011)

The supply of rural timber for Tang Gewog during the period from 2006 to 2011 has been given in the table below. The supply was converted to volume in m^3 using the conversion factor as given in the Royalty Rates on Forest Produce, 2006. The timber supplied during the period (2006-2011) was 2912.79m^3 with supply volume fluctuating between 6,257.71 cft to 102,879.80 cft.

Table 7.1: supply of subsidized timber in Tang Gewog (2006-2011)

Supply o f Rural Timber in Tang Gewog (2006-2011)

Product Types	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	Total
Bakals(NMB)	0	0	0	0	120	120
Cham(NMB)	560	635	319	14	328	1856
Dangchung(NMB)	190	45	40	0	10	285
Drashing(NMB)	147	120	56	112	72	507
Poles(NMB)	0	0	0	20	639	659
Post(NMB)	80	237	312	116	529	1274
Shinglep(NMB)	16	5	0	0	0	21
Tsim(NMB)	256	40	45	140	220	701

Table 7.2: Cumilative of all product types

Year	M^3	Cft
2006-2007	872.742	30825.25
2007-2008	881.334	31128.72
2008-2009	444.059	15684.16
2009-2010	177.172	6257.715
2010-2011	537.486	18984.01
Total	2912.793	102879.8

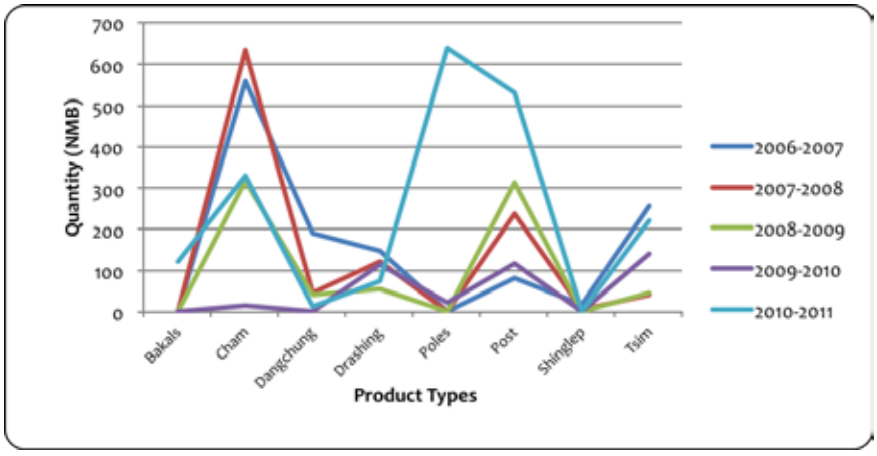

Figure7.2: Rural Timber Supplied in Tang Gewog (2006-2011)

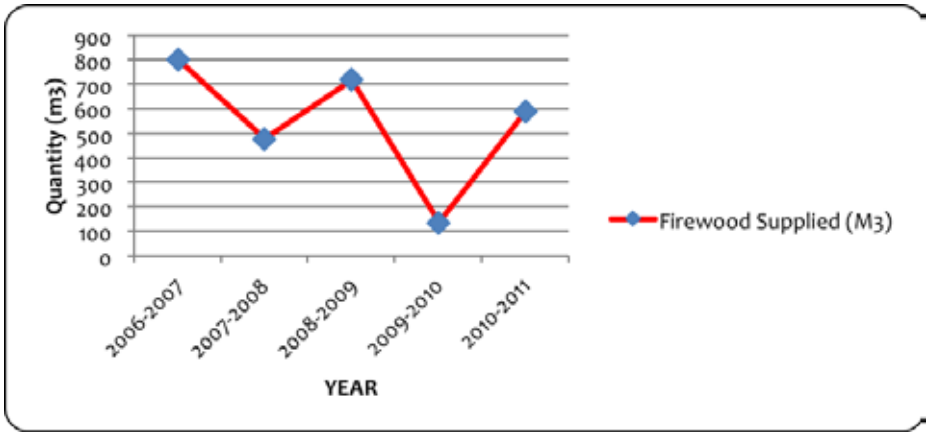

Figure 7.3: Firewood Supplied in Tang Gewog (2006-2011)

Besides the sale of timber by NRDCL through open auction, Timber and fuel wood are also directly supplied by the Territorial Division (TD) within the Dzongkhag. The rural subsidized timber for house construction, repair/renovation/extension and other purposes form a major portion of the timber supplied through TD. Supply from 2006 to 2011 fluctuated between 6,257.715 Cft and 31,128.72 Cft, attributable to the periodicity of entitlement of subsidized timber every 25 years for new construction and once in a block period of 5 years for repair, extension and renovation and natural disasters.

7.3 Projected wood demand for Bumthang Dzongkhag

Timber for commercial use can only be produced within established FMU. Therefore, timber production and timber disposal depend on the production capacity of established FMUs (i.e. AAC) not on timber as such. However, the demand for timber is the driving factor for opening of additional FMUs (*FRPA for Bhutan, 2004*).

According to NRDCL information booklet, 2007, timber production from Jakar Division has been between 0.14 million cft in 2002 and 0.35 million cft in 2006. The production of timber for the Division went up in 2007 and 2008 with 0.13 million cft additional timber coming from Zangling and Uruk Working Scheme falling under the Division. Huge volumes of timber are also collected annually from operations such timber removal from main/farm road construction and widening, clearing for transmission lines and corridors.

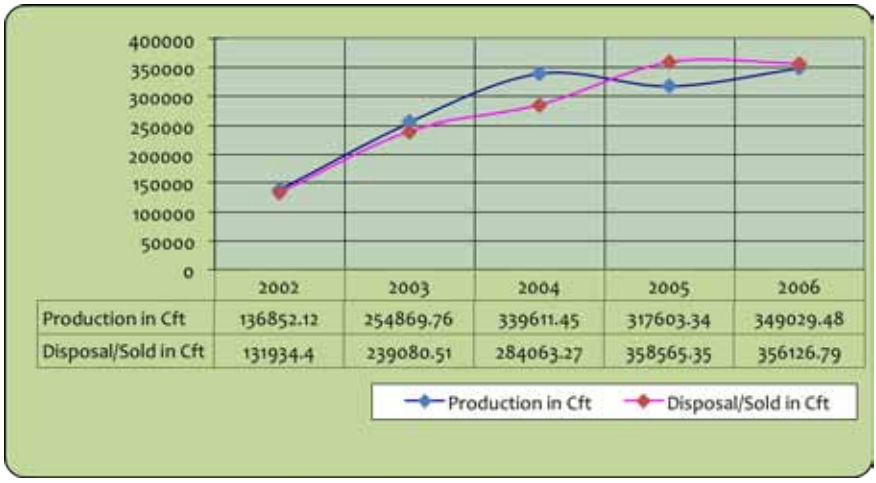

Figure 7.4 Production & disposal of timber by NRDCL

Very little is known about the actual wood demand in the Dzongkhag and the only way of assessing the wood demand in the Dzongkhag is by studying the past supply trends. The subsidized rural timbers are allocated through territorial Divisions and are recorded in the territorial statistics. However, the informal collections of firewood are not recorded in the territorial statistics and therefore, the wood demand for the Dzongkhag may be underestimated.
For the commercial demand, the disposal of timber from the Jakar may not reflect the actual demand of the Dzongkhag as the sale of timer is conducted through open auctions where any Bhutanese citizens were allowed to participate and there is also free movement of timber within the country with proper documentation as used to be the trend in the past. During the ninth five year plan, the total commercial timber disposed from Jakar Division was 1.4 million cft with an average timber disposal of 0.27 million cft/annum.

With the ever increasing demand for timber, fuel wood and other forest products, the Department of Forests and Park Services is under pressure to meet these demands and at the same time to maintain 60% forest cover for all times to come. With lots of upcoming Dzong Conservation Projects, constructions and vis-a-vis the policy of the Government to cap the price of the timber, the demand for timber is expected to increase by manifolds.

The people living within and in the periphery of FMU have been using these forests for fulfilling their daily needs.The rural allotments were given in the form of *shinglep, drashing, cham, tsim, dangchhung* and firewood.The trees are marked on single tree selection system. The demand for rural timber is fluctuating for the last six years. On an average, the rural timber demand for Tang geog is about 20,575.90 cft/year.

8. SILVICULTURAL ASSESSMENT

The main forest types found within the forest management unit as follows:

8.1 Blue Pine

In FMU, this type of forest occupies the areas near the habitation. Due to its preference over other timber in the construction and repair of the houses, the blue pine has been intensively used and as a result the blue pine stand are mostly young and we can also observe dense young saplings through out the blue pine zone. The Blue Pine is dominant and demonstrates fast colonization. The regeneration of shade tolerant species at higher elevation in closed stands of Blue Pine forest gradually leads to a conversion into mixed conifer forests.

8.2 Mixed Conifer Forest

Mixed conifer is found in the upper valley and occupies the largest portion of the FMU. This forest type is dominated by Spruce and Hemlock. Hemlock tends to be found on wetter slopes than spruce. At the lower altitude Spruce and Hemlock is mixed with Oak and at the higher altitude, they are mixed with Juniper, Larch, Maple and Birch. Mixed conifer forest covers extensive areas of the FMU where the gradation is gradual

8.3 Fir Forest

Fir forest in FMU is confined to the uppermost ridges and occurs mostly as pure stand. In few places this forest is mixed with Birch and the dense canopy provide environment for luxuriant understorey for *Rhododendron spp*. and other shrubs. Most of the Fir at the higher elevation is over matured and are in the state of die back. Towards the treeline the fir forests become stunted and grade into juniper and rhododendron scrub. These forests play a very important protection function in the upper watersheds.

Table 8.1: FMU Forest Types

Forest Types	Area (ha)	Area %
Agriculture	379.33	4.12
Blue pine	1921.17	20.87
Fir	681.41	7.40
Meadows	566.99	6.16
Mixed Conifer	4831.31	52.48
Scrub Forest	803.32	8.73
Settlements	22.66	0.25
Total	9206.19	100

9. ORGANIZATION AND ADMINISTRATION

9.1 Organization

FMU is under the jurisdiction of the Bumthang Territorial Division, and is directly administered by the Chief Forestry Officer (CFO). The CFO will be supported by the Unit-In-Charge, who will supervise the FMU operations. Operational plans will be developed and written by the FMU management, with assistance and input from the CFO, Bumthang. The office of unit in-charge will be located at Tang. All activities within the FMU will be administered by the CFO, Bumthang.

9.2 Health and Safety

The forestry operation involves major risk during harvesting and transportation of timber. Site specific risk assessment is required for the FMU to ensure health and safety of the field staffs. During the process of felling, the chain saw should be equipped with full functioning chain breaks and feller should ensure to keep two tree lengths apart while felling. The danger of falling timbers and overhead cable lines is inevitable and care should be taken while stacking. The stacking should be done to a standard height in the same direction.

9.3 Record Keeping

The unit office shall maintain the records of all the activities within the FMU as per the record-keeping format of the Forest Management Code of Bhutan, 2004.

10. INFRASTRUCTURE, TRANSPORT AND EQUIPMENTS

10.1 Roads

A 26Km, Tang-Wobthang feeder road touches most of the villages in the Tang geog. A New motorable bridge across Tang Chhu connecting Ugyenchholing Monastry has been constructed to facilitate tourists visiting the monastery. The villages within the FMU can also be accessed by means of three suspension bridges across Tang River.

A New motorable bridge will have to be constructed across Tang Chhu at Chamthang for the extraction of timber from the FMU. A new forest road to Chamthang Bridge (150 m) will have to be constructed from the existing Tang-Wobthang Feeder road following the existing footpath to Chamthang suspension bridge. The proposed FMU road is not only for the purpose of timber extraction from the FMU but will also immensely benefit people dwelling both within and outside the FMU. The proposed new road length during this ten years plan period is approximately 23km. For the entire FMU total length of forest road network comes around 40km.Therefore, the unit In-charge can accordingly calculate the length of the road construction in a year, based on the available stock and mention in the Operational Plan.

PART 2

THE FURURE MANAGEMENT

11. INTRODUCTION

In order to utilize and manage the forest resources and forest land, sustainably and to fulfill social, economic, ecological and cultural needs of the present and future generation, the Royal Government of Bhutan has set a firm forest policy of maintaining at least 60% of the country's land under the forest covers for all times to come.

11.1 Forest Policy

Over the years, there has been increasing pressure on the environment and the natural resources, the alarming consequences of which are becoming evident in the increasing propositions. The National Forest Policy, 2012 consists of a long term goal, major policy objectives and specific statements to enable various aspects of forest production, use and management. It has five guiding principles i.e. equity and justice in terms of access, poverty alleviation through integrated approach, deregulation and devolution, integration of science and indigenous knowledge and allowing import of logs and swan timber.

According to the FNCA, 1995, management plan needs to be prepared for all protected areas and for all forests where commercial logging is to be under taken and needs to be approved before implementation. This plan has been prepared in line with the Act and the Forest and Nature Conservation Rules of Bhutan.

The Four Forest Sector Policy Goals set by RGoB are:

Goal 1: Protection of the land, its forests, soil, water resources and biodiversity against degradation such as loss of soil fertility, soil erosion, landslides, floods and other ecological devastation and improvement off all the degraded forest and areas through proper management systems and practices.

Goal 2: Contribution to the production of food, water, energy and other commodities by effectively coordinating interaction between forestry and farming systems.

Goal 3: Meeting long term needs of the Bhutanese people for wood and other forest products by placing all the country's production forest resources under sustainable management.

Goal 4: Contribution to the growth of national economies, including export opportunities, through fully developed forest-based industries and to contribute to balanced human resources development through training and creation of employment opportunities.

FNCA, 1995 provides the legislative framework for the community participation in the forest management and streamline the preparation of supporting forest rules and regulations. The regulation lay out the best practices that apply nationwide.

11.2 Goals

To manage the forest on the multiple use, sustained yield basis for the production of timber, fuel wood and other forest products; and for conservation of watershed, wildlife and environment.

11.3 Objectives

- Classifying the management area into Protection, Production, Non-Production and Non-Wood Forest Products (Overlapping) circles based on ecological and environmental grounds and prescribe the most appropriate management prescription in consistent with the goal and objectives.
- Deciding AAC on sustainable basis from the available growing stock and operable area within the production forests.
- Allocating the AAC rationally, to the local people, urban and government organizations and for commercial purposes.
- Construction of environmental friendly forest road network for accessibility.
- Monitoring and evaluating the implementation of the plan.
- Organizing suitable implementation arrangement through the Territorial Forest Division and the Natural Resource Development Corporation Limited (NRDCL).

Protection Management Circle

- To check soil erosion and denudation in the catchment areas of rivers, lakes and reservoirs in the interest of soil and water conservation.
- To protect the forest from encroachment, fire, grazing and other illegal activities
- To conserve and enhance wildlife habitats and biodiversity.
- To meet local needs of NWFPs on sustainable basis.
- To raise awareness, conserve the biodiversity and respect the sanctity of religious and historical sites.

Non-Production Management Circle

- To maintain and improve the forest condition.
- To manage and regulate grazing for livestocks.
- To meet the local demand for NWFPs.
- To conserve and enhance biodiversity.
- To conserve the catchment area.

Production Management Circle

- To maintain a sustainable, healthy, and productive forest
- To meet the timber production targets set under ABSD initiatives
- To meet the local requirement, as priority, for timber, fuel wood and other forest products on a sustainable basis.
- To manage the FMU for commercial timber production on sustainable basis.
- To protect the forest from fire and illegal activities and over grazing.

- To create employment opportunities for the local people.
- To enhance and improve forest condition and productivity to meet national needs.

Non-Wood Forest Products Management Circle

- To meet the local demand for NWFPs on sustainable basis.
- To create employment opportunities for the local people and to help local people in generating income from NWFPs.
- To conserve and enhance biodiversity.

11.4 Management Based on Forest Function

11.4.1 Introduction

Forest function mapping is the term used for grouping the different potential uses of the forest. The different forest potential includes soil conservation, watershed conservation, habitat for flora and fauna and resource based for many kinds of human needs. Forest function in general are not based only on subjective human demands, they are significantly and objectively limited by site condition of forest stand. For this reason, categorization of every forest stand into different forest function is mainly based on the dominant site, forest type, accessibility, slopes, flora and fauna present. However, some forest function represents certain exception to this rule and these functions are designated on the basis of social importance.

Forest function defines all the ecological, environmental and social function within the FMU, so as to balance the often diverging interest of commercial logging. Alongside it identifies areas of production forest, limited production forest and protected areas. It also provides the FMU in-charge with first hand information on the location of different forest functions in order to enable him to specify the required management prescriptions and to control their implementation.

The Main Objectives of Forest Function mapping for this Management Plan are:

- To define different environmental and social functions of the forest and depict them on the map
- To identify production, non-production and protection area within the FMU
- To provide a tool for the management planner for balancing the requirement of nature conservation, environment protection, social forestry and commercial timber production and also to provide spatial information required to compute the sustainable AAC.
- To provide the FMU In-charge with information on the location of different forest function in order to specify the required management prescriptions on the ground and to control their implementation.

11.4.2 Function Groups

The functions used in this management plan are listed in the table below. Some of these groups include functions that differ only in the degree of intensity of their management prescriptions.

Table 11.1: Different Forest Function Used in the Plan

Code	Function Group (Bold) and Functions	Code	Function Group (Bold) and Functions
S	Soil Conservation	NWP	Wildlife Protection
SC	Soil Conservation	NWC	Wildlife Conservation
SP	Soil Protection	Soc	Social Function
W	Water and Watershed Conservation	SocL	Social (Local Use Only)
WRR	Riparian Reserve Protection	SocRS	Religious Site Protection
WSh	Watershed Conservation	SocLC	Local cum Commercial Use
WLS	Local Water Supply Protection	RB	Road Buffer
N	Nature Conservation		

11.4.3 Mapping Forest Functions

The criteria used to prepare forest function map for Rodungla FMU is given below:

Table 11.2: Criteria for Mapping Forest Functions

Function Group and Codes	Criteria for Mapping
Soil Conservation	**SP**: Very steep areas (slopes greater than 100%), areas with indication of slight to moderate erosion
	SC: Steep or sensitive areas (slopes of 76-100%)
Water & Watershed Conservation	**Wsh**: Catchment areas of watercourses on steep slopes and on poorly drained areas; other sites serving as water retention areas or water sources
	WRR: areas within 30m along all perennial streams, water logged area and swamps
	WLS: Upper catchment areas of streams serving as drinking water supply for settlement downstream
Nature Conservation	**WNP**: Alpine areas, ecosystem of high conservation value.
	WNC: Areas identified as biological corridors and all areas rich in wildlife, both in species and number.

Social Function	**SocL**: Area close to or accessible to settlement or village, the areas traditionally used with definite boundaries.
	SocRS: Lhakhangs/gornpas, gneys and other religious sites.
	SocLC: Areas which are used by local population for the collection of wood and NWFP
Road Buffer	**RB**: 200m uphill and 100m downhill for motorable public road, 30m uphill and 10m downhill for unstable forest road.

11.4.4 Restriction of Forest Functions

The specific restrictions to be applied to forest in various categories are summarized in table below. These restrictions should be applied in conjunction with the objectives set for each Management Circle.

Table 11.3: Forest Function Restrictions

Code	Function	Restriction on Commercial Use	Restriction on Local Use
NB	Biodiversity Protection	No commercial use	No local use
SP	Soil Protection	No commercial use	No tree felling, minimize human interference
WRR	Riparian Reserve Protection	No commercial use	Only collection of NWFP; no *tsamdo*; no *sokshing*
RB	Road Buffer	No commercial use	No tree felling
NWP	Wildlife Protection	No commercial use	Restriction to activities that do not change habitat quality and disturb wildlife
WLS	Local Water Supply Protection	No commercial use	Low impact use only; no cattle grazing
SocRS	Religious Site Protection	No commercial use	Only use which do not disturb sanctity of place
SocL	Social (Local Use Only)	No commercial use	No restriction
SC	Soil Conservation	No clear cutting; no conversion into plantation; extension of rejuvenation periods	Low impact local use; no intensive cattle grazing
WSh	Watershed Conservation	No clear cutting; no conversion into plantation; ,minimize disturbance to understorey vegetation	No intensive cattle grazing; low impact local use

NWC	Wildlife Conservation	No clear cutting; no conversion into plantation; leave snags; leave some undisturbed patches,; minimize disturbance to understorey vegetation	Low impact local use
SocLC	Social (Local cum Commercial Use)	Low impact commercial use	No restriction

12. QUANTITATIVE RESOURCE ASSESSMENT

12.1 Forest Inventory Management

Inventory Design of Rodungla Forest Management Unit

Inventory of Rodungla FMU was carried out by FRMD Inventory Crew from May, 2004 to February, 2005. The standard FMU inventory technique was used, with data being collected for trees >10 cm DBH (OB*). A total of 190 plots were laid throughout the Rodungla FMU at the spacing 650m x 560m, thus a plot representing an area of 52ha.* The inventory was designed with target sampling error of +/- 10% at 95% confidence level using the coefficient variation of 68% calculated from earlier inventories. About 25% of the sample plots were measured as special plots.

The general objective of the inventory was to make available essential background information for preparation of Management Plan. The inventory was carried out to provide accurate overview of the growing stock and regeneration potential of the natural forest in the area, according to major forest types. Further it was also intended to provide an overview of the general characteristics of the natural forest, indication of timber quality and furnish essential data on tree height to generate local volume table for main species.

12.2 Forest Management Inventory Result[1]

The summary of the inventory results is shown in the table below;
Table 12.1 Summary of Inventory Results

Stratum Name	Gross Area (ha)	Number of Plots	Avg. no. of trees per ha	SE%	Avg. Gross Volume (m^3/ha)	SE%	Avg. Basal Area (m^2/ha)	SE %
Mixed Conifer	5127.7	68	1207	21.41	598.58	18.03	68.63	16.63
Blue Pine	1058.1	16	1472	60.08	533.78	45.1	67.325	43.18
Fir	1464.95	32	865.625	24.92	553.51	23.69	59.957	19.66

Table 12.2 Annual Increments

Strata	Avg. Periodic Annual Increment (m3/ha/yr	Sampling error % (P=0.95)	Reliable Minimum Estimate (m3/ha/yr)
Mixed Conifer	9.61	54.88	4.34
Blue pine	5.02	33.99	3.31
Fir	6.12	19.31	4.94

13. AREA ORGANISATION

13.1 Spatial Organization

The strategy for forest resource management begins with the formation of working circles. Therefore, the formation of working circle is an important step in the planning process. The working circle is further divided into blocks, compartments and sub-compartments whenever necessary. The blocks have been demarcated according to natural drainage and terrain features whenever possible. Rodungla FMU has been divided into 4 blocks Viz: Doyungchu, Ugyenchholing, Jinergang and Benzabi. The boundaries of the compartments are based on identifiable topographic or planimetric features such as streams, rivers, ridges, etc.

1 *SE= sampling error (95%level of probability) NB: All the area sampled is less than the area of FMU. The inventory results are only calculated for the operable/accessible areas of the FMU.*

Table 13.1 Block, Compartment and Sub-compartment with their Corresponding Area (ha)

Sl. No	Block	Compartment	Sub Compartment	Sub-Compartment Area (ha)	Total Compartment Area (ha)
1	Doyungchhu	I			402.38
		II	a	415.31	761.74
			b	346.43	
		III			822.62
		IV	a	312.25	548.11
			b	235.86	
		V	a	350.62	856.35
			b	173.3	
			c	332.43	
2	Benzabi	I	a	301.28	998.42
			b	697.14	
		II	a	507.5	1090.43
			b	582.93	
		III			848.61
		IV	a	451.08	1056.14
			b	605.06	
3	Ugyencholing	I	a	531.05	1236.36
			b	463.47	
			c	241.84	
		II	a	483.41	983.07
			b	499.66	
		III	a	727.87	946.52
			b	218.65	
		IV	a	206.3	498.07
			c	291.77	
4	Jinergang	I	a	183.95	628.69
			b	208.86	
			c	235.88	
		II			607.79
		III			528.87
		IV			599.97
		V	a	329.15	579.97
			b	250.82	
		VI	a	285.35	692.43
			b	147.64	
			c	259.44	
Total Area (ha)					**14686.58**

13.2 Determining Operable Area

Forests are managed for multiple purposes. The role of forest in serving people assumes utmost significance. The multiple uses of forests are generally protective,

climatic, productive, scientific, recreational, etc. But while managing a unit area of forest, all such purposes cannot be equally harmonized. One purpose has to take precedence over other. The area for commercial and rural forestry activities are those that are left after areas for other critical functions were identified and mapped out, using GIS and inventory information. The functions that take precedence over commercial and rural forestry activities are:

- Soil protection areas (slope greater than 100%)
- Soil conservation
- Agricultural uses
- Riparian buffers and zones
- Local water supply protection
- Biodiversity areas (wildlife conservation and protection)
- Religious site protection
- Road buffer

13.3 Organization into Management Circles and WorkingCircles

Function mapping was used to delineate three broad management circles for Rodungla FMU. The three broad management circles for Rodungla FMU are Protection, Production and Non-production Management Circles.

Table 13.2 Area statement for Management Circles and Working Circles[2]

Management and Working Circles	Area (ha)
Protection Management Circles	
Soil protection	2998.79
Soil conservation	2517.39
Riparian Reserve	2988.50
FMU Road Buffer	313.58
Religious Site Protection	3.14
Non-Production Management Circle	
Private/Cultivated Land	231.52
Meadows	704.53
Non forest area	53.09
Production Management Circle	
Mixed Conifer Working Circle	5127.69
Blue pine Working Circle	1058.10
Fir Working Circle	1464.95

2 *In many cases forest function overlap, especially those which depend on the same parameter (i.e. slope), e.g. SP/SC and WSh. On other hand overlap of functions should be done intentionally, in order to maximize the production forest area and to make optimal use of forest resources. This implies, for example, for NWP/NWC with SP and SC.*

13.3.1 Protection Management Circle

The Protection Working Circle is the sum of all protection functions; wildlife protection, soil protection, riparian reserve protection, religious site protection and local water supply protection where commercial activities are not allowed. The total area under protection management circle is 5694.54ha. The outline of management objectives and options of the protection management circle are given below.

Table 13.3: Protection Management Circle

Management Objectives	Management Options	Responsibility
To conserve and enhance wildlife habitats and biodiversity	Avoid disturbance	All parties
	Promote research	Territorial
To conserve the water catchments functions and watershed value of the FMU	Minimal intervention	All parties
To meet local needs for NWFPs on sustainable basis	Resource assessment	Territorial Division
	Regulate harvesting on sustainable basis	
To protect forest form grazing, fire and illegal activities	Involve local people in implementing conservatives measures	Territorial Division
To raise awareness of the important biodiversity areas	Public meeting	Territorial Division
	Research	
To respect the sanctity of religious places	Non-intervention	All parties

The removal of trees may be permitted in the Protection management circle to deal with outbreaks of pest and diseases and silvicultural operations may be carried out to improve stocking and reforest the degraded areas.

13.3.2 Non-Production Management Circle

The non-production management circle includes areas where production is not economical or feasible. It generally comprises of non-forest areas, settlements, *tsamdrog* and cultivations. The total area under non-production management circle is about 7136.68ha.

Table 13.4: Non-Production Management Circle

Management Objectives	Management Options	Responsibility
To meet local needs for collection of NWFPs	Promote Community Monitoring	Territorial Division

To maintain and improve the forest condition	Regeneration	NRDCL/ Territorial Division
	Silvicultural operation	
To regulate grazing by livestock	Fodder tree plantation and people's participation	Territorial Division / Gup
Environmental conservation	Environmental concern are to be taken into consideration while activities are implemented	NRDCL/ Territorial Division

13.3.4 Production Management Circle

The Production Management Circle comprises of the area that is left after identifying the critical functions and mapping out by using GIS. This management circle comprises of areas which are more stable and stocked with commercially important species which would be harvested for both local and commercial uses. The total area under this circle is 7650.75ha.

Table 13.5: Production Management Circle

Management Objectives	Management Options	Responsibility
To meet local need for timber and other forest produce on sustainable basis	Priority must be given to local people	Territorial Division
Manage commercial timber production on sustainable basis	Scientific and systematic harvesting	NRDCL/ Territorial Division
Enhance and improve forest condition and productivity	Suitable silvicultural operation	NRDCL/ Territorial Division
	Plant degraded area	
Create employment	Involve local people	NRDCL/ Territorial Division
Maintain Biodiversity within production area by habit management	Field visit & Research	Territorial Division

13.3.5 Non-Wood Forest Products Management Circle (Overlapping)

Non-Wood Forest Products (NWFPs) are important part of the economy, and also an effective incentive to conserve forests, woodland and other ecosystems. The use of NWFPs by the rural people in making a living has developed to involve assets, income generating activities and entitlements, contributing to their livelihood.

To sustainably manage the ecosystem that support these NWFPs and reduce the vulnerability of those people entirely dependent on these, there is need to evaluate losses in harvesting these resources against the potential benefits accruing from them. This Management plan is not intended to provide an in-depth analysis of various inventory techniques but to re-visit some of them, which are inevitable. Hence the need to meaningfully integrate NWFP Working Circle in this Forest Management Plan appears to be necessary.

The Management Circle shall overlap with all other Management Circles, including Protection, Non-Production and Production Management Circles which constitutes the entire FMU area. The overall objective of this management circle is to manage the NWFPs in Rodungla on a sustainable basis, and monitor the impact of collection.

13.4 Management of Working Circles

The Production Management Circle has been divided into three regular working circles. The activities in each working circle will differ. For the ease of implementation, these working circles will be managed through the formation of blocks, compartments and sub-compartments. The working circles have been created on the consideration of stands requiring similar silvicultural treatment and having similar rotation age. The three working circles are:

1. Mixed Conifer Working Circle
2. Fir Working Circle
3. Blue Pine Working Circle

The objectives, management options, responsibilities, monitoring and evaluation and silvicultural systems specific to each working circle is given below:

Table 13.6 Mixed Conifer Working Circle[3]

WORKING CIRCLE: MIXED CONIFER		AAC= 10483m³		
Management Objectives	**Management Options**	**Responsibility**	**Monitoring**	**Silvicultural systems**
To meet local requirement as a priority, for timber, fuel wood and other forest products on a sustainable basis	Controlled marking of trees	Territorial Division	Territorial	**Group Selection System** Due to the lack of research into the light requirements needed for regeneration, the coupe sizes are a guideline that must be followed unless new information on silvicultural system is obtained. Cable lines will be laid to their full capacity. Cable corridors will be not more than 4m wide.Group opening will not exceed 0.15ha.The distance between the cable lines will not be less than 60m and between groups along cable line will not be less than 50m. All merchantable trees >10cm DBH will be felled. Dead, dying, malformed and diseased tree will be felled by priority. Opening can be irregular shapes and should be based on terrain features and stand condition. Damage to residual tree must be minimized
To manage the commercial timber production on sustainable basis	Use appropriate logging and Silviculture method Ensure cable-line lay out allows inter line logging Operate entire cable line Encourage cleaning of entire cable lines	Territorial/ NRDCL Territorial/ NRDCL Territorial/ NRDCL NRDCL	Territorial Territorial Territorial Territorial	
To enhance and improve forest condition and productivity	Ensure that all barren areas are restock with suitable native species Use appropriate logging and silvicultural method Monitor on the attack of pest and disease Involve local communities	NRDCL/ Territorial NRDCL/ Territorial Territorial NRDCL/ Territorial	Territorial Territorial Territorial NRDCL	
To protect the forest from overgrazing, fire and other illegal activities	Control over grazing, fire and other illegal activities through participation and dialogue and acceptable fencing	Territorial	Territorial	
To create local employment	Employ local people Employ local contractor	NRDCL/ Territorial NRDCL	NRDCL NRDCL	
To maintain biodiversity within the production area	Low impact Silviculture system	Territorial/ NRDCL	Territorial	
To conserve the water catchment functions	Minimal intervention Abide by stream buffer regulation	Territorial/NRDCL NRDCL/Territorial	Territorial Territorial	
To protect the forest form fire, illegal activities and form grazing in regeneration areas	Control grazing, fire, poaching and illegal felling with local community participation	Territorial	Territorial	

1. *All objectives will be evaluated annually by the FMU Level Management Committee.*
2. *Lead responsibility will be taken by the agency listed first.*
3. *All objectives and activities will be evaluated during the mid-term review*

Table 13.7 Fir Working Circle[4]

Working Circle : Fir		AAC= 2578m^3		
Management Objectives	**Management Options**	**Responsibilities**	**Monitoring**	**Silvicultural Systems**
To meet local requirement, as a priority, for timber, fuel wood and other forest products on a sustainable basis	Controlled marking of tree and proper monitoring	Territorial	Territorial	**Group Selection System** Due to the lack of research into the light requirements needed for regeneration, the coupe sizes are a guideline that must be followed unless new information on silvicultural system is obtained. Cable lines will be laid to their full capacity. Cable corridors will be not more than 4m wide. Group opening will not exceed 0.15ha. The distance between the cable lines will be not less than 60m and between groups along cable line will be not less than 50m. All merchantable trees >10cm DBH will be felled. Dead, dying, malformed and diseased tree will be felled by priority. Opening can be irregular shapes and should be based on terrain features and stand condition. Damage to residual tree must be minimized.
To manage the commercial timber production on sustainable basis	Operate entire length of cable line Ensure cable-line layout allows interline logging Use prescribed logging and silviculture methods Ensure cleaning of entire cable lines	Territorial/ NRDCL Territorial/ NRDCL Territorial/ NRDCL Territorial/ NRDCL	Territorial Territorial Territorial Territorial	
To enhance and improve forest productivity	Ensure that barren areas are restock sufficiently with desired species composition Plantation with protection Harvest all Fir (Dieback) areas to ensure the next rotation has less rot using full cable line lengths Work with local communities for planting/ restocking activities Use stand tending techniques Create favorable conditions for regeneration and growth	NRDCL/Territorial NRDCL Territorial/NRDCL NRDCL/Territorial NRDCL/Territorial NRDCL	Regeneration Survey Territorial Territorial Territorial Territorial Territorial	
To create the local employment opportunities	Employ local people Employ local contractor	NRDCL NRDCL	NRDCL NRDCL	
To maintain biodiversity within the production area	Low impact Silviculture systems	Territorial/ NRDCL	Territorial	
To protect the forest from fire, illegal activities and from grazing in regeneration areas.	Control grazing, fire, poaching and illegal felling with local community participation	Territorial	Territorial	
To conserve the water catchment functions	Minimal intervention Abide by stream buffer regulation	Territorial NRDCL/Territorial	Territorial	
WORKING CIRCLE: BLUE PINE		**AAC= 1938m^3**		

1. *All objectives will be evaluated annually by the FMU Level Management Committee.*
2. *Lead responsibility will be taken by the agency listed first.*
3. *All objectives and activities will be evaluated during the mid-term review*

Table 13.8 Blue Pine Working Circle[5]

WORKING CIRCLE: BLUE PINE		AAC= 1938m^3		
Management Objectives	**Management Options**	**Responsibility**	**Monitoring**	**Silvicultural systems**
To meet local requirements, as a priority, for timber, fuel wood and other forest products on a sustainable basis	Controlled marking of trees Systematic thinning	Territorial Territorial	Territorial Territorial	***Thinning*** The young Blue pine stands will be worked under thinning. Marking trees will depend on the number of stem per hectare, age or size class and spatial distribution. Pole crop stand should have a target of 400 trees/ha (5m spacing). The spacing can be decrease or increase with size class. Dead, dying, malformed and diseased trees will be thinned on priority basis. ***Seed Tree System*** For cable harvesting, felling areas of 1000m x 30m can be logged, leaving 20-25 trees/ha as a seed source. Harvesting line must not run directly downhill. Lines must be 90m apart to allow 2 interlines operation. On exposed or sensitive sites harvesting must leave 40-50 trees/ha & all understorey vegetation. Seed tree must of good form, not over matured & representative of existing stand. In mixed stand equal distribution of seed tree must be left.
To manage the commercial timber production on sustainable basis	Encourage use of small diameter wood Promote commercial harvesting	NRDCL NRDCL/Territorial	NRDCL Territorial	
To enhance and improve forest productivity	Mark trees for rural use as planned thinning exercise NRDCL to commercially thin stand Use appropriate logging and silvicultural methods Restock logged or barren areas Create favorable condition for regeneration and growth Involve local communities for planting and restocking activities Use stand tending techniques, such as bush clearing and spacing Harvest all areas regardless of financial return	Territorial NRDCL Territorial/ NRDCL NRDCL NRDCL/ Territorial NRDCL/ Territorial NRDCL NRDCL/Territorial	Territorial Territorial Territorial Regeneration Surveys Territorial Territorial Territorial	
To maintain biodiversity within the production area	Low impact Silviculture system	Territorial/ NRDCL	Territorial	
To create local employment opportunities	Employ local contractor Provide proper training Employ local people	NRDCL NRDCL/Territorial NRDCL	NRDCL Territorial NRDCL	
To protect the forest from over grazing, fire and illegal activities	Control overgrazing, poaching, prevent fire and illegal activities with local community participation	Territorial	Territorial	
To conserve the water catchment functions	Minimal intervention Abide by stream buffer regulations	Territorial NRDCL/Territorial	Territorial Territorial	

1. *All objectives will be evaluated annually by the FMU Level Management Committee.*
2. *Lead responsibility will be taken by the agency listed first.*
3. *All objectives and activities will be evaluated during the mid-term review*

13.5 Implementing Management of Working Circles

The Forest Function planning concept has been used in this plan to allocate land use among the forest in the FMU, so that strategic planning for sustainable yield can be carried out. The problem remains to implement these prescriptions on the ground. Later sections indicate that this will be done through an operational planning process whereby information that is more detailed are collected through inventory, interviews and discussions with all the stakeholders. However, even when this more detailed data is collected, the requirement remains to locate individual Forest Function on the ground so that the prescription and the objectives can be implemented. Although maps have been prepared indicating the boundaries of the Forest Functions, location on the ground can be quite complex. In addition, experience in the field indicates that the 1:50,000 topographic maps are often inaccurate and difficult to use for implementation of operational plans.

Therefore, the Unit In-charge will have to use the provided maps to the best of their ability. Areas should be observed on the forest functions maps prior to going to the field. Once in the field visual observation within the operable areas should be able to provide the needed information. For example, stream buffer will occur in all the perennial streams and steep slopes should be measured and observed for soil protection or conservation. The forest function maps will be updated accordingly as per the field observations.

14. YIELD REGULATION AND HARVESTING

14.1 Determination of Annual Allowable Cut (AAC)

14.1.1 Introduction

Principle of sustainability, the backbone of Forest Management is an accepted norm in Forest management and forms the core principle of organized forestry. The concept has evolved from the basic consideration that the later generation may derive the benefits as the present generation. The principle of sustained yield ensures the stability and continuous supply of raw materials to the industries and meets the local needs of the people.

Sustained yield allows harvesting of forest resources in a way by which annual cut and other losses of timber do not exceed the average annual growth and assures continuity of harvest, indefinitely, without impairment of the productivity of the soil. Calculation of Sustained Yield is expressed as AAC.

14.1.2 Increment Based AAC

In theory, with a prefect structured normal forest it should be possible to sustainably cut the annual increment each year. Some calculation methods rely heavily on increment. Unfortunately, data on growth rate is still limited for

Rodungla FMU and Bhutan in general, and it will be some time before valuable data from permanent plots are available. The forests are not perfectly structured, but have very varied natural growing stock (of different cohorts), some of which (particularly Fir zone) is actually in negative increment at present as the rate of decay exceeds new growth. In the long term, increment should increase as over matured stands are replaced by younger stocks, but it will be many decades before this second growth is available for harvest. There is an over-matured growing stock and too little and unreliable increment data to use in determining AAC, therefore, increment based AAC's are currently unsuitable for Bhutan.

14.1.3. The Most Appropriate AAC Method

A wide range of formulae and calculation approaches are available and advantages and disadvantages can be argued for each.
Whilst it is difficult to define the best method for the country, there is strong belief for standardization around a fairly simple and robust methodology. The method which is used for the calculation of AAC in FMU is based on combination of area, volume and rotational age of species.

The following method is used for calculating the AAC for Rodungla FMU:

$$\textit{AAC per Working Circle} \quad \frac{\textit{Net Operable Area}}{\textit{Rotation}} * \textit{Average Standing Volume per Ha}$$

This method is applied for calculating the AAC for each working circle and are added together to calculate the total AAC.

14.1.4 Calculation of AAC for Rodungla FMU

Net Operable Area
The total operable area is identified through mapping using GIS technique. But it has been observed that in most of the FMUs that the total operable area cannot be always subjected to harvesting. Within the mapped area there can be small rocky terrain, water bodies and other conservation areas which often prevent harvesting operations. This occurs mainly when the cable lines are being laid out. Beside this, Group Selection System almost inevitably leads to some patches of mature timber being left in later phases due to the presence of new regeneration and the possibility of damage. In such challenging terrains in Bhutan, exact geometric-shape group layout is rarely possible. Due to the above inevitable fact around 20% of area from the gross operable area has been reduced to calculate the net operable area in commercial working circles. In case of local use, the gross operable area has not been reduced because of the fact that Single Tree Selection System will be applied.

Table 14.1: Calculation of Net Production Area

Forest Types	Gross Operable Area (ha)	Calculation	Net Production Area (ha)
Mixed Conifer	5127.7	Gross operable area – 25%	3845.775
Blue Pine	1058.1	Gross operable area – 25%	793.575
Fir	1464.95	Gross operable area – 25%	1098.71
Total	**7650.75**		**5738.06**

Rotation:

Species rotation is an imprecise concept in silvicultural system other than clear cutting and replanting. Since reliable increment data is still very limited for Bhutan, assumed rotation lengths need to be cautious. For Group Selection System, the objective is to have more or less even aged regeneration in areas worked out at each cut.

The assumed rotation length for mixed conifer like Hemlock and Spruce is 140 years and for Fir is 160 years. The assumed rotation length for Blue pine which grows at relatively lower altitude is 110 years. Consideration of regeneration period while calculating rotation lengths is a crucial factor. Therefore, calculating AAC for Rodungla FMU 20 years of regeneration period has been added to the rotation age of mixed conifer and for fir, while for Blue pine, 10 years of regeneration period has been added. As a safeguard for this FMU, the rotation length for mixed conifer and Fir forests is fixed at 180 years since the overall elevation of the FMU is relatively high.The assumed rotation lengths for the calculation of AAC in Rodungla FMU are:

Fir working circle	: 160+20 years
Mixed Conifer working circle	: 160+20 years
Blue pine working circle	: 110+10 years

Average Standing Volume:

The mature average standing volume is taken from the inventory information that is calculated using <PLOT>; data processing software developed especially for data analysis. Owing to the high sampling error, the range of possible standing volume at 95% probability level is large, meaning that there is a high level of uncertainty with these figures. The sampling error and RME for each stratum is given below:

Table 14.2: Average Standing Volume

Strata	Average Standing Volume (m3/ha)	Sampling error % (at P=0.95)	Reliable Minimum Estimate (m3/ha)
Mixed Conifer	**598.58**	**18.03**	**490.66**
Blue pine	**533.78**	**45.1**	**293.05**
Fir	**553.51**	**23.69**	**422.38**

AAC for Each Working Circle

Table 14.3: AAC for each Working Circles

Strata	Net Operable Area (ha)	Rotation	RME of mature standing volume (m3/ha)	AAC (m3/ year)	Clear cut Equivalent (ha)
Mixed Conifer	3845.775	180	490.66	10483	21.37
Blue Pine	793.575	120	293.05	1938	6.61
Fir	1098.71	180	422.38	2578	6.10
Total	**5738.06**			**14999**	**34.08**

The total AAC for Rodungla FMU is fixed at 14999m^3 in standing volume, the equivalent of which is 8999m^3 in log volume.

The AAC for each working circle must be adhered to. It is not permitted to transfer AAC allocation from one working circle to another. However, it is permissible to vary the AAC by plus or minus 10% in individual years, but the volume cut in each five year period must be not more than five times the AAC.

14.2 Recording and Accounting for AAC

AAC will be monitored through the records of tree marked (Tree Marking Register) for both commercial and local use in all the working circles. AAC has been calculated as gross volume and this is the measure that should be totaled on annual basis from the Tree Marking Register.

14.3 Allocation of AAC

Allocation of AAC has taken into account in the need of rural people (living within and near to Rodungla FMU). The AAC for rural use has been alloted based on the demand and the Local Use Area. The Local Use Area has not been demarcated due to scattered pattern of settlement but priority should be given to rural allotment since the demand is very small owing to small population of Tang Gewog.

Table 14.4: Allocation of AAC

Standing Volume (m^3)	Allotted to
2999	Local Use: Allotted to local user (Local villagers and the general public)
12000	NRDCL: Allotted to NRDCL for meeting the timber demand in the market.

14.4 Distribution of the Cut

AAC has been calculated by Working Circles, thereby providing the basic distribution of the cut. AAC between working circles is non-transferable, therefore to provide a properly organized and regulated management, economical harvesting and regeneration, an orderly and sequential system of the harvesting has to be adhered to.

Although AAC is volume based, it is essential to monitor the area that is being subjected to harvesting. Assuming the reliability of the inventory data (average standing volume) to be reasonably high, the volume per hectare will be calculated to represent the number of lines that can be feasibly operated and mentioned in Operational Plan. Therefore, if the Unit In-charge notices that more cable lines (or less) is being harvested annually then AAC must be adjusted.

In order to make sustainable operation of Rodungla FMU, initial phase of operation shall be carried out from Benzabi Block and shall continue towards Doyungchhu Block, strictly adhering to the measurement layout of cable lines.

15. SILVICULTURAL SYSTEM

15.1 Group Selection System

For the Mixed Conifer Working Circle and Fir Working Circle in the FMU, Group Selection is the prescribed Silvicultural System. The particular Silvicultural System has been selected based on the ecosystem and natural regeneration system. Under the Group Selection System small opening will be created in the stand allowing light to reach the forest floor and creating conducive micro climate for seed germination and establishment of seedlings. The opening will be no longer than one and half tree length in the Hemlock, Spruce and Fir Stand.

Working Pattern

The groups will be opened along cable lines. The distance between cable lines

will be not less than 60 meters and between groups along cable line will be not less than 50 meters. The width of the corridors should not exceed four meters. The effective area within the limit of standard cable length is 6 hectares (1000meters x 60 meters), less the area of the corridor 0.40 hectares (1000 meters x 4 meters), thus the one third removal would be equivalent to (1.87 ha.) which is the area available for group openings. Thus, it would be possible to open up around 9 to 10 groups along the standard cable lines, if the average tree height is taken around 35 meters and further, the diameter of any opening will not exceed 50 meters.

The individual openings need not be uniform in shape or size and systematically located along cable lines. In most cases the openings will be irregular in shape and systematic location of groups will be almost impossible. Aspect, slope and silvicultural requirements would influence the actual size of the groups. An average of 0.15ha opening is recommended. However, group opening in Fir Working Circle will not exceed 0.1 ha.

Existing opening in the stands which can be expanded, signs of existing windfall in the stands, stands which are mature or diseased, and stands infested with mistletoes should be chosen as groups as priority. In order not to lose the site protection effect of the surrounding trees it is necessary that the specified size for opening should be strictly adhered to. The tree should be felled towards the centre of the group opening whenever possible to avoid damage to the unmarked trees. Terrain with steep slope and exposed South and South-West aspects should be avoided, or the opening should be smaller to match with the terrain and site conditions or the selection system should be applied.

In areas where opening cannot be created under Group Selection System (in between two cable lines) such areas should be operated under Single Tree Selection System. However, care should be taken that spatial distribution of the trees are strictly followed and should match with openings created under Group Selection System.

The Group Selection System has the following advantages:

- Regeneration in the small groups under even-aged condition gives better stem form
- Larger openings in comparison to that under single tree selection system permit the establishment of intolerant species
- Harvesting is more concentrated, so the logging cost is lower
- Harvesting in group lower damages to residual stands
- Intermediate cuts may be made less frequently
- Aesthetically and environmentally more acceptable than clear cutting system

Table 15.1 Workout for Cable Lines[6]

Stratum	Volume (m3/ ha)	A A C (m3/year)	Clear cut Equivalent (ha)	Clear cut Equivalent of one Cable Line (ha)	No of Cable lines per Year
Mixed Conifer	490.66	11793	21.37	3.4	6
Bluepine	293.05	1938	6.61	3.4	2
Fir	422.38	2578	6.10	2.27	3

But in reality the length of cable line varies between 600m to 1,100m. So the number of cable lines will also vary as per the length of the cable line and this will be reflected in the operational plan.

15.2 Seed Tree System

Blue pine Working Circle in Rodungla FMU will be worked under the silvicultural system of Tree Seed system. Seed Tree is the silvicultural system that involves retaining a number of trees to supply seed for regeneration after rest of the trees being harvested. Blue pine regenerates easily when light is abundant and ground vegetation is sparse. It is important to note that this Seed Tree system is not suitable on steep and exposed south and southwest sites; rather group selection system should be preferred on such condition.

Working Pattern

For cable line harvesting, the felling area of 1000 x 30 m can be logged, if the felling is confined only to Blue pine stand stratum with the retention of about 20-25 trees/ha that are phenotypically superior. Harvesting lines must not run directly downhill. Lines must be 90m apart, allowing 2 interline operations. Dead, dying, malformed and diseased tree will be removed on priority basis. On exposed or sensitive site harvesting must leave 40 to 50 trees/ha. The distance between the seed bearers should not be more than one crown length as it can be easily colonized by weeds and/or regeneration of unwanted species.

Seed Tree System has the Following Advantages:

- Compare with artificial sowing, the seed from seed trees is gradually released over the time and this can increase the probability of seed being on the ground when the desired germination conditions occur.
- The expense of collecting and sowing of seed is avoided where there is

6 *Assuming 12 nos of groups with 0.156ha area for each group in fir and 0.25ha area for each group in mixed conifer/blue pine. Assuming the length of the average cable line to be 1000m)*

suitable on-site seed
- The local gene pool is more closely reproduced, leading to better adaptation to the site
- Harvesting is more concentrated, so logging cost is reduced
- Aesthetically and environmentally more acceptable than clear cutting

16. FOREST PROTECTION

16.1 Fire

Until date, there has been no record of major fire outbreak. However, most area of FMU being conifer there is high risk of fire outbreak if proper preventive measures are not taken. The needles and resin of the conifer species adds fuel to the fire, which will enhance the outbreak of forest fire especially during the dry seasons of winter. Two major incidences of fire took place in Chamkhar town from 2010 to 2011, which destroyed the town, but it was prevented from spreading into the forest.

The Unit In-charge and the Range Manager of NRDCL will need to review forest fire protection programs at regular interval in consultation with the local communities and the various stakeholders involved with activities of FMU. The danger of forest fire outbreak from burning of field debris should be well informed to the local people, as it is the common practice followed by the local people.

16.2 Pest and Diseases Management

To date, there is no record of any pest and diseases outbreak in Rodungla FMU but there can be always chances of pest and diseases outbreak. Therefore, periodic monitoring of the forests to check any outbreak of pest and diseases will be done. In order to detect and report any outbreak of pest and diseases, the FMU staffs will conduct regular inspection to enable the initiation of earliest possible remedial and preventive measures. Reports should be submitted to the CFO, Bumthang and also to the Specialist (s) contacted.

The following are the control measures suggested:

- Regular periodic survey of the forest and removal of deformed trees.
- Regular survey of regenerated areas and burning of infected plants after slashing and detaching barks.
- Education extension program for the people and the workers in the forest to report symptoms of the disease will be part of the pest and disease management program within the FMU.

The planting stock at any nursery, which will be supplied to the Unit for further plantation, will need to be monitored for pest and diseases. The infected seedlings should not be supplied instead destroy by burning at the nursery itself.

16.3 Grazing

In line with the multiple-use of the forests and as provided in the Forest Policy of Bhutan, grazing will be allowed in some parts of the FMU.

Grazing will not be allowed in areas identified as protection areas and light grazing will be permitted in areas identified as conservation areas. The strategies those are aimed at reducing and regulating grazing in the forests and at improving the breeds of cattle and their productivity per unit will be promoted under this plan. These strategies would include the development of improved pasture near villages, planting of fodder trees, introduction of high yielding breeds of cattle etc. A participatory approach to secure the cooperation of local villagers in keeping their cattle out of environmentally sensitive areas and away from regeneration coupes will be adopted with high priority. Regeneration areas will be fenced but timely monitored and supervision of the fences will be carried out by the Unit In-charge.

17. ENVIRONMENTAL IMPACT ASSESSMENT

The Environment Act (2000) requires all developmental proposals in Bhutan to meet a series of environmental criteria. Chapter III (s/c 18) lists five general requirements that must be fulfilled by any applicant requesting for the environmental clearance. The National Environment Commission has developed various Sectoral Environmental Guidelines to be adopted by the applicants. The Environmental Clearance Guideline for Forestry Activities specifies the detail criteria to be met by any applicant to carry out the forestry activities. It is assumed in this chapter that if the Sectoral Guidelines are met, the requirement of the Act will also be met.

This section of the Plan provides information on how the forestry activities will be carried out and controlled so that the proposed activity meets the requirements of the Act.

17.1 Project Description

17.1.1 Introduction

The demand for timber is continuously increasing in the market. But the supply of the timber is more or less remaining the same. The price of the timber was escalating very high until the Royal Government has fixed the price of log and sawn timber in the market, in order to make the timber affordable to all the citizens of the country.

17.1.2 Objectives

- To maintain and improve the present vegetation cover and also to protect the environment, soil, watershed and biodiversity.

- To ensure sustainable supply of timber, construction poles and posts, fuelwood and other Non-wood Forest Products, for the local people through regulated harvesting and collection.
- To strengthen the awareness of the communities within the Forest Management Unit to participate in forest protection and conservation.
- To ensure that multiple use of forest does not result in unacceptable level of ecological and environmental disturbances.
- To generate employment opportunities for the local people in forest based activities.
- To regulate grazing to maintain the ecology and natural regeneration potential of forests.
- To promote local research, demonstration, aesthetic and educational values of the natural forest ecosystem.

17.1.3 Project Location and Area

Rodungla Forest Management Unit falls under Bumthang Dzongkhag and lies between 27°33'22.00'' to 27°38'30.95''N and 90°51'01.85'' to 91 °00'30.98'' E. The entire FMU is situated within Tang gewog of Bumthang Dzongkhag and FMU is under the jurisdiction of Bumthang Territorial Division.

The total area of Rodungla Forest Management Unit is 14686.58 ha. The entire area will be not subjected to harvesting, only about 7650.75ha of area will be subjected to timber harvesting in a scientific and sustained manner. Rest of the area is categorized under various protection zones.

17.1.4 Benefits

In the vicinity of settlement most of the bluepine stands are young while in some mixed conifer and fir stand of FMU are over-matured and at the moment are not putting any increment. It is anticipated that by felling the over matured trees and creating space for regeneration would improve the overall forest condition. Regeneration is always a problem in the natural forest due to limited space and light, grazing pressure from the domestic animals and competition from unwanted species like dwarf bamboo dominate the commercial species. The mass flowering of *Yushina macrophylla* is likely to increase the risk of forest fire in the upper parts of the FMU. It is hoped that sustainable operation of FMU will improve the overall forest conditions and foster regeneration of important species. It is also anticipated that forest road will benifit the people of Tang gewog and the tourists.

The operation of the FMU would create job opportunities and the priority will be given to the local residents. The existing forest roads will be improved and further construction will be carried out through the FMU and more transportation facilities will be available to the local people. The FMU will be managed on the principle of sustainability. The over matured timber which otherwise would rot in the forest would be brought to the market to earn revenue for the government and at the same time improve the forest stand.

17.2 Forest Management Unit: Planning and Zoning

All the Management Plans will have to be written based on Forest Management Code of Bhutan (2004). Very comprehensive and consultative land use planning has to be carried out while preparing the forest management plan. The process is briefly outlined below:

Potential area with well stocked forests was identified close to the road using GIS and was followed by the reconnaissance survey. Consultation with the community was carried out to ascertain potential conflicts between forestry use and existing local use. A forest resource inventory was carried out to provide the information about tree stocking, regeneration, timber volumes, site characteristics, wildlife presence and under storey species.

Forests zoning is based on above data collected, using the forest function mapping prescribed in the Forest Management Code of Bhutan. The area is divided into different forest type called working circle and they are further divided into blocks, compartments and sub-compartments. The protection areas such as soil protection, wild life protection, rivers and streams buffer protection, etc. are excludedfrom the net operable area.

The silvicultural system to be implemented is Group Selection System for fir and mixed conifer forests. No clear cutting will be allowed and all the trees will be harvested using the skyline cable crane. The opening of the group size can vary between 0.1ha to 0.15ha depending upon the stand composition and condition. The distance between the cable lines will be not less than 60 meters and distance between the groups will be not less than 50 meters.

17.3 Harvesting and Extraction

Fixed volume of timber expressed as Annual Allowable Cut (AAC) is prescribed in this management plan. The AAC prescribed in this management plan is 14999m^3 per year. This means that the maximum volume that can be extracted from the Rodungla FMU will not exceed 14999m^3 per year. Out of 14999m^3, 12999m^3 will be allotted to NRDCL for commercial harvesting and rest will allotted for rural use. The timber will be extracted using the skyline cable crane, manual dragging and rolling is strictly prohibited.

17.4 Road Construction and Maintenance

Physical assessment for the road construction in Rodungla FMU was carried out by the team comprising of planners and other officers from FRMD, engineers from NRDCL, officials from Bumthang Territorial Division and Tang Beat Office. During the assessment two options were identified. These two access road options are:

Option I: Extension from the end of existing farm road, from Ugyenchholing

Option II: Construction of new motorable bridge across Tang Chhu from the existing Chamthang suspension bridge.
The proposed location of new motorable bridge across Tang Chhu at Chamthang and FMU road has been agreed by general public of Tang Gewog during the consultation meeting held at Tang Gewog Administration office on 17th September, 2012.

Road construction in Rodungla is aimed at minimum negative environmental impacts. During the road construction NRDCL engineer will supervise all the activities and no deviation from the proposed road alignment should take place. The road has been aligned in such a way that none of the religious sites are affected. For stream crossing, culvert, Hume pipes and bridges has been designed to minimize the negative impacts on streams. As a general rule, excavator will be deployed instead of bull dozer. Road standard recommended by FRMD and the general principles and practices of the forest road construction as identified by NEC Forestry Sectoral Guidelines will be followed. These will ensure that the road construction in Rodungla FMU will meet the recommendations and also ensure that any erosion or other negative impacts will be minimized or eliminated. Complete Road Standard is given in annex 4.

17.5 Regeneration and Post Harvesting Treatments

It is prescribed in the management plan that harvesting will be followed by the natural regeneration. But if the natural regeneration fails then the regeneration will be supplemented by artificial planting of the principle local species. The series of operation after harvesting is prescribed in the management plan in details. Regular maintenance of the plantation will be done by NRDCL and Chief Forestry Officer; Bumthang Territorial Division shall evaluate the regeneration or plantation at the end of three years. If the survival percentage is lower than 70-80%, immediate beating up will be carried out with the same local species.

17.6 Existing Environment

17.6.1 Topography and Geology

The terrain within the FMU is relatively gentle compared to other regions of Bhutan. The valleys are not very deep and are U-shaped with lower slopes and flatter areas under cultivation. 10385.44ha (73.87%) of the total FMU areas are below 35% slope and the remaining 4298.62ha are above 35% slope. Most of these steep areas are located along the streams as result of river erosion through geological cycle. The terrain is also dissected by many small rivulets, mostly flowing east into the main river, Tang Chhu. Slope classification was done based on digitized 40m contour lines. TIN feature was created and surface analysis was carried out to classify the area into different slope classes.

Areas that were considered over 100% slope were delineated on the Function Map as SP-Soil Protection where no activities can take place. Slopes that ranged from 76-100% are classified as SC-Soil Conservation where limited activities can take place.

The elevation ranges from 2638 meters at the lowest valley floor within the FMU to 4230 meters amsl at the ridge top. The rock formation of Rodungla FMU is characterized by mica-schist, quartzite-schist, calc-silicate, graphite schist, marble etc.

17.6.2 Hydrology

The entire Rodungla FMU is the watershed for Tang Chhu. The FMU is dissected by many small rivulets, mostly flowing east into the main river, Tang Chhu. Peak flows occur during the monsoon season and minimum flow is evident during the winter months. Residents of the FMU are dependent heavily upon these water sources, for drinking, running water mills and cultivations. Besides, these rivers and the streams serve as the source of water for the livestock.

17.6.3 Air Quality and Noise

The air quality in the FMU is excellent as pollution is negligible. The historic Ugyenchholing falls within FMU. Limited number of tourists visits Ugyenchholing Monastry where traditional artifacts are displayed. The number of tourists visiting Tang is increasing every year due to its religious significance and easy access from Chamkhar town.

17.6.4 Plant, Animal Species and Habitat

Multi-resource inventory was carried out by FRMD inventory crew from 2004-2005. During the inventory, the crew recorded various signs and sighting of wild animals over the entire period and corresponding data were collected based on indirect/direct evidences (footprints, scats, droppings, pellets etc.). Wild animals like Barking deer, Sambar deer, Wild pig, Himalayan black beer and Musk deer were recorded. Since the data did not indicate the number of different species in a particular area, the measure of density of the population of different species at this planning stage may not be possible.
Rodungla Forest Management Unit has good floral diversity, due to its altitudinal variation and aspects. No threatened/endangered plant species has been recorded within the production area of the FMU.

17.6.5 Scenic Qualities

The area has no popular sites with scenic beauty. The traditional route to Rodungla passes through the FMU.

17.6.6 Cultural Significant Sites

The historic Ugyenchholing Monastry falls within the boundary of the FMU. This museum attracts quite good number tourists from both within and outside Bhutan. This site is mapped out from the production area.

17.7 Assessment of Impacts and Mitigating Measures

17.7.1 Impact on Water

Pollution

Workers engaged for road construction and harvesting operations might pollute the rivers and streams through garbage disposal and sewage. Other pollutants might come from the oil spills from machineries and vehicles.

Drying up of water source

The proposed construction road doesn't pass through the drinking water source but during the construction phases, damage to the surrounding vegetation is inevitable. Sustained operations and opening of forests is likely to increase species diversity and better management of watershed thereby increasing the volume of water.

Mitigations

A buffer of 30 meters in the main river, drinking water source and other perennial streams has been maintained. The forested area where the drinking water source is located will not be subjected to commercial harvesting. The coupe will be laid in such a way that they are located away from the streams and rivers. Proper pit latrines and garbage disposal will be in place and the camp site will be at least 100m away from the main streams.

During the road construction NRDCL site engineer will monitor the construction activities. Moreover the bulldozer will be replaced by excavator in order to avoid the blockage of river and streams from windrow. Few forest road passes through streams and rivers sources but to mitigate the impacts, 100 meters buffer have been allotted to prevent damage to the water source. Water pipes will be replaced, if damaged during road construction.

17.7.2 Impact on Forest Resources

The silvicultural system prescribed in this management plan is the Group Selection System for Mixed Conifer and Fir forests. The opening of corridors and groups during the harvesting operation might open the area for grazing with less regeneration of principle timber species. This could result in reducing the total forest cover within the FMU. More opening would provide more area for under

growth, which in turn might results into more grazing ground for the cattle.

It is likely that operation would occur along the rivers and streams buffer whereby polluting the water sources. Many of the streams and river sources originate from the forest area and if the buffers are not respected, there could be conflict between the implementers and the local communities. Improper harvesting techniques by untrained personnel would result into damaging the surrounding trees that may not require felling.

Mitigations

The management plan for the whole area for a period of ten years is prepared before the harvesting operations. Harvesting will not exceed the prescribed allowable annual cut in the management plan. The size of the opening will not be in any cases larger than that prescribed in the management plan. If the natural regeneration fails to establish then the area will be planted with local principle timber species. The introduction of exotic species will not be allowed.

For proper planning, implementation and monitoring of activities in the Forest Management Unit, a full time dedicated staff for the FMU will be required from both DoFPS and NRDCL. The Department has already committed for providing sufficient manpower, to support the implementation of the plan. The wetlands and marshy areas have been avoided during the road alignment to minimize the impacts on the ecology.

17.7.3 Impacts on the Faunal Diversity

Wildlife is very important component in the forest ecosystem. Due to the construction of road and harvesting operation there might be degradation/loss of wildlife habitat and thereby reducing wildlife population in the area.

Mitigations

The species composition and forest type is similar throughout the Forest Management Unit. The protected and non harvested area will provide sufficient space, food and cover for movement of the wild animals. Hollow and fruiting trees and sufficient number of snags will be retained during the operation.

The coupe openings will be fenced to protect the regeneration from cattle and wild animals. If natural regeneration fails even after three years, the area will be supplemented with artificial regeneration of the principal local species. The animals require good forest for foraging, shelter and cover. Therefore, clear felling of large stretch of forest will be avoided and the harvested forest areas will be brought under forest cover within short span of time either by natural regeneration or by reforestation.

17.7.4 Impacts on Ecology (Flora)

The most anticipated impact on ecology is the change of present forest composition from over matured stand to normal stand especially within the operated areas in the long run.

Mitigations

While harvesting timbers from the forest, elite mother trees will be retained. Apart from the elite mother trees, some over matured individuals will also be retained as snag trees.
Forest road has been aligned so that it does not pass through any of the critical area where the disturbance could be more. In many of the critical areas that might damage the surrounding, Hume pipes, culverts and bridges have been designed.

17.8 Monitoring and Evaluation

The Management plan, which is for the period of ten years, will be prepared by FRMD, DoFPS. It will be approved by the Ministry of Agriculture and Forests. The plan will be implemented by NRDCL under the supervision of Chief Forestry Officer, Bumthang Territorial Division. Annual Operational Plans will be prepared by Bumthang Territorial Division in consultation with the stakeholders, based on the management plan. The OP will be approved by the Head of the Department. Annual monitoring will be carried out by Bumthang Territorial Division (CFO and Unit In-charge). A report will be submitted to FRMD, Department of Forest and Park Services, Ministry of Agriculture and Forests, Thimphu, based on the annual monitoring forms. FRMD will also monitor the implementation of the activities. The plan will be reviewed after five years and at the end of plan period, evaluation will be done prior to the revision of the management plan.

18. FINANCIAL AND ECONOMIC APPRAISAL

Ten year financial forecast and economic appraisal has been drawn for Rodungla FMU. This is intended to identify the revenue to NRDCL, treasury (via royalty), the cost and royalty paid by NRDCL. Overhead costs to NRDCL are not included. Some of the figures are estimates based on the assumption listed and the information made available to the planner. The assumptions for the forecast are listed in table 18.1. A summary of the forecast is presented in table 18.2 and forecast itself in table 18.3

Table 18.1 Assumption used for Financial Forecast

Assumptions	Figures
M^3 to cft	35.31
Recovery volume (%)	60

Road construction (Nu/km)	1300000
Length of proposed new road (km)	25
Road maintenance (Nu/km/yr)	12000
Distance to depot (km)	2.5
Cable crane (Nu/cft)	20.02
Rural allotment (m^3)	2000
Regeneration maintenance (for cable line) (Nu/ha)	3500
Creation of plantation	4 ha
Plantation cost (as per plantation norms and standard, SFD)	50000

Table 18.2 Financial Forecast Summary (For this plan period)

Particulars	Amount (Nu)
Total Revenue for NRDCL	332293437.00
Total Costs for NRDCL	175567970.9
Total Royalty for NRDCL	6884920.35
Total Revenue-Total Costs-Total Royalty	87876262.56

Table 18.3 Financial Forecast for Paro-Rodungla FMU(For 10 Years)

					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	10 Years
	AAC (m3)	Rec. Vol (m3)	Nu/cft	Nu/m3	Nu	Nu	Nu	NU	Nu	Nu	Nu	Nu	Nu	Nu	Total (Nu)
Revenue:NRDCL															
Timber-Commercial	12000.00	7200.00	120.66	4260.50	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	306756000.00
Timber-Rural	2000.00														
Total Revenue: NRDCL					30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	30675600.00	306756000.00
Costs: NRDCL															
Bridge Construction					5000000.00										5000000.00
Unit Office Construction & Office Set up					1500000.00										1500000.00
Road Construction					3250000.00	3250000.00	3250000.00	3250000.00	3250000.00	3250000.00	3250000.00	3250000.00	3250000.00	3250000.00	32500000.00
Road Maintenance					30000.00	30000.00	30000.00	30000.00	30000.00	30000.00	30000.00	30000.00	30000.00	30000.00	300000.00
Marking Cost			0.08	2.82	36657.18	36657.18	36657.18	36657.18	36657.18	36657.18	36657.18	36657.18	36657.18	36657.18	366571.80
Inventory Cost			0.08	2.82	36657.18	36657.18	36657.18	36657.18	36657.18	36657.18	36657.18	36657.18	36657.18	36657.18	366571.80
Felling and Crosscutting cost			2.58	91.10	1184208.90	1184208.90	1184208.90	1184208.90	1184208.90	1184208.90	1184208.90	1184208.90	1184208.90	1184208.90	11842089.00
Debarking			0.25	8.83	114781.17	114781.17	114781.17	114781.17	114781.17	114781.17	114781.17	114781.17	114781.17	114781.17	1147811.70
Cable Craning			20.02	706.91	9189123.09	9189123.09	9189123.09	9189123.09	9189123.09	9189123.09	9189123.09	9189123.09	9189123.09	9189123.09	91891230.90
Transportation to Depot			7.95	280.71	2189369.57	2189369.57	2189369.57	2189369.57	2189369.57	2189369.57	2189369.57	2189369.57	2189369.57	2189369.57	21893695.74
Stand Tending/Spacing															
Regeneration Maintenance (Nu/ha)		Nu 3500/ha			13200.00	13200.00	13200.00	13200.00	13200.00	13200.00	13200.00	13200.00	13200.00	13200.00	132000.00
Creation of Plantation		Nu 50000/ha			200000.00	200000.00	200000.00	200000.00	200000.00	200000.00	200000.00	200000.00	200000.00	200000.00	2000000.00
Plantation maintenance		Nu 3200/ha			12800.00	12800.00	12800.00	12800.00	12800.00	12800.00	12800.00	12800.00	12800.00	12800.00	128000.00
Total Costs: NRDCL					22756797.09	16256797.09	16256797.09	16256797.09	16256797.09	16256797.09	16256797.09	16256797.09	16256797.09	16256797.09	175567970.94
Total Revenue less Total Cost: NRDCL					7918802.91	14418802.91	14418802.91	14418802.91	14418802.91	14418802.91	14418802.91	14418802.91	14418802.91	14418802.91	137688029.06
Royalty: Commercial			15	529.65	6355800.00	6884920.35	6884920.35	6884920.35	6884920.35	6884920.35	6884920.35	6884920.35	6884920.35	6884920.35	68320083.15
NB: The plantation area is for cable lines and does not include plantation areas															
Total Revenue: (Revenue less Cost less Royalty): NRDCL					1563002.91	7533882.56	7533882.56	7533882.56	7533882.56	7533882.56	7533882.56	7533882.56	7533882.56	7533882.56	69367945.91

19. RESEARCH

Research programs will be collaborated with the relevant Research Centres. The FMU Level Management Committee for Rodungla FMU will discuss, during the yearly meeting and decide what research is deemed necessary in the FMU for the coming year.

Some suggestions on research topics are;

- Fate of Fir regeneration in extracted cable lines - competition with the understory species *Rhododendron hodgsonii* and *Yushania microphylla*
- Nutrient stress in fir zone due to commercial harvesting
- Mortality of *Abies densa* due to harvesting operations
- Light requirement for regeneration in the mixed conifer zones.
- Size of the group opening in conifers.
- Impact of climate change on tree-line.
- Impact of commercial harvesting on wildlife

PART 3
IMPLEMENTATION OF THE PLAN

20. IMPLEMENTATION AGENCY

The Department is vested with the responsibility of both protecting the natural resources as well as meeting peoples' basic needs. The DoFPS will discharge this responsibility through the Territorial Division. Bumthang Territorial Division will be responsible for the implementation and monitoring of this Management Plan. The CFO, Bumthang Territorial Division will be assisted by the Unit In-charge and other support staff.

20.1 Cutting Cycle

The cable line spacing must be properly laid so as to enable the subsequent passes in the future. To enable two passes in the future, a minimum distance of 60m needs to be kept in between the cable lines. Mixed Conifer Working Circle has a rotation period of 160 years, which means that the two cable lines that will be implemented in the future are occurring at year 53 and year 106. The original line will therefore, be harvested in year 160. This gives sufficient time to the adjacent area to regenerate and also prevents the area from large opening.

The same method of cable line layout is applied to the Fir Working Circle except that the two interlines in the future would occur at the interval of 60 years which means at the year 60 and year 120. Size of the group opening will vary between 0.1ha to 0.15ha but in no case the opening shall exceed 0.15ha.

Problem of laying cable line is inevitable in the field due to the inescapable rough terrain. The layout in the field must be adapted to suit the terrain and to the best possible guidelines must be followed.

The Blue pine Working Circle, which will be worked under Seed Tree System, requires 90m spacing between initial cable lines. Thus, the two interlines in the future will be harvested at year 40 and 80, with original line being harvested at year 120.

Annual Coupe

Accessibility, slope, stand condition and other environmental conditions are criteria for selecting the annual coupe for harvesting in the operable area. Based on the Silvicultural System for each Working Circle, the annual coupe will follow the required spacing designed. Coupes must comply with the following conditions:

- The Unit In-charge will determine the location and extend of cable lines in the compartment to be harvested annually, in consultation with NRDCL staff.
- All prescriptions and restrictions laid down in the plan must be considered and followed strictly.
- The Unit In-charge will arrange to mark the trees
- Cable line layout will be based on safety, stand composition, environment and cost consideration. This will be done in consultation with the Unit In-charge.
- The cable lines may traverse slopes greater than 100% but extraction is not allowed.

20.3 Tree Marking Rules

- Groups of mature and over-mature trees are selected systematically

according to the group size given in the plan.

- Trees within stream buffer stripes and on slopes greater than 100% must not be marked.
- The direction of the tree lean and topography has to be taken into account to prevent large tree being felled on nearby advanced growth.
- Some dead, dying, malformed or damaged (snags, scars, conk, etc) and fruiting trees will be retained in between groups, and in the interline spaces, to safeguard the niches or habitats for the flora and fauna, but not in the harvested group themselves, where there is risk of wind throw and danger to personnel working underneath.
- Diseased trees (bark beetle, mistletoe) will be removed to protect the quality of the remaining stand.
- All species listed for protection under the Forest and Nature Conservation Act, (1995) must be protected if encountered.
- The trees selected will be marked with the authorized marking hammer close to ground level by Unit staff, and diameter measurements, along with estimated total tree height and tree species, will be entered in the Marking Register.
- The volume of each tree will be estimated using an appropriate Volume Table. The standing volume marked will be recorded in the Marking Register. Log volume at the NRDCL Depot will be recorded.

20.4 Harvesting

To reduce the negative impact to the forest and environment due to extraction, the hauling method for transporting logs from the coupe to road will be done by skyline crane system. This system will allow logs to be kept above the forest floor during extraction and will enable logs to be taken across sensitive ecological sites, gullies and riparian filter buffer zones. Cutting trees 10cm above the ground level will be strictly followed to avoid the wastage. To maintain the sanitation and hygienic condition of the forest, the cut over debris must be disposed off and if possible burn in a proper place avoiding forest fire. The skyline cable system has the following advantages:

- Minimizes soil disturbance and initiation of soil erosion
- Maximizes work safety (if used correctly according to the manufacturer's directions and according to the safety practices in the Code of Logging Practice)
- Avoid damage to residual reserve stands
- Avoid disruption to wildlife corridors in the valley bottoms
- Minimizes noise and dust pollution on any adjacent farmland and villages
- Eliminates the need for log extraction tracks and feeder road construction

Harvesting in the Working Circle is to be carried out in accordance with the following prescriptions:

- The layout of the cable lines should be planned and undertaken well in advance of the harvesting operations after the logging coupe has been demarcated. Suitable log landing site should be identified and incorporated into the forest road design.

- Care should be taken to avoid lines in and along gullies and other protected areas, but lines may cross these at an angle. Trees to be felled will be enumerated and marked in time so as not to delay harvesting operations.

- The cable corridor shall not exceed the prescribed width stated in the Silvicultural System for each working circle.

- Trees will be felled, de-limbed, crosscut, extracted on the cable, loaded and hauled to the log depot. Only chain saws and hand saws will be permitted in felling operations. Trees will be felled, where possible, into natural openings, into harvested openings or in a direction that will not damage residual stands. Damage to soil should be minimized at all times.

- The use of axes is discouraged except in fuel wood splitting.

- All infected Blue pine and Spruce, if any will be debarked as soon as they are felled to avoid the spread of bark beetles.

- All logs will be measured and recorded in the Log Yard Register. This should be kept up-to-date and made available to inspecting officers as required. A copy of the list of log/timber entered in the Log Yard Register will be submitted to concern CFO every month. This information will be used for royalty calculation and issuance of removal permits. Logs will be transported by private haulage contractors and all deliveries will be made to designated depots and/or sawmills.

- Records of all trees marked and issued for local use or for conversion within the forest, by blocks and compartments will be maintained by the Unit staff and furnished monthly to the concern CFO.

- The CFO and the Divisional Manager, NRDCL will co-operate and co-ordinate to ensure that the logging operation and log outturn are conducted smoothly and in accordance with local and other demands.

- Fuel wood will be collected from harvesting residues. It is important that all lops and tops for fuel wood are collected along entire cable lines, not just the easily accessible areas. It is desirable that the trees to be used as fuel wood are extracted with the cable line and fuel wood conversion occurs at the designated log landing areas.

20.5 Reforestation of Harvested Sites

It is necessary that the forest crop continue with natural regeneration for sustainable development and management of the forest resources. It is crucially important that harvested areas are effectively regenerated as soon as possible after harvesting. In Rodungla FMU natural regeneration will be given preference over artificial regeneration, but if natural regeneration fails either enrichment or complete stocking by planting must be carried out. It is observed that in many FMUs, reforestation has not been successful and in some cases, it has been a total failure. It is highly imperative that the harvested areas are regenerated successfully and adequate time and resources be invested in this program to ensure better seedling survival rates, if the FMUs are to be managed on a sustainable basis.

The limiting factors that can encounter during natural regeneration process are; grazing pressure, protracted harvesting periods, weeds and brush growth. These problems must be considered, analyzed and eliminated to acquire a successful regeneration in the harvested areas of the FMU. It is recommended in this plan period to adopt more tending operations, such as weeding, brushing and fencing, so that regeneration has a chance to establish. This would also reduce the cost of reforestation as clearing and replanting a failed area would cost much more than the initial tending for natural regeneration.

If possible, NRDCL must raise nurseries for the local viable species in advance to supply the planting stock for subsequent plantation. The harvested area shall be planted with commercially viable local species. Regular maintenance of the plantation must be done to ensure the survival percentage of the plants. The concern CFO shall evaluate the plantation at the end of three years and if the survival percentage is lower than 80%, immediate beating up must be carried out with the same species.

Although a monitoring process has been adopted in FRMD, it is recommended that regeneration surveys be conducted every three years, until it is established. If the second survey (6^{th} year) indicates poor stocking, remedial action must be taken in the following planting season.The Unit In-charge will ensure that stocking of natural regeneration is first monitored within three years following completion of the harvesting operation.

Enrichment planting, if necessary, will be carried out by NRDCL. Fencing and other necessary action to protect regeneration will also be carried out by NRDCL, in consultation with FMU In-charge and the FMU Level Management Committee.

20.6 Sequence of Operations Related to the Annual Coupe:

Table 20.1 Sequence of Operations Relating to Annual Coupe

Operation Description	Timing (months) (-before felling; + after felling)
Unit In-charge decides regarding the location and size of annual coupe in accordance with the Biennial Operation Plan	-12
NRDCL and FMU In-charge prepares an estimate of human, material, equipments and financial resources required.	-10
Unit In-charge finalizes the annual coupe size, demarcates the coupe and instructs NRDCL to carry out pre-logging planning	-6
NRDCL prepares cable line layout and alignment plan, proposed log depot and log landing points and submits these to Unit In-charge for approval	-3
Unit In-charge marks the carriage corridor trees and the tress to be felled in the first sub-coupe	-2
NRDCL manually fells trees that are in the way of the skyline installation and installs the skyline and cable crane	-1
NRDCL commences systematic harvesting and extraction operation according to the approved sequence in the Biennial Operation Plan	0
NRDCL/Contractor completes harvesting and extraction	When completed
The Unit In-charge will inspect the coups when harvesting is completed and will issue a Coupe Clearance Certificate only if all aspects of the operation are satisfactory.	When works completed
DoFPS asses success of natural regeneration	As per Guidelines
NRDCL completes post harvesting operation	As per instruction by Unit In-charge

20.7 Road Construction

Despite the negative impact of forest road on forest and environment, it still forms an important part of managed forest estate, both for timber extraction and to provide for forest management and monitoring. Road construction in the FMU requires extra precautions to achieve best environmental practice. The necessity during the forest road construction is to avoid steep and fragile areas, to provide a proper drainage system, especially for safe discharge of run-off water during the monsoon, with enough culverts, and cross drains, to have an efficient draining

compacted road surface.

For forest road construction in Rodungla FMU, two options have been preliminary identified.

Option I : Extension from the end of existing farm road, from Ugyenchholing

Option II : Construction of new bridge across Tang Chhu from the existing Chamthang suspension bridge

During this ten years plan period NRDCL shall construct around 25km forest road in the FMU.

Road Standards

A set of road standards has been developed by Forest Engineers of TFDP. These road standards, although developed in the East, address policies that are required throughout Bhutan. These standards are adopted in all FMUs and NRDCL road engineers must follow these standards, given in annex 4, during designing and estimating and providing supervision during construction. Road design in FMU should follow the recommended road profile given in the Figure 20.7 to avoid excessive water pooling leading to rutted road surfaces that inhibit access during monsoon season. Improper drainage may lead to landslide.

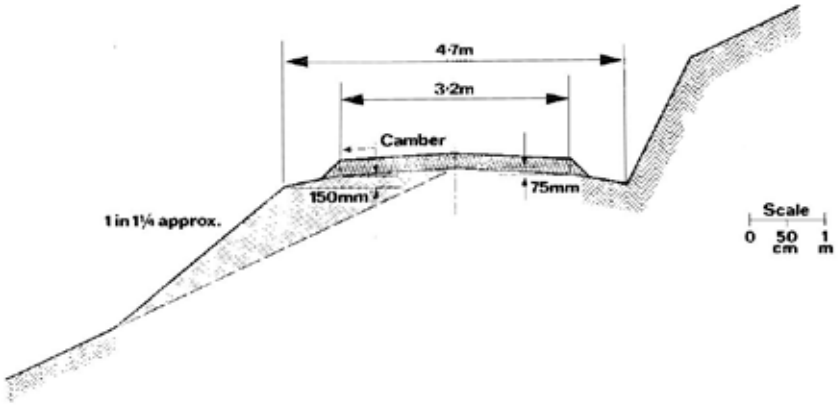

Figure 20.7 Recommended Road Profile

21. PLANNING

21.1 Operational Plan

For the timely implementation of the Management Plan, Operational Plan will be prepared by the CFO, Bumthang Territorial Division and the Unit In-charge.

Guidelines for preparation of Operational Plan are given in the Forest Management Code of Bhutan (2004) and a copy of each is available to all Territorial Divisions.

The Operational Plan is the tool used to provide for changes that cannot be foreseen or allowed for in the FMU Plan, such as insect and disease outbreaks, severe fire, etc. If and when these occur, the current Operational Plan should be immediately reviewed and the areas and/or methods of operation modified to deal most effectively with possible changes in the sustainable level of harvest.

The Operational Plan is a rolling one prepared annually but the plan period is for two year. Therefore, activities for the second year of the plan are carried forward into the first year of the next plan. This has important implication in budgeting. It allows participatory process since planning is carried out a year before the start of the activity. The primary aim in preparing the Operation Plan is to determine and co-ordinate the timely input of resources.

Table 21.2 Concept of Rolling Plan

Year 1	**2**	**3**	**4**	**5**	**6**	**……**
Detailed	Outline	Detailed	Outline	Detailed	Outline	Etc.
	Detailed	Outline	Detailed	Outline	Detailed	Outline

The Operational Plan will be prepared in consultation with all the agencies and parties. Inclusion of a consultation process with local communities in the preparation of the plan is particularly important so that potential issues concerning communities in the forthcoming operational areas are worked through, before the plan is implemented. The process for preparing and implementing the Operational Plan is given below

Table 21.3: Preparation and Implementation of Operational Plan

Activity (Planning Step)	Objective	Output	Responsibility (lead)	Comments
1. Approved FMP				
2. PRAs with local Stakeholders	To prepare participatory plan for fire management, grazing control and rural timber	Participatory plan for fire management, grazing management and rural timber harvesting (to be incorporated within the OP)	DoFPS/FMU In-charge/ DzFO	First step is to enter into discuss with stakeholders and their representatives
	To involve relevant stakeholders in planning for activities which have a direct impact in their "interest"			Use PRA technique to prepare the plan Plan cost are included in the OP
3. Operational inventory	To assess the resource availability for the planned harvesting area	Site-level inventory data for the operational area to be harvested	FMU In-charge/ NRDCL	For the areas proposed for harvesting during the next two years
	Calculation of the harvestable volume	Precise estimate of volume to be removed during the coming year		May be combine with harvesting plan and cable line survey
4. Harvesting plan and cable line survey	To plan for harvesting and extraction activities	Agreed extraction and roading plan	NRDCL	Within the selected identified harvestable area for the year
5. Preparation of Operational plan	To prepare a plan for implementation during the next two years (involving stakeholders for some activities)	Approved operational plan with budget	FMU In-charge with stakeholders as required	Activities linked with objectives identified in the FMP and following options and guidelines in the FMP
	To formalize local institutional responsibility for planed activities (e.g. grazing, fire management , rural timber distribution)	Identified responsibilities for each planned activities Calculate cost for each planned activities		Each activity with identified responsibility for implementation, estimated cost, and site-specific location

6. FMU annual report presented to the FMU Level Management Committee	To review progress and identify and address any implementation problems To identify any future actions necessary based on issues arising	FMU Annual report endorsed by FMU Level Management Committee	FMU Manager presents to the FMU Level Management Committee	During FMU Level Management Committee annual meeting Implementation problems need to be addressed before endorsing the new OP
7. OP review by FMU Level Management Committee and endorsed	For the FMU Level Management Committee to endorse the OP (prior to approval by DoFPS) To endorse expenditure estimates for the coming financial year	OP endorsed by FMU Level Management Committee	FMU Manager presents to the FMU Level Management Committee	During FMU Level Management Committee annual meeting

Table 21.4: Preparation and Implementation of Operational Plan

Activity (Planning Step)	Objective	Output	Responsibility (lead)	Comments
8. NRDCL financial commitment within OP agreed	To ensure that NRDCL is committed to funding the agreed activities in the OP	Budget estimates for the OP endorsed by NRDCL and FMU Level Management Committee	FMU Level Management Committee	Meeting needs to take by November to ensure that budget requirements can be included in the NRDCL APO for the next financial year
9. OP approved by Director, DoFPS	To approve OP for implementation	Approved plan and budget	Approved by FRMD and Director, DoFPS	OP approved linked with sanctioned budget for all planned activities
10. OP implementation by NRDCL	To carry out planed activities	Harvested timber; protected area; roads; fuel wood etc	According to responsibilities identified in the OP e.g. FMU In-charge , NRDCL, DzFO etc	Each activity with specific responsibility and budget

11. Monitoring of activities	To assess the level of achievement of planned activities	Information for FMU annual report	FMU In-charge	DoFPS responsibility is to monitor the implementation of activities carried by NRDCL Monitoring cost need to appear in the OP
12. DoFPS, Unit In-charge prepares FMU annual report	To report progress against planned activities To highlight any problems being encountered in implementation	FMU Annual report	FMU In-charge	Prepared annually Progress is reported against each FMP objective and the associated activities
13. Prepare the next year's OP (step 2-5)	To prepare the next OP taking into account progress over the past year	Operational Plan	FMU In-charge	OP may alter in response to FMU management committee suggestions and recommendations

21.2 Mid-term Review of the FMU Plan

Based on the information collected during the annual monitoring and from other sources, the Head, FRMD, will ensure that the plan is evaluated at an interval of five years after the implementation. The results of Mid-term Review should be discussed with the FMU Level Management Committee.

21.3 FMU Level Management Committee

Members:
CFO, Bumthang Territorial Division, Chair Person
FRMD Representative
Regional Manager, Bumthang, NRDCL
FMU Unit In-charge, Rodungla FMU
Unit Manager, Bumthang, NRDCL
DzFO, Bumthang Dzongkhag
Gup Tang Gewog, Bumthang Dzongkhag
Key Village Elders

Terms of Reference for the FMU Level Management Committee:

During FMU Management Plan Preparation:

- To support the interest of the stakeholder groups during the planning process
- To discuss and agree upon FMU forest management objectives for different

parts of the forest based on national priority and specific local condition and needs.
- To consult (along with FRMD) with specific groups of stakeholders likely to be significantly affected by proposed activities such as road construction and timber harvesting ensuring that their interest are effectively accommodated in the final plan.
- To review and endorse the draft Forest Management Plan before it is presented to Director, DoFPS and Minister, MoAF for final approval.

During Operational Planning, Implementation and Monitoring:

- To represent the interests of identified stakeholders group during planning and review of activities under Operational Plans.
- To review achievements during the past year (based on annual report submitted by the FMU Unit In-charge) and advice and act on any issue identified.
- To make recommendation for changes in the proposed Operation Plan for the coming year based on previous year's experience and on the need to achieve the agreed objectives in the forest management plan.
- To review and endorse the draft Operational Plan before submission to the Director, DoFPS for approval.
- To participate in the 5-year mid-term review of the forest management plan.
- To hold additional meetings as required in response to specific issues arising from the implementation of the Forest Management Plan and Operational Plan.

21.4 Staff

The CFO, BumthangTerritorial Division is the overall controlling officer of the area. The controlling and management of the Rodungla FMU will be looked after by the FMU In-charge. They will be under the administrative control of the Chief Forestry Officer, Bumthang Territorial Division. The Chief Forestry Officer is the direct representative of DoFPS in the field and as such he is solely responsible for all forestry activities, both technical and administrative within his jurisdiction.

20.4.1 Responsibility

For the smooth monitoring and implementation of the plan in the FMU, following staff will be required;

Table 21.5 Staff requirement in the FMU

Unit In-charge	1
Deputy Ranger	1
Asst. Forester	4

The Unit In-charge under the guidance of CFO will be directly responsible for the day-to-day implementation of the plan. The Unit In-charge will keep records of all the works, supervise and initiate other silvicultural activities as envisaged in this plan. Unit In-charge will be responsible to inform/report to CFO, Bumthang Territorial Division.

Deputy Ranger will be responsible for carrying out operational inventory, help to prepare the operational plan, supervise road construction and maintenance and keep the track of regeneration of the harvested areas. Deputy Ranger will also be responsible for supervising the tree marking and felling, timber extraction, transport of logs to depot and reporting the coupe clearance. He will also be responsible for marking of thinning, fire and pest activities. The Asst.Foresters will be assigned to help the Deputy Ranger.

21.5 Buildings

A unit office for the Unit In-charge and his/her subordinate staff will have to be constructed at Tang. A staff quarter for the staff will have to be constructed by Bumthang Territorial Division. NRDCL will also have to build an office for the Unit Manager and his/her subordinate staff.

21.6 Vehicles and equipments

For the smooth monitoring and implementation of the Rodungla Management Plan, following equipments will be necessary:

Table 21.6 Vehicles and Equipments Required

Items	Quantity
Motor cycle	1
Suunto clinometers	1
Suunto Compass	1
Diameter tapes	2
Distance measuring tape	2
Altimeter	1
Computer	1 set
Printer	1
Walkie-talkie	3 to 4
Binocular	1
Trimble Juno SC GPS	1
Camera	1

22. MONITORING AND EVALUATION

The primary focus of the Royal Government of Bhutan's forest policy is to ensure conservation of the environment and, only thereafter, to allow the derivation of economic benefits from the forest.

To ensure that this policy is being carried out in the management of FMUs, a two stage verification process is necessary. The first stage, checks that on-ground activities are being carried out as planned in the short term, the second stage, checks that the objectives of the plan are being achieved over the longer term. Monitoring (checking on inputs on year to year basis) is the term used for first stage and evaluation (checking achievements against objectives over five year periods) is the second stage.

Standard forms for monitoring and evaluation were prepared and are available from the Forest Management Code of Bhutan (2004). The forms for monitoring were subdivided into Physical, Financial and Environmental sections that contained an exhaustive set of questions and the forms for evaluation were also subdivided into Evaluation form A and Evaluation form B.

22.1 Monitoring

Monitoring is the continuous/periodic review undertaken by management at every level of implementation, of an activity to ensure that input deliveries, work schedules, targeted output and other required actions are proceeding according to the plan. The CFO, Bumthang Territorial Division will ensure that monitoring is carried out on an annual basis according to the guidelines issued by FRMD.

22.2 Evaluation

Evaluation is the examination of whether objectives are being achieved. In the context to FMU evaluation, sufficient time has to elapse before a realistic assessment can be made of progress towards fulfilling objectives (Incoll 1999). Evaluation should be carried out at the intervals of five year, based on the information collected by annual monitoring.

The Head, FRMD will ensure that evaluation is carried out at five-year intervals, based on the information collected by annual monitoring and other necessary information. Copies of necessary forms can be collected from FRMD, Thimphu.

Corrective action if necessary may require changes to a range of inputs or to implementation methodology. The evaluation will be carried out by staff that is independent of the field implementation activities.

The Director, DoFPS, will appoint the Evaluation Team.

23. CONSTRAINTS AND RISKS

The possible risk and constraints in smooth implementation of the management plan are:

- Uncertainty of natural regeneration due to grazing pressure and undergrowth competition
- Lack of research information
- Lack of skilled and trained forest workers
- Lack of sufficient support to UIC
- Poor communication between field and office staff and between involved parties

Forest Management Plan relates to multiple uses of forest resources. Typical uses include wildlife habitat management, watershed management, livestock grazing, and/or timber production. Increasing benefits of one type may impair or damage others. For, instance, timber management may lead to under production of non-wood forest products and degradation of bio-diversity. For effective assessment, not only the production function, demand and price structure of each product need to be understood, but also the relationship and conflicts of resource use should be fully comprehended.

24. DEVIATIONS FROM PLAN PRESCRIPTION

The annual harvested AAC should be made to allow for unforeseen situations. For these and other bonafide reasons, the annual AAC may vary +/- 10%. However, the total volume harvested over successive five year period must be no more than five times the ACC volume.

Unforeseen circumstances may warrant deviation from the plan prescriptions. In such event, the CFO, Bumthang Territorial Division must obtain prior written approval from the Director, DoFPS. Any such request for plan deviation(s) must fully justified and such approved deviation(s) entered into the Management Plan during its next scheduled revision. The NEC Secretariat must be informed of the plan deviations approved by the Head of Department if any.

25. REFERENCES

- **RGoB, MoAF, DoFPS, FRMD.** Forest Management Code of Bhutan, 2004
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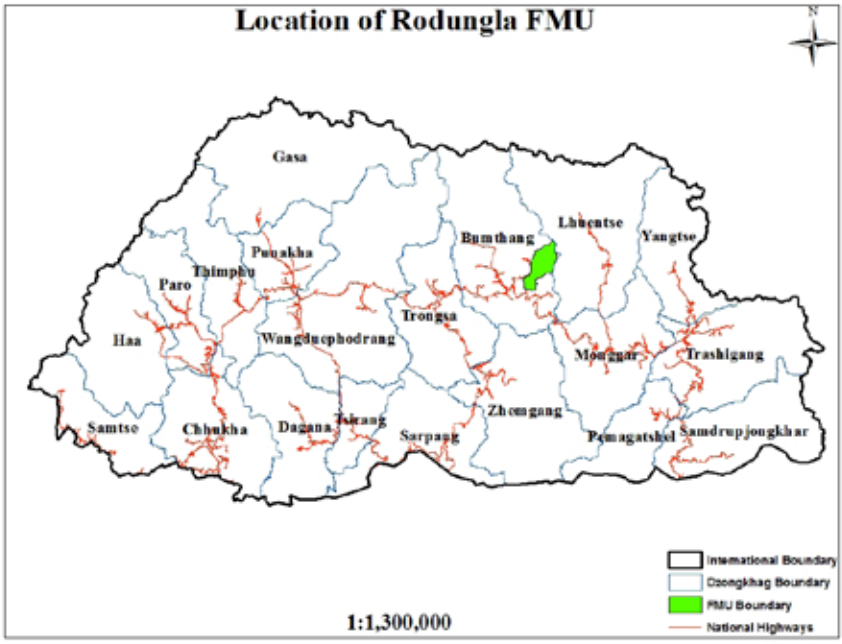
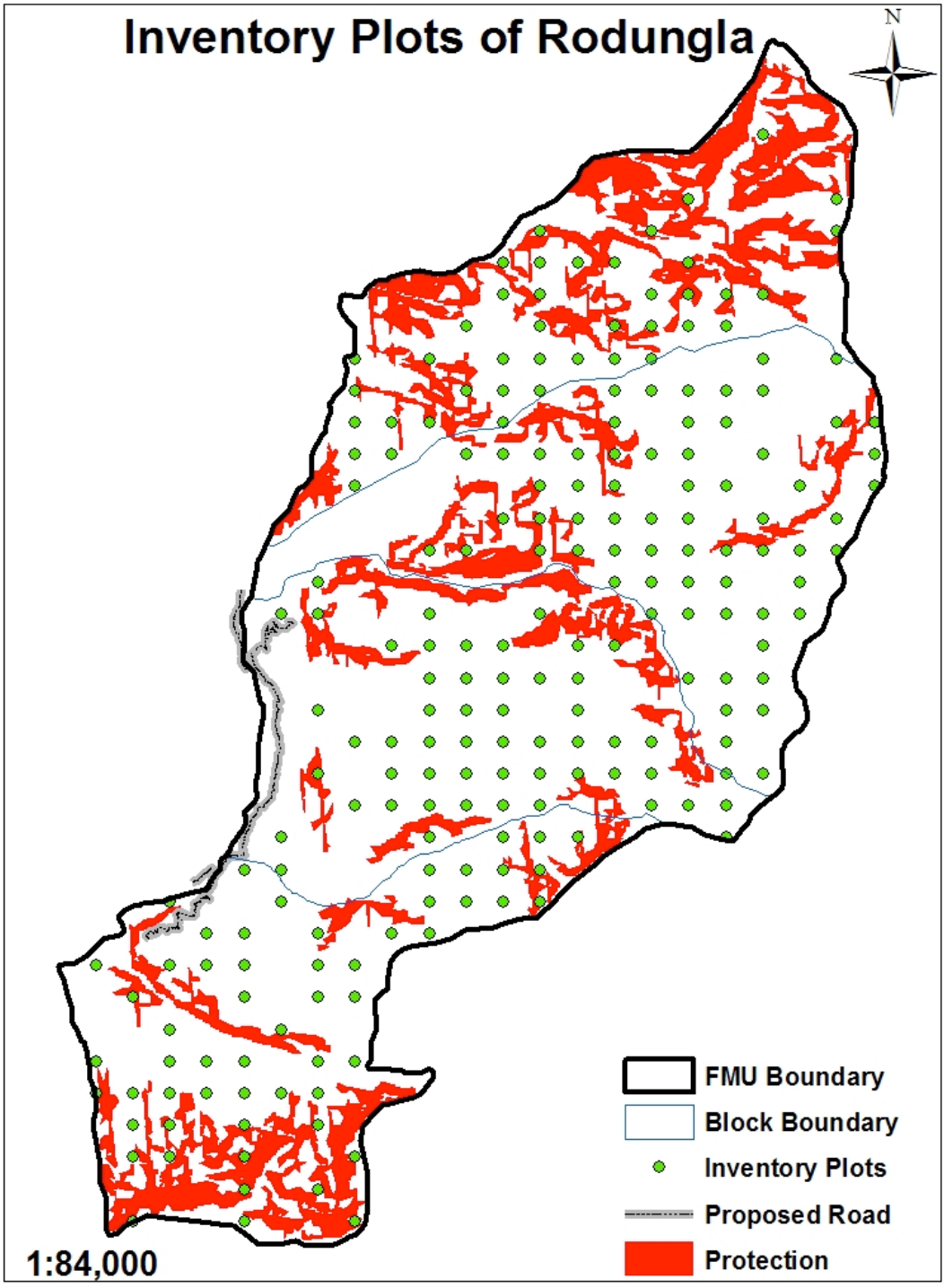
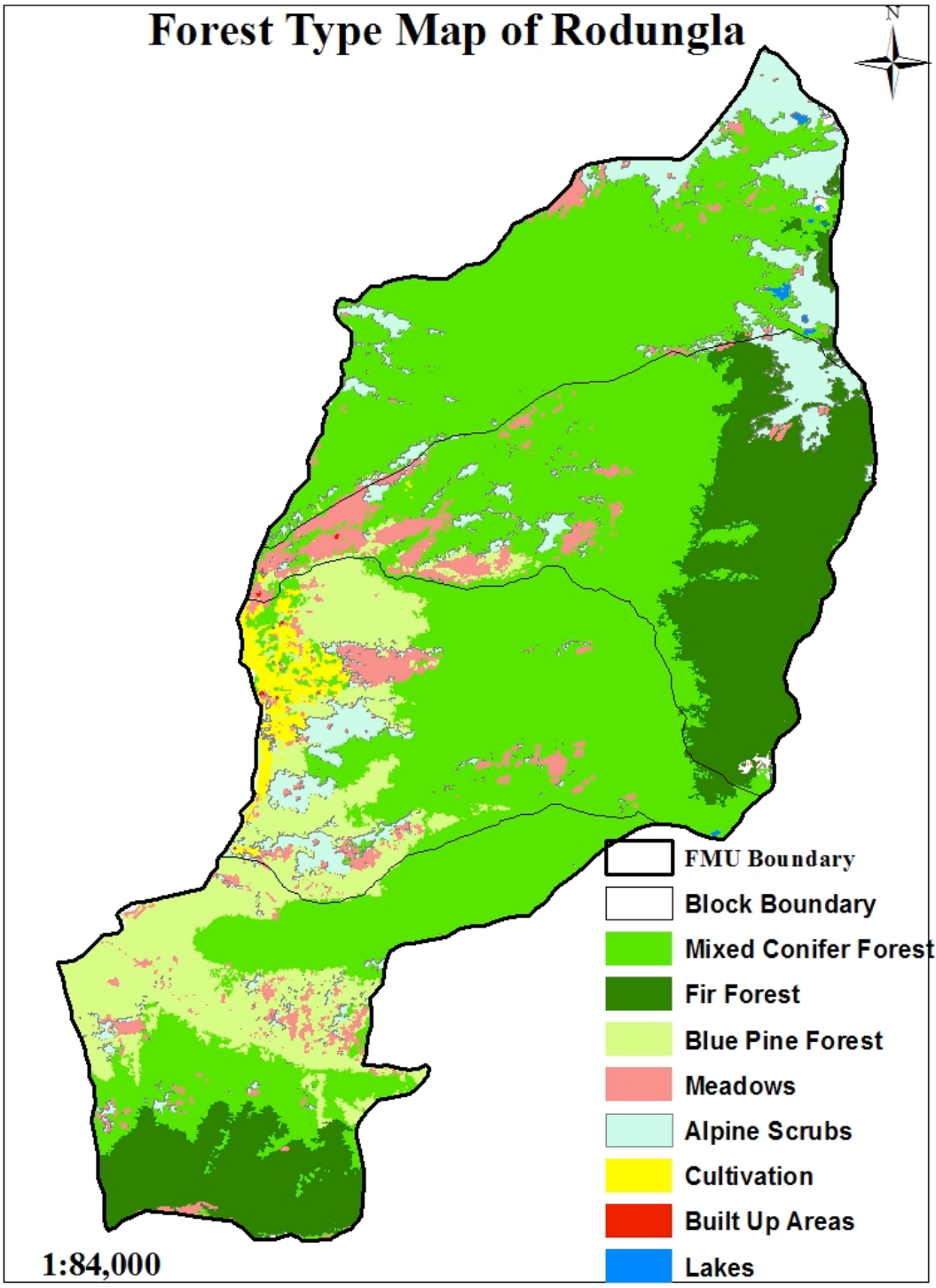
- **NEC 1999.** Forest Sectoral Guidelines. Bhutan Environment Assessment Sectoral Guidelines

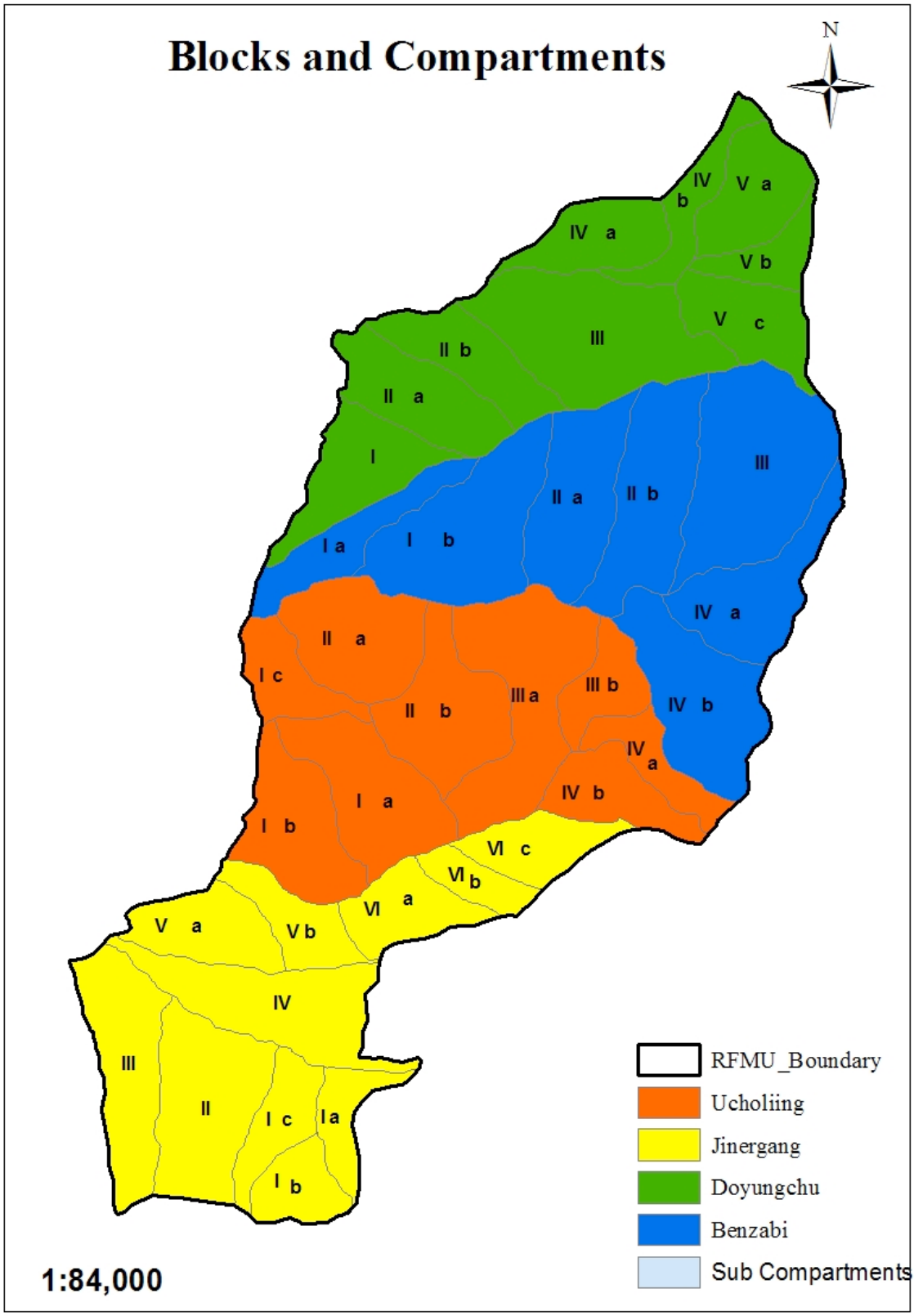
- **RGOB (1995)** Forest and Nature Conservation Act of Bhutan, 1995. Thimphu
- **SCHINDELE, W. and DHITAL, D.B (1997).** Guidelines for the Preparation of a Forest Function Map and definition of Management Prescription/Restrictions. Bhutan-German Sustainable RNR Development Project. Working Paper No.11. Ministry of Agriculture, Royal Government of Bhutan.
- **BEBARTA, KAILASH CHANDRA (2002).** Planning for Forest Resources and Bio-diversity Management
- **PRAKESH, RAM and KHANNA, L.S (1991).** Theory and Practices of Silvicultural System. IBD, Dehradun
- **RGoB, NEC 2004.** Application for Environmental Clearance Guideline for Forestry Activities
- **Burgi Anton, 1989**. Management Plan for the Dhur Forestry Unit (1986/87 to 1995/1996)
- **Burgi Anton, 1993**. Management Plan for Lame Gompa Research Forest. (1st January 1993 to 31st December, 2001)
- **Dorji Lobzang, 2000**. Management Plan for Paro-Zongzela Forest Management Unit. (July 2000 to June 2010)
- **Rai Arun, 2010**. Management Plan for Lonchu Forest Management Unit. (1st January 2010 to 31st December, 2019)
- **Tshering, 2010**. Management Plan for Selela Forest Management Unit. (1st January, 2011 to 31st December, 2020)
- **Dhendup Phub**, **2011**. Management Plan for Dawathang Forest Management Unit(1st January, 2011 to 31st December, 2020)

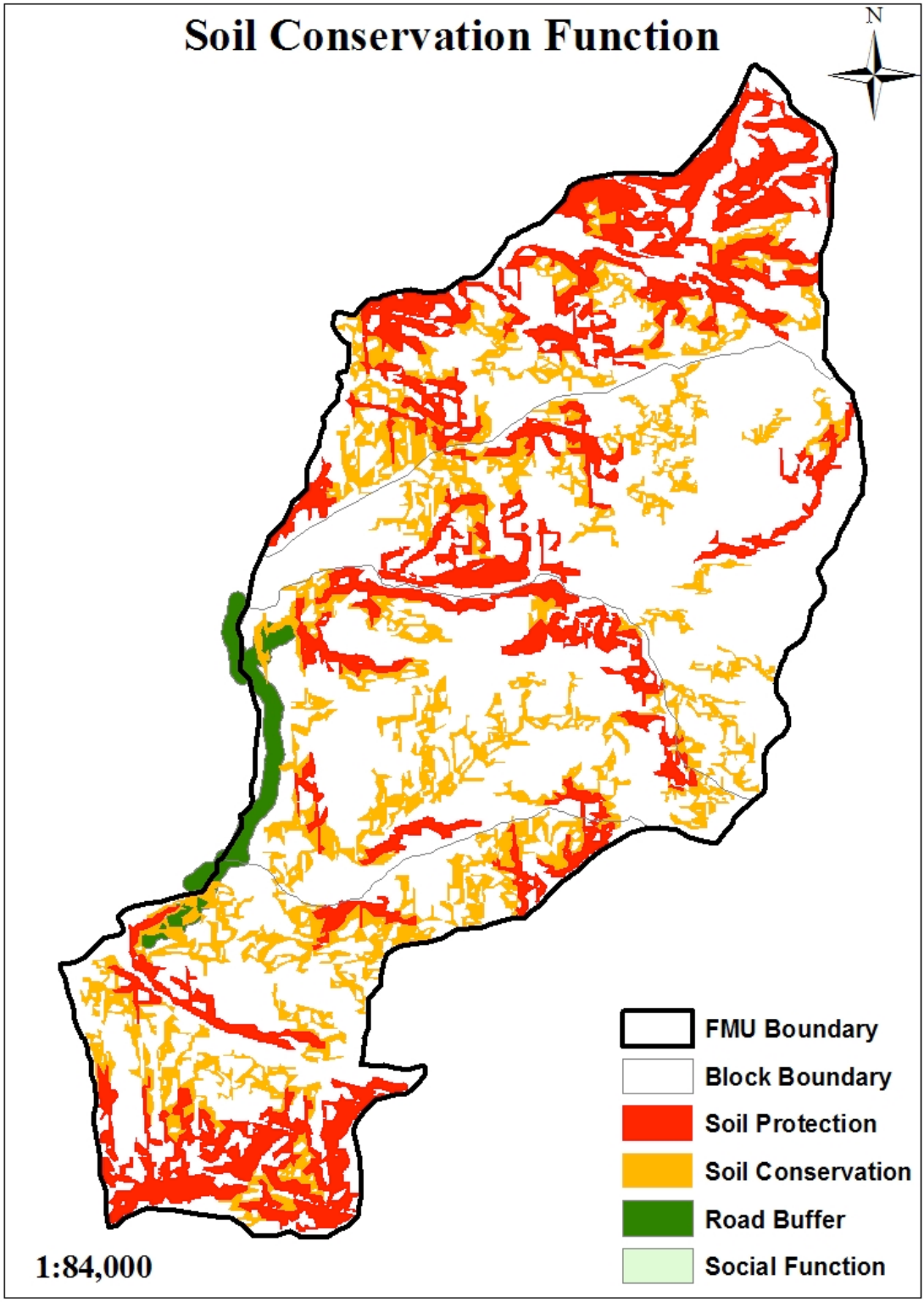
Annexure 1: Maps of Rodungla Forest Management Unit

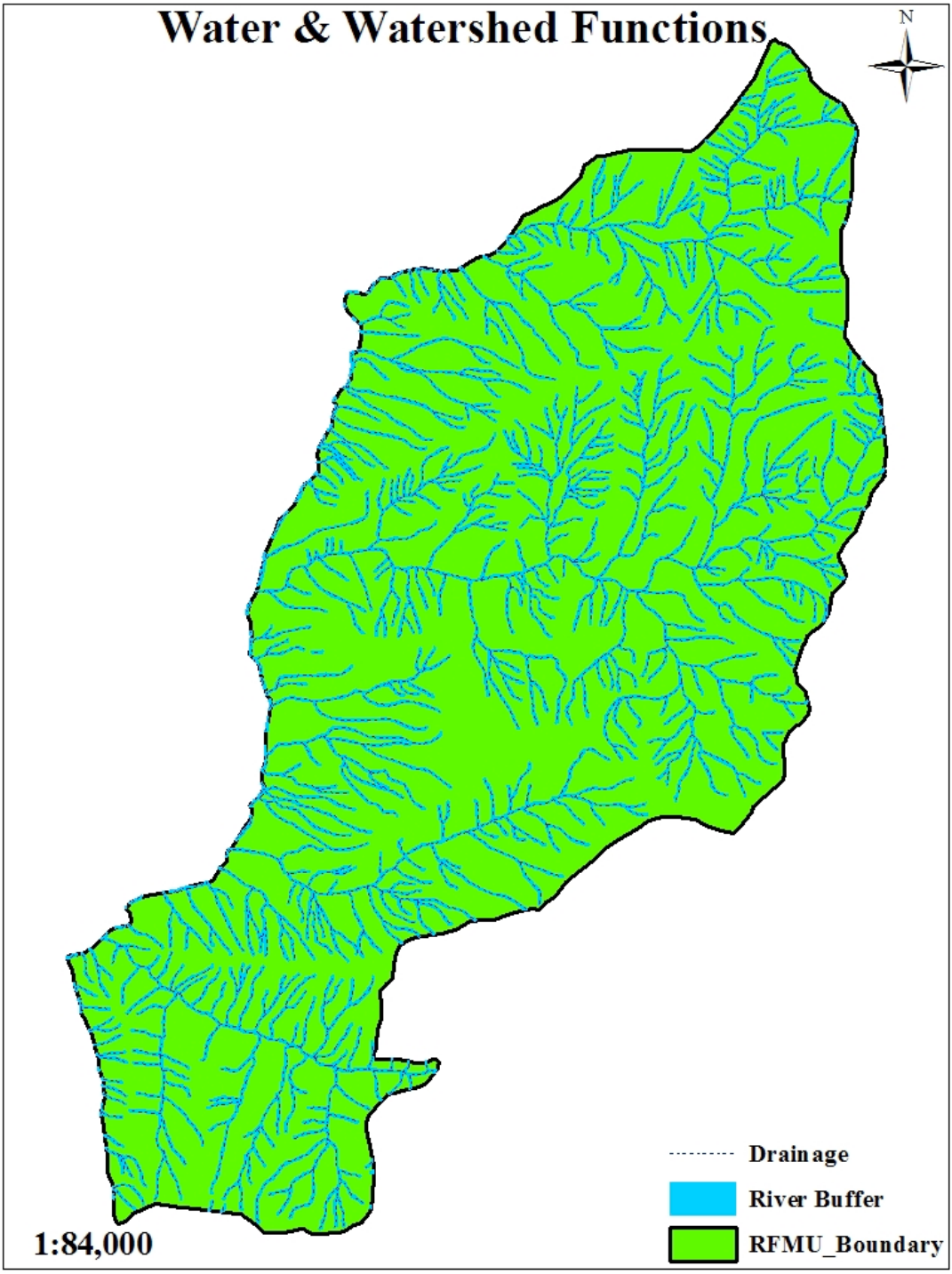


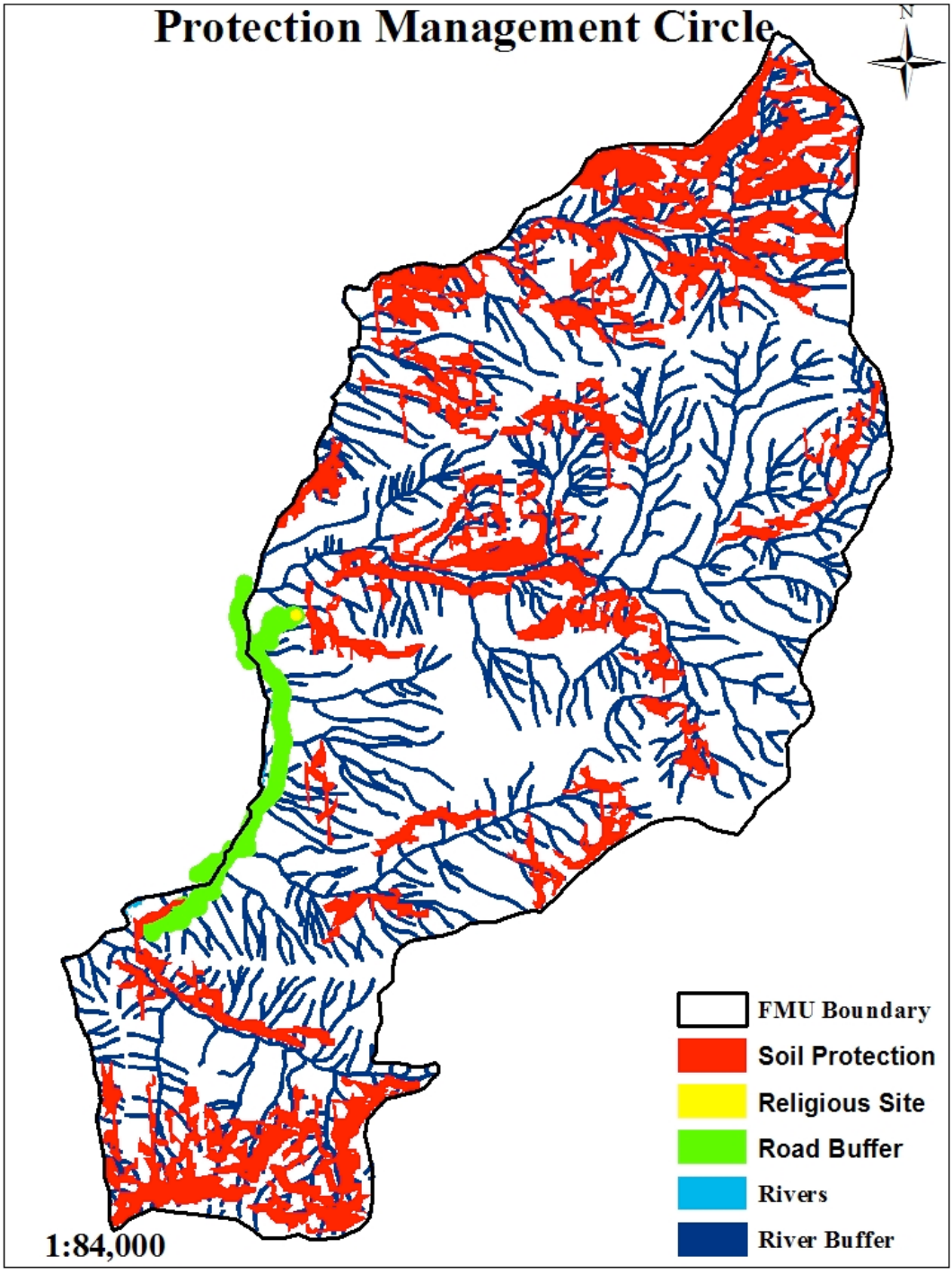

Inventory Plots of Rodungla
N
FMU Boundary
Block Boundary
Inventory Plots
Proposed Road
Protection
1:84,000

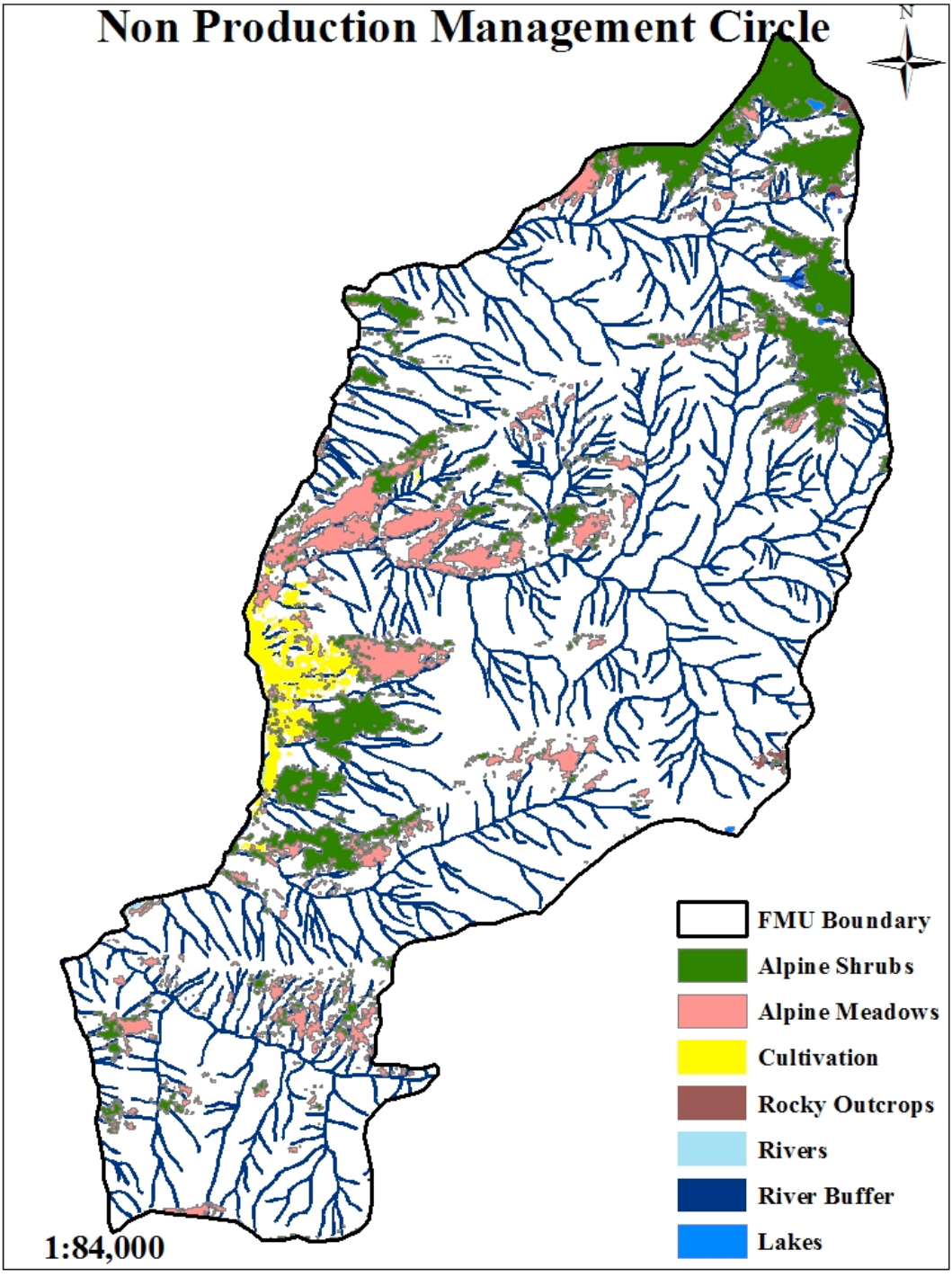

Forest Type Map of Rodungla
N
FMU Boundary
Block Boundary
Mixed Conifer Forest
Fir Forest
Blue Pine Forest
Meadows
Alpine Scrubs
Cultivation
Built Up Areas
Lakes
1:84,000

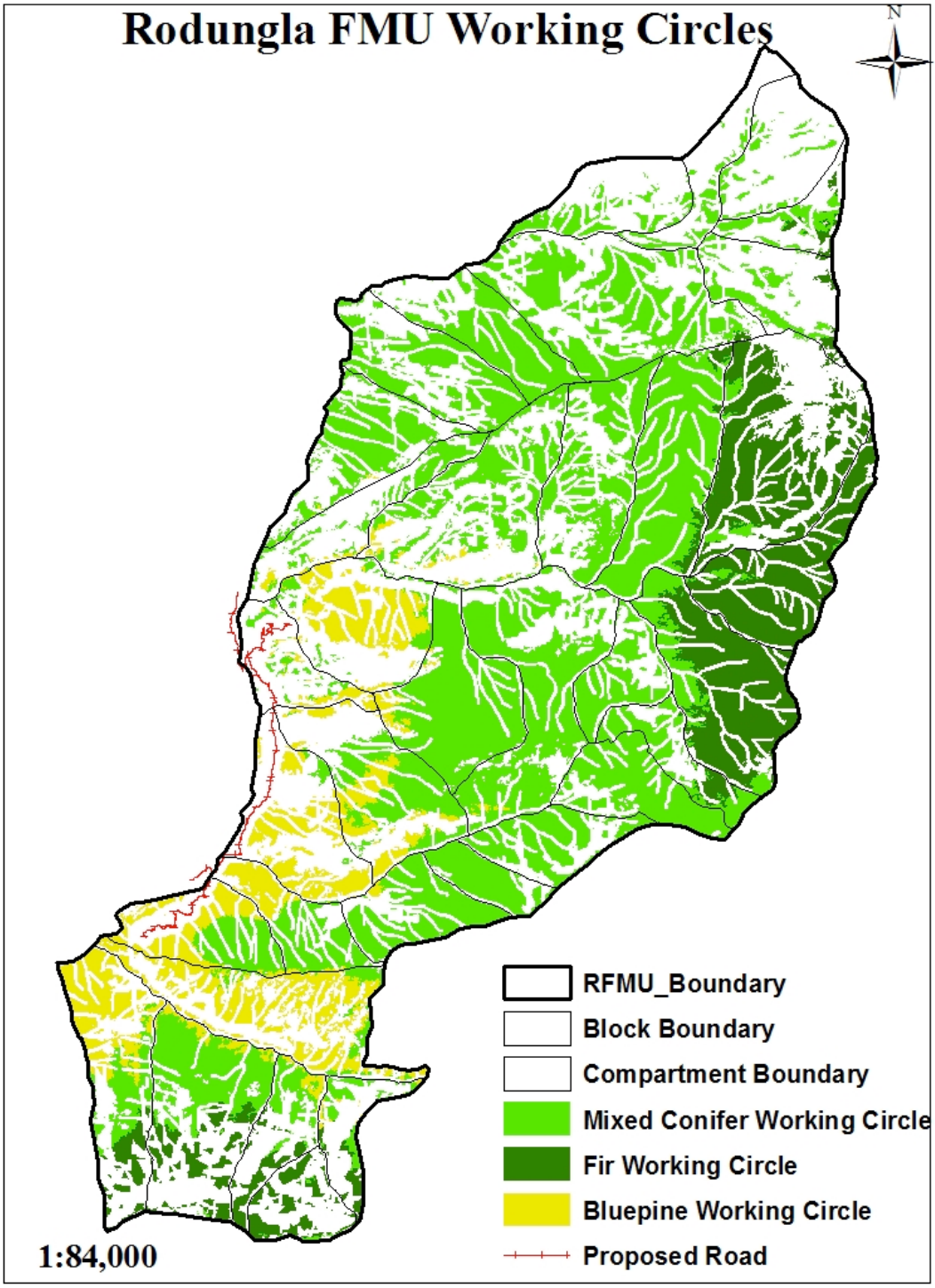

Blocks and Compartments
N
IV b
V a
IV a
V b
V c
III
II b
II a
I
III
II a
II b
I a
I b
IV a
II a
I c
III a
III b
II b
IV b
IV a
IV b
I a
I b
VI c
VI b
VI a
V a
V b
IV
III
II
I c
I a
I b
RFMU_Boundary
Ucholiing
Jinergang
Doyungchu
Benzabi
Sub Compartments
1:84,000


Soil Conservation Function
N
FMU Boundary
Block Boundary
Soil Protection
Soil Conservation
Road Buffer
Social Function
1:84,000


Water & Watershed Functions
N
Drainage
River Buffer
RFMU_Boundary
1:84,000


Protection Management Circle
N
FMU Boundary
Soil Protection
Religious Site
Road Buffer
Rivers
River Buffer
1:84,000


Non Production Management Circle
N
FMU Boundary
Alpine Shrubs
Alpine Meadows
Cultivation
Rocky Outcrops
Rivers
River Buffer
Lakes
1:84,000


Rodungla FMU Working Circles
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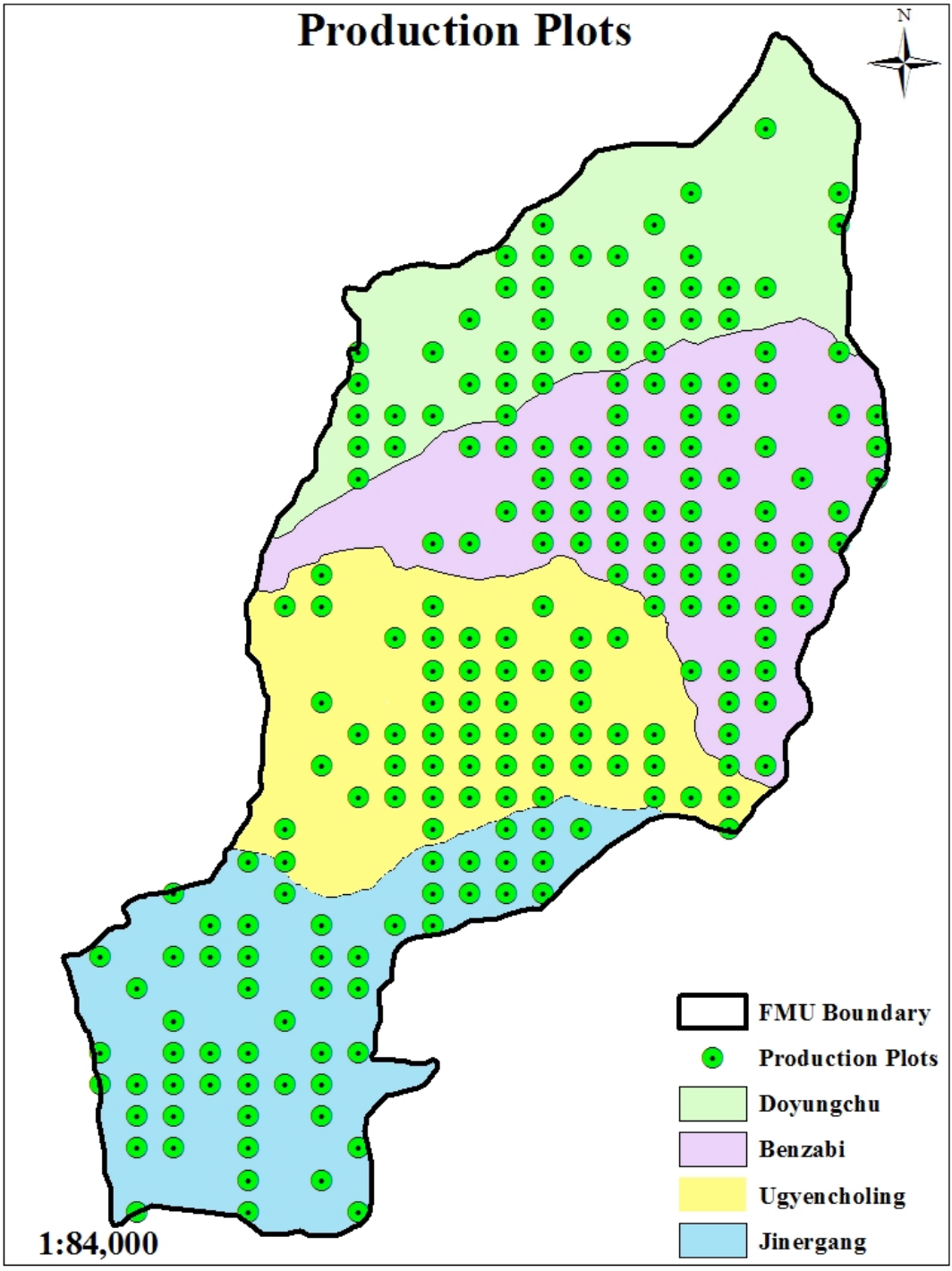
RFMU_Boundary
Block Boundary
Compartment Boundary
Mixed Conifer Working Circle
Fir Working Circle
Bluepine Working Circle
Proposed Road
1:84,000


Production Plots
N
FMU Boundary
Production Plots
Doyungchu
Benzabi
Ugyencholing
Jinergang
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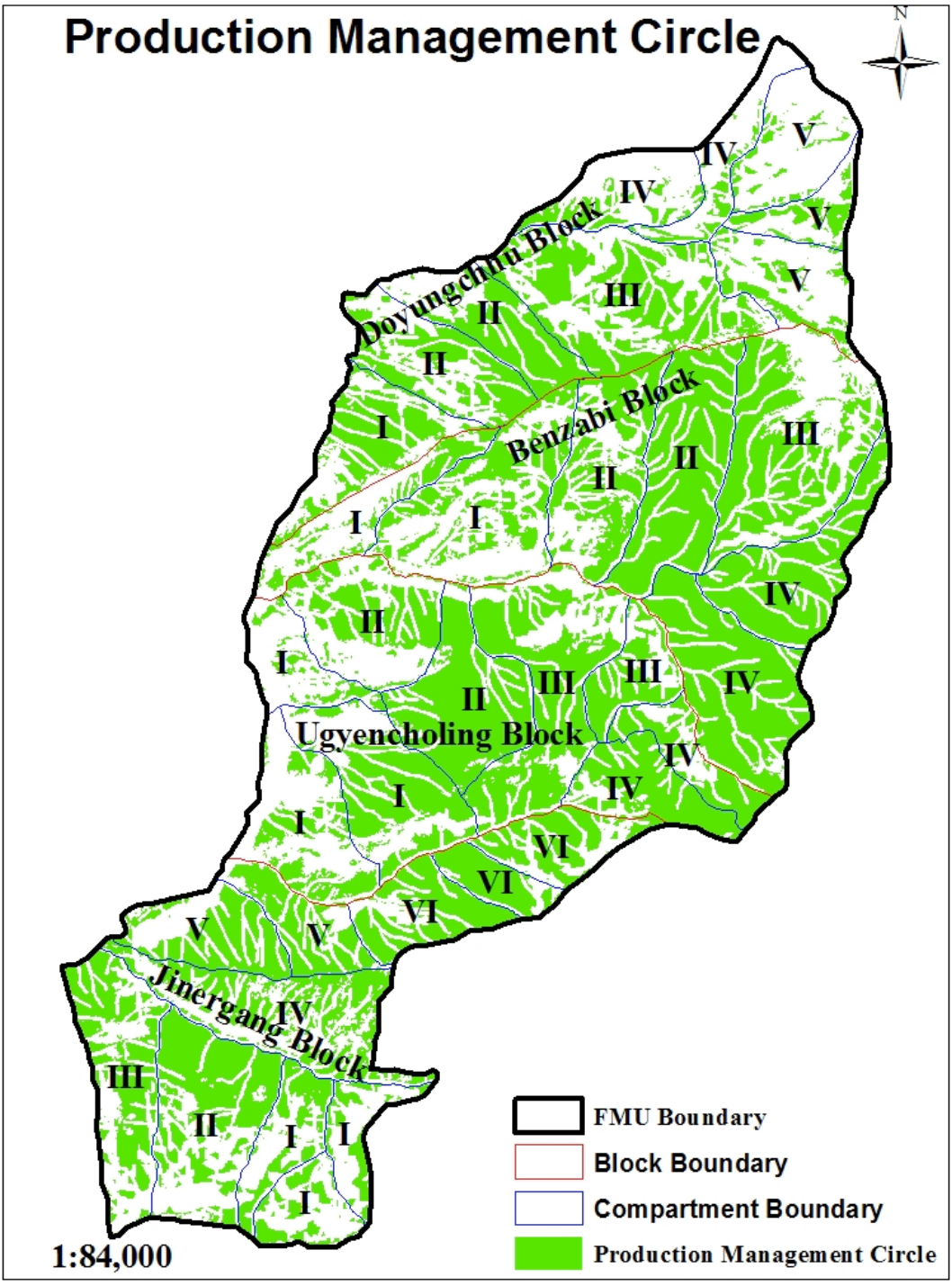
Production Management Circle
N
Doyungchhu Block
Benzabi Block
Ugyencholing Block
Jinergang Block
FMU Boundary
Block Boundary
Compartment Boundary
Production Management Circle
1:84,000

Annexure 2: Forest Inventory Results of Rodungla FMU

Main Table 1. Survivor Trees >= 10 cm Dbh: Average Number of Trees per Ha.

Inventory Unit : Rudongla
Stratum : Fir Working Circle
Area (ha) : 1465.0
Period : 20/08/04 to 09/03/05

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 32
Estimate of Total : 865.625
t (0.975, 31) : 2.040
Sampling Error% for Estimate (at P=0.95) : 24.92

Estimated Parameter : AVERAGE NUMBER OF TREES PER HA (/ha)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.00	0.00	3.13	0.00	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.00	1.88	5.63	0.65
Pinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	25.00	6.25	3.13	9.38	2.50	1.25	2.50	1.25	0.63	0.00	2.50	1.25	10.63	66.25	7.65
Fir	46.88	53.13	28.13	37.50	7.50	6.25	2.50	9.38	5.00	10.00	9.38	6.88	31.88	254.38	29.39
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	71.88	59.38	34.38	46.88	10.00	7.50	5.63	10.63	5.63	10.00	11.88	8.13	44.38	326.25	37.69
Acer	18.75	31.25	18.75	0.00	0.63	0.00	0.00	1.25	0.00	0.00	0.00	0.00	0.00	70.63	8.16
Betula	6.25	12.50	15.63	6.25	1.88	1.25	0.63	0.63	0.00	0.00	0.00	0.00	0.00	45.00	5.20
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	140.63	87.50	40.63	15.63	0.63	0.63	0.63	0.00	0.00	0.00	0.00	1.25	0.63	288.13	33.29
other broadl.	75.00	43.75	12.50	3.13	0.00	0.63	0.63	0.00	0.00	0.00	0.00	0.00	0.00	135.63	15.67
total broadl.	240.63	175.00	87.50	25.00	3.13	2.50	1.88	1.88	0.00	0.00	0.00	1.25	0.63	539.38	62.31
total	312.50	234.38	121.88	71.88	13.13	10.00	7.50	12.50	5.63	10.00	11.88	9.38	45.00	865.63	100.00
%	36.10	27.08	14.08	8.30	1.52	1.16	0.87	1.44	0.65	1.16	1.37	1.08	5.20	100.00	

Additional Statistics for Main Table 1

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE NUMBER OF TREES PER HA (/ha)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Fir Working Circle
Area (ha) : 1464.95400000
Stratum Weight : 1.00000000
Number of Sampling Units : 32
Degrees of Freedom : 31
Sampling Intensity : 0.00109218
Finite Population Correction : 0.99890782

t (0.975, 31) : 2.04000000
t (0.950, 31) : 1.69500000
Estimate : 865.62500000
Standard Deviation : 598.38997695
Coefficient of Variation % : 69.12808398
Standard Error : 105.72362068
Sampling Error (P=0.95) : 215.67618618
Sampling Error % : 24.91566050
Reliable Minimum Estimate (P=0.95) : 686.42346295

Main Table 4. Survivor Trees >= 10 cm Dbh: Average Basal Area per Ha.

Inventory Unit : Rudongla
Stratum : Fir Working Circle
Area (ha) : 1465.0
Period : 20/08/04 to 09/03/05

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Estimated Parameter : AVERAGE BASAL AREA PER HA (m^2/ha)

Number of Strata : 1
Number of Sampling Units : 32
Estimate of Total : 59.957
t (0.975, 31) : 2.040
Sampling Error% for Estimate (at P=0.95) : 19.66

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
Spruce	0.00	0.00	0.12	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	1.09	1.29	2.16
Pinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	0.25	0.13	0.10	0.54	0.19	0.12	0.33	0.22	0.12	0.00	0.72	0.43	6.99	10.14	16.92
Fir	0.49	1.25	1.07	2.11	0.61	0.66	0.36	1.60	1.05	2.52	2.75	2.37	18.60	35.45	59.12
Other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total conifer	0.73	1.38	1.29	2.65	0.80	0.78	0.78	1.82	1.18	2.52	3.47	2.80	26.68	46.88	78.20
Acer	0.21	0.63	0.72	0.00	0.05	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	1.82	3.03
Betula	0.07	0.33	0.62	0.37	0.14	0.13	0.09	0.12	0.00	0.00	0.00	0.00	0.00	1.86	3.11
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	1.52	1.88	1.53	0.90	0.04	0.06	0.08	0.00	0.00	0.00	0.00	0.43	0.38	6.81	11.37
Other broadl.	0.80	0.96	0.50	0.17	0.00	0.07	0.08	0.00	0.00	0.00	0.00	0.00	0.00	2.58	4.30
Total broadl.	2.61	3.79	3.36	1.43	0.23	0.26	0.25	0.33	0.00	0.00	0.00	0.43	0.38	13.07	21.80
Total	3.34	5.18	4.65	4.08	1.03	1.04	1.03	2.15	1.18	2.52	3.47	3.23	27.06	59.96	100.00
%	5.58	8.64	7.75	6.81	1.72	1.73	1.71	3.59	1.96	4.20	5.79	5.38	45.13	100.00	

Additional Statistics for Main Table 4

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE BASAL AREA PER HA (m^2/ha)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Fir Working Circle
Area (ha) : 1464.95400000
Stratum Weight : 1.00000000
Number of Sampling Units : 32
Degrees of Freedom : 31
Sampling Intensity : 0.00109218
Finite Population Correction : 0.99890782
t (0.975, 31) : 2.04000000
t (0.950, 31) : 1.69500000

Estimate : 59.95651020
Standard Deviation : 32.69829708
Coefficient of Variation % : 54.53669163
Standard Error : 5.77713947
Sampling Error (P=0.95) : 11.78536453
Sampling Error % : 19.65652185
Reliable Minimum Estimate (P=0.95) : 50.16425879

Main Table 5. Survivor Trees >= 10 cm Dbh: Average Gross Volume per Ha.

Inventory Unit : Rudongla
Stratum : Fir Working Circle
Area (ha) : 1465.0
Period : 20/08/04 to 09/03/05

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 32
Estimate of Total : 553.511
t (0.975, 31) : 2.040
Sampling Error% for Estimate (at P=0.95) : 23.69

Estimated Parameter : AVERAGE GROSS VOLUME PER HA (m^3/ha)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
Spruce	0.00	0.00	0.74	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00	11.43	12.91	2.33
Pinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	0.88	0.66	0.66	3.53	1.44	1.17	2.99	1.87	1.49	0.00	8.04	4.02	76.29	103.05	18.62
Fir	2.25	7.26	7.23	15.89	6.21	6.06	3.95	16.32	10.55	25.50	29.42	25.46	198.08	354.19	63.99
Other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total conifer	3.13	7.92	8.63	19.42	7.65	7.23	7.69	18.19	12.04	25.50	37.46	29.48	285.79	470.14	84.94
Acer	1.56	4.26	4.80	0.00	0.46	0.00	0.00	2.58	0.00	0.00	0.00	0.00	0.00	13.66	2.47
Betula	0.32	1.91	4.14	3.22	1.12	1.12	0.87	1.19	0.00	0.00	0.00	0.00	0.00	13.89	2.51
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	6.34	9.79	9.41	6.26	0.33	0.51	0.66	0.00	0.00	0.00	0.00	4.55	4.07	41.93	7.58
Other broadl.	3.31	5.04	3.16	1.14	0.00	0.55	0.70	0.00	0.00	0.00	0.00	0.00	0.00	13.89	2.51
Total broadl.	11.53	21.00	21.51	10.63	1.91	2.18	2.23	3.77	0.00	0.00	0.00	4.55	4.07	83.37	15.06
Total	14.67	28.92	30.13	30.05	9.56	9.41	9.92	21.96	12.04	25.50	37.46	34.03	289.86	553.51	100.00
%	2.65	5.23	5.44	5.43	1.73	1.70	1.79	3.97	2.18	4.61	6.77	6.15	52.37	100.00	

Additional Statistics for Main Table 5.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE GROSS VOLUME PER HA (m^3/ha)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Fir Working Circle
Area (ha) : 1464.95400000
Stratum Weight : 1.00000000
Number of Sampling Units : 32
Degrees of Freedom : 31
Sampling Intensity : 0.00109218
Finite Population Correction : 0.99890782

t (0.975, 31) : 2.04000000
t (0.950, 31) : 1.69500000
Estimate : 553.51149879
Standard Deviation : 363.82824080
Coefficient of Variation % : 65.73092729
Standard Error : 64.28122195
Sampling Error (P=0.95) : 131.13369278
Sampling Error % : 23.69123190
Reliable Minimum Estimate (P=0.95) : 444.5548275

Main Table 14. Survivor Trees >= 10 cm Dbh: Total Gross Volume.

Inventory Unit : Rudongla
Stratum : Fir Working Circle
Area (ha) : 1465.0
Period : 20/08/04 to 09/03/05

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)
Estimated Parameter : TOTAL GROSS VOLUME ('000 m^3)

Number of Strata : 1
Number of Sampling Units : 32
Estimate of Total : 810.869
t (0.975, 31) : 2.040
Sampling Error% for Estimate (at P=0.95) : 23.69

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
Spruce	0.00	0.00	1.08	0.00	0.00	0.00	1.09	0.00	0.00	0.00	0.00	0.00	16.74	18.91	2.33
Pinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	1.30	0.96	0.97	5.18	2.11	1.72	4.38	2.74	2.18	0.00	11.78	5.88	111.76	150.96	18.62
Fir	3.30	10.64	10.58	23.28	9.10	8.88	5.79	23.91	15.46	37.36	43.10	37.30	290.18	518.87	63.99
Other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total conifer	4.59	11.60	12.64	28.45	11.21	10.60	11.26	26.65	17.64	37.36	54.88	43.18	418.68	688.74	84.94
Acer	2.29	6.24	7.03	0.00	0.67	0.00	0.00	3.77	0.00	0.00	0.00	0.00	0.00	20.00	2.47
Betula	0.46	2.79	6.07	4.72	1.64	1.64	1.27	1.75	0.00	0.00	0.00	0.00	0.00	20.35	2.51
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	9.29	14.35	13.79	9.18	0.48	0.75	0.97	0.00	0.00	0.00	0.00	6.66	5.96	61.42	7.58
Other broadl.	4.85	7.38	4.62	1.67	0.00	0.80	1.03	0.00	0.00	0.00	0.00	0.00	0.00	20.35	2.51
Total broadl.	16.89	30.77	31.51	15.57	2.79	3.19	3.27	5.52	0.00	0.00	0.00	6.66	5.96	122.13	15.06
Total	21.48	42.37	44.14	44.02	14.00	13.79	14.53	32.17	17.64	37.36	54.88	49.85	424.64	810.87	100.00
%	2.65	5.23	5.44	5.43	1.73	1.70	1.79	3.97	2.18	4.61	6.77	6.15	52.37	100.00	

Additional Statistics for Main Table 14

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : TOTAL GROSS VOLUME ('000 m^3)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Fir Working Circle
Area (ha) : 1464.95400000
Stratum Weight : 1.00000000
Number of Sampling Units : 32
Degrees of Freedom : 31
Sampling Intensity : 0.00109218
Finite Population Correction : 0.99890782
t (0.975, 31) : 2.04000000
t (0.950, 31) : 1.69500000
Estimate : 810.86888419

Standard Deviation : 532.99163668
Coefficient of Variation % : 65.73092729
Standard Error : 94.16903322
Sampling Error (P=0.95) : 192.10482777
Sampling Error % : 23.69123190
Reliable Minimum Estimate (P=0.95) : 651.25237288

Main Table 23. Survivor Trees >= 10 cm Dbh: Total Stocked Area.

Inventory Unit : Rudongla
Stratum : Fir Working Circle
Area (ha) : 1465.0
Period : 20/08/04 to 09/03/05

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Estimated Parameter : TOTAL STOCKED AREA (ha)

Number of Strata : 1
Number of Sampling Units : 32
Estimate of Total : 1419.174
t (0.975, 31) : 2.040
Sampling Error% for Estimate (at P=0.95) : 6.58

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.00	0.00	3.56	0.00	0.00	0.00	1.34	0.00	0.00	0.00	0.00	0.00	16.31	21.21	1.49
Pinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	5.68	3.27	0.80	9.75	4.07	5.40	5.17	6.09	1.00	0.00	22.43	5.83	115.93	185.41	13.06
Fir	13.12	35.56	35.49	49.92	16.43	18.43	9.31	41.09	33.43	72.06	70.73	67.55	405.17	868.28	61.18
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	18.80	38.83	39.85	59.67	20.50	23.83	15.81	47.18	34.43	72.06	93.16	73.38	537.42	1074.90	75.74
Acer	5.56	16.76	15.74	0.00	0.38	0.00	0.00	11.73	0.00	0.00	0.00	0.00	0.00	50.17	3.54
Betula	1.33	12.65	16.23	20.99	7.09	12.29	5.15	3.54	0.00	0.00	0.00	0.00	0.00	79.27	5.59
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	34.91	44.93	26.77	16.19	0.85	1.37	1.97	0.00	0.00	0.00	0.00	6.94	12.28	146.22	10.30
other broadl.	19.46	26.91	12.98	5.36	0.00	2.12	1.78	0.00	0.00	0.00	0.00	0.00	0.00	68.60	4.83
total broadl.	61.26	101.26	71.72	42.54	8.33	15.78	8.90	15.26	0.00	0.00	0.00	6.94	12.28	344.27	24.26
total	80.06	140.09	111.57	102.21	28.83	39.61	24.72	62.44	34.43	72.06	93.16	80.32	549.70	1419.17	100.00
%	5.64	9.87	7.86	7.20	2.03	2.79	1.74	4.40	2.43	5.08	6.56	5.66	38.73	100.00	

Main Table 24. Conifer Survivor Trees >= 10 cm Dbh: Average Measured Periodic Annual Increment of Gross Volume per Ha.

Inventory Unit : Rudongla
Stratum : Fir Working Circle
Area (ha) : 1465.0
Period : 20/08/04 to 09/03/05

Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 32
Estimate of Total : 5.024
t (0.975, 31) : 2.040
Sampling Error% for Estimate (at P=0.95) : 33.99

Estimated Parameter : AVERAGE PERIODIC ANNUAL INCREMENT OF GROSS VOLUME PER HA (m^3/(ha*yr))

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.00	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.15	0.19	3.81
Pinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	0.05	0.04	0.03	0.12	0.03	0.02	0.06	0.02	0.03	0.00	0.10	0.06	0.67	1.23	24.52
Fir	0.17	0.35	0.24	0.39	0.11	0.09	0.05	0.18	0.12	0.23	0.26	0.20	1.21	3.60	71.66
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	0.22	0.39	0.30	0.51	0.14	0.12	0.13	0.21	0.15	0.23	0.36	0.26	2.03	5.02	100.00
Acer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total	0.22	0.39	0.30	0.51	0.14	0.12	0.13	0.21	0.15	0.23	0.36	0.26	2.03	5.02	100.00
%	4.35	7.73	5.88	10.06	2.84	2.34	2.50	4.10	2.90	4.61	7.19	5.11	40.39	100.00	

Additional Statistics for Main Table 24.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE PERIODIC ANNUAL

INCREMENT OF GROSS VOLUME PER HA (m^3/(ha*yr))
Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Fir Working Circle
Area (ha) : 1464.95400000
Stratum Weight : 1.00000000
Number of Sampling Units : 32

Degrees of Freedom : 31
Sampling Intensity : 0.00109218

Finite Population Correction : 0.99890782
t (0.975, 31) : 2.04000000
t (0.950, 31) : 1.69500000
Estimate : 5.02358969
Standard Deviation : 4.73730758
Coefficient of Variation % : 94.30124413
Standard Error : 0.83698813
Sampling Error (P=0.95) : 1.70745579
Sampling Error % : 33.98875895
Reliable Minimum Estimate (P=0.95) : 3.60489481

Main Table 25. Conifer Survivor Trees >= 10 cm Dbh: Total Measured Periodic Annual Increment of Gross Volume.

Inventory Unit : Rudongla
Stratum : Fir Working Circle

Number of Strata : 1
Number of Sampling Units : 32

Area (ha) : 1465.0
Period : 20/08/04 to 09/03/05

Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

Estimate of Total : 7.359
t (0.975, 31) : 2.040
Sampling Error% for Estimate (at P=0.95) : 33.99

Estimated Parameter : TOTAL PERIODIC ANNUAL INCREMENT OF GROSS VOLUME ('000 m^3/yr)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.00	0.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.22	0.28	3.81
Pinus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tsuga	0.07	0.05	0.05	0.17	0.05	0.04	0.09	0.03	0.04	0.00	0.15	0.08	0.98	1.80	24.52
Fir	0.25	0.52	0.34	0.57	0.16	0.14	0.07	0.27	0.17	0.34	0.38	0.29	1.78	5.27	71.66
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	0.32	0.57	0.43	0.74	0.21	0.17	0.18	0.30	0.21	0.34	0.53	0.38	2.97	7.36	100.00
Acer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total	0.32	0.57	0.43	0.74	0.21	0.17	0.18	0.30	0.21	0.34	0.53	0.38	2.97	7.36	100.00
%	4.35	7.73	5.88	10.06	2.84	2.34	2.50	4.10	2.90	4.61	7.19	5.11	40.39	100.00	

Additional Statistics for Main Table 25.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : TOTAL PERIODIC ANNUAL INCREMENT OF GROSS VOLUME ('000 m^3/yr)
Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)
STRATUM : Fir Working Circle
Area (ha) : 1464.95400000
Stratum Weight : 1.00000000
Number of Sampling Units : 32
Degrees of Freedom : 31
Sampling Intensity : 0.00109218
Finite Population Correction : 0.99890782

t (0.975, 31) : 2.04000000
t (0.950, 31) : 1.69500000
Estimate : 7.35932782
Standard Deviation : 6.93993769

Coefficient of Variation % : 94.30124413
Standard Error : 1.22614911
Sampling Error (P=0.95) : 2.50134419
Sampling Error % : 33.98875895
Reliable Minimum Estimate (P=0.95) : 5.28100507

Main Table 1. Survivor Trees >= 10 cm Dbh: Average Number of Trees per Ha.

Inventory Unit : Rudongla
Stratum : Bluepine working circle
Area (ha) : 1058.1
Period : 05/08/04 to 29/10/04

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 16
Estimate of Total : 1472.500
t (0.975, 15) : 2.131
Sampling Error% for Estimate (at P=0.95) : 60.08

Estimated Parameter : AVERAGE NUMBER OF TREES PER HA (/ha)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.00	0.00	0.00	0.00	1.25	0.00	2.50	0.00	0.00	1.25	0.00	0.00	0.00	5.00	0.34
Pinus	450.00	275.00	206.25	118.75	20.00	15.00	10.00	1.25	3.75	3.75	2.50	6.25	6.25	1118.75	75.98
Tsuga	0.00	18.75	37.50	25.00	3.75	6.25	3.75	3.75	2.50	5.00	0.00	2.50	10.00	118.75	8.06
Fir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	450.00	293.75	243.75	143.75	25.00	21.25	16.25	5.00	6.25	10.00	2.50	8.75	16.25	1242.50	84.38
Acer	18.75	25.00	18.75	25.00	0.00	1.25	0.00	0.00	0.00	1.25	1.25	0.00	0.00	91.25	6.20
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	18.75	6.25	6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.25	2.12
other broadl.	50.00	43.75	6.25	6.25	0.00	0.00	0.00	1.25	0.00	0.00	0.00	0.00	0.00	107.50	7.30
total broadl.	87.50	75.00	31.25	31.25	0.00	1.25	0.00	1.25	0.00	1.25	1.25	0.00	0.00	230.00	15.62
total	537.50	368.75	275.00	175.00	25.00	22.50	16.25	6.25	6.25	11.25	3.75	8.75	16.25	1472.50	100.00
%	36.50	25.04	18.68	11.88	1.70	1.53	1.10	0.42	0.42	0.76	0.25	0.59	1.10	100.00	

Additional Statistics for Main Table 1.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE NUMBER OF TREES PER HA (/ha)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Bluepine working circle
Area (ha) : 1058.10200000
Stratum Weight : 1.00000000
Number of Sampling Units : 16
Degrees of Freedom : 15
Sampling Intensity : 0.00075607
Finite Population Correction : 0.99924393

t (0.975, 15) : 2.13100000
t (0.950, 15) : 1.75300000
Estimate : 1472.50000000
Standard Deviation : 1661.22645456
Coefficient of Variation % : 112.81673715
Standard Error : 415.14958352
Sampling Error (P=0.95) : 884.68376248
Sampling Error % : 60.08039134
Reliable Minimum Estimate (P=0.95) : 744.74278009

Main Table 4. Survivor Trees >= 10 cm Dbh: Average Basal Area per Ha.

Inventory Unit : Rudongla
Stratum : Bluepine working circle
Area (ha) : 1058.1
Period : 05/08/04 to 29/10/04

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Estimated Parameter : AVERAGE BASAL AREA PER HA (m^2/ha)

Number of Strata : 1
Number of Sampling Units : 16
Estimate of Total : 67.325
t (0.975, 15) : 2.131
Sampling Error% for Estimate (at P=0.95) : 43.18

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.00	0.00	0.00	0.00	0.09	0.00	0.33	0.00	0.00	0.31	0.00	0.00	0.00	0.73	1.08
Pinus	5.21	6.17	7.59	6.86	1.60	1.55	1.34	0.23	0.76	0.94	0.77	2.19	6.48	41.69	61.92
Tsuga	0.00	0.38	1.37	1.33	0.32	0.67	0.54	0.67	0.49	1.27	0.00	0.90	10.65	18.58	27.60
Fir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	5.21	6.55	8.96	8.19	2.01	2.22	2.20	0.90	1.25	2.51	0.77	3.09	17.14	61.00	90.60
Acer	0.25	0.49	0.63	1.36	0.00	0.12	0.00	0.00	0.00	0.30	0.35	0.00	0.00	3.50	5.20
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	0.16	0.14	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.80
other broadl.	0.59	0.95	0.22	0.31	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	2.29	3.41
total broadl.	1.00	1.58	1.08	1.67	0.00	0.12	0.00	0.23	0.00	0.30	0.35	0.00	0.00	6.33	9.40
total	6.21	8.14	10.04	9.86	2.01	2.34	2.20	1.12	1.25	2.81	1.12	3.09	17.14	67.32	100.00
%	9.22	12.09	14.92	14.64	2.98	3.48	3.27	1.67	1.85	4.17	1.66	4.59	25.46	100.00	

Additional Statistics for Main Table 4.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE BASAL AREA PER HA (m^2/ha)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Bluepine working circle
Area (ha) : 1058.10200000
Stratum Weight : 1.00000000
Number of Sampling Units : 16
Degrees of Freedom : 15
Sampling Intensity : 0.00075607
Finite Population Correction : 0.99924393
t (0.975, 15) : 2.13100000

t (0.950, 15) : 1.75300000
Estimate : 67.32452689
Standard Deviation : 54.58903838
Coefficient of Variation % : 81.08343409
Standard Error : 13.64209948
Sampling Error (P=0.95) : 29.07131399
Sampling Error % : 43.18086637
Reliable Minimum Estimate (P=0.95) : 43.40992650

Main Table 5. Survivor Trees >= 10 cm Dbh: Average Gross Volume per Ha.

Inventory Unit : Rudongla
Stratum : Bluepine working circle
Area (ha) : 1058.1
Period : 05/08/04 to 29/10/04

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 16
Estimate of Total : 533.783
t (0.975, 15) : 2.131
Sampling Error% for Estimate (at P=0.95) : 45.11

Estimated Parameter : AVERAGE GROSS VOLUME PER HA (m^3/ha)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.00	0.00	0.00	0.00	0.65	0.00	2.81	0.00	0.00	2.90	0.00	0.00	0.00	6.37	1.19
Pinus	22.52	34.78	51.06	58.88	12.09	14.90	12.68	2.68	7.82	10.52	10.14	27.31	54.51	319.88	59.93
Tsuga	0.00	1.79	7.95	8.63	2.35	5.19	4.36	5.65	4.21	11.26	0.00	8.29	106.55	166.23	31.14
Fir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	22.52	36.58	59.02	67.51	15.09	20.09	19.85	8.33	12.02	24.68	10.14	35.61	161.05	492.48	92.26
Acer	1.72	3.30	4.43	10.10	0.00	0.71	0.00	0.00	0.00	2.11	4.13	0.00	0.00	26.51	4.97
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	0.58	0.75	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.81	0.53
other broadl.	2.66	4.13	0.70	2.06	0.00	0.00	0.00	2.42	0.00	0.00	0.00	0.00	0.00	11.97	2.24
total broadl.	4.97	8.18	6.62	12.16	0.00	0.71	0.00	2.42	0.00	2.11	4.13	0.00	0.00	41.30	7.74
total	27.49	44.76	65.63	79.67	15.09	20.80	19.85	10.74	12.02	26.78	14.27	35.61	161.05	533.78	100.00
%	5.15	8.39	12.30	14.93	2.83	3.90	3.72	2.01	2.25	5.02	2.67	6.67	30.17	100.00	

Additional Statistics for Main Table 5.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE GROSS VOLUME PER HA (m^3/ha)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Bluepine working circle
Area (ha) : 1058.10200000
Stratum Weight : 1.00000000
Number of Sampling Units : 16
Degrees of Freedom : 15
Sampling Intensity : 0.00075607
Finite Population Correction : 0.99924393

t (0.975, 15) : 2.13100000
t (0.950, 15) : 1.75300000
Estimate : 533.78282855
Standard Deviation : 452.11753405
Coefficient of Variation % : 84.70065163
Standard Error : 112.98664637
Sampling Error (P=0.95) : 240.77454341
Sampling Error % : 45.10721037
Reliable Minimum Estimate (P=0.95) : 335.71723747

Main Table 14. Survivor Trees >= 10 cm Dbh: Total Gross Volume.

Inventory Unit : Rudongla
Stratum : Bluepine working circle
Area (ha) : 1058.1
Period : 05/08/04 to 29/10/04

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Estimated Parameter : TOTAL GROSS VOLUME ('000 m^3)

Number of Strata : 1
Number of Sampling Units : 16
Estimate of Total : 564.797
t (0.975, 15) : 2.131
Sampling Error% for Estimate (at P=0.95) : 45.11

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.00	0.00	0.00	0.00	0.69	0.00	2.97	0.00	0.00	3.07	0.00	0.00	0.00	6.74	1.19
Pinus	23.83	36.80	54.03	62.30	12.79	15.77	13.41	2.83	8.27	11.13	10.73	28.90	57.67	338.47	59.93
Tsuga	0.00	1.90	8.42	9.13	2.49	5.49	4.62	5.98	4.45	11.91	0.00	8.78	112.74	175.89	31.14
Fir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	23.83	38.70	62.45	71.43	15.97	21.26	21.00	8.81	12.72	26.11	10.73	37.67	170.41	521.10	92.26
Acer	1.82	3.49	4.69	10.69	0.00	0.76	0.00	0.00	0.00	2.23	4.37	0.00	0.00	28.05	4.97
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	0.62	0.80	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.98	0.53
other broadl.	2.82	4.37	0.74	2.18	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	12.67	2.24
total broadl.	5.26	8.66	7.00	12.87	0.00	0.76	0.00	2.56	0.00	2.23	4.37	0.00	0.00	43.70	7.74
total	29.09	47.36	69.45	84.30	15.97	22.01	21.00	11.37	12.72	28.34	15.10	37.67	170.41	564.80	100.00
%	5.15	8.39	12.30	14.93	2.83	3.90	3.72	2.01	2.25	5.02	2.67	6.67	30.17	100.00	

Additional Statistics for Main Table 14.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : TOTAL GROSS VOLUME ('000 m^3)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Bluepine working circle
Area (ha) : 1058.10200000
Stratum Weight : 1.00000000
Number of Sampling Units : 16
Degrees of Freedom : 15
Sampling Intensity : 0.00075607
Finite Population Correction : 0.99924393

t (0.975, 15) : 2.13100000
t (0.950, 15) : 1.75300000
Estimate : 564.79667845
Standard Deviation : 478.38646701
Coefficient of Variation % : 84.70065163
Standard Error : 119.55139650
Sampling Error (P=0.95) : 254.76402593
Sampling Error % : 45.10721037
Reliable Minimum Estimate (P=0.95) : 355.22308040

Main Table 23. Survivor Trees >= 10 cm Dbh: Total Stocked Area.

Inventory Unit : Rudongla
Stratum : Bluepine working circle
Area (ha) : 1058.1
Period : 05/08/04 to 29/10/04

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Estimated Parameter : TOTAL STOCKED AREA (ha)

Number of Strata : 1
Number of Sampling Units : 16
Estimate of Total : 991.971
t (0.975, 15) : 2.131
Sampling Error% for Estimate (at P=0.95) : 14.20

	Dbh class (cm)													
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
Spruce	0.00	0.00	0.00	0.00	4.52	0.00	7.19	0.00	0.00	6.88	0.00	0.00	0.00	18.59	1.87
Pinus	58.10	67.18	62.75	86.45	11.88	53.79	56.03	8.72	21.03	20.56	5.82	25.38	88.64	566.33	57.09
Tsuga	0.00	4.28	19.57	16.52	4.26	13.56	10.04	14.42	8.11	29.90	0.00	12.04	107.74	240.44	24.24
Fir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	58.10	71.46	82.32	102.97	20.65	67.35	73.25	23.14	29.14	57.34	5.82	37.42	196.39	825.36	83.20
Acer	4.85	11.40	15.93	38.20	0.00	6.10	0.00	0.00	0.00	15.06	17.93	0.00	0.00	109.48	11.04
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	1.01	0.91	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.46	0.35
other broadl.	11.90	25.11	3.22	1.98	0.00	0.00	0.00	11.47	0.00	0.00	0.00	0.00	0.00	53.68	5.41
total broadl.	17.77	37.41	20.68	40.17	0.00	6.10	0.00	11.47	0.00	15.06	17.93	0.00	0.00	166.61	16.80
total	75.87	108.87	103.00	143.15	20.65	73.45	73.25	34.61	29.14	72.41	23.75	37.42	196.39	991.97	100.00
%	7.65	10.98	10.38	14.43	2.08	7.40	7.38	3.49	2.94	7.30	2.39	3.77	19.80	100.00	

Main Table 24. Conifer Survivor Trees >= 10 cm Dbh: Average Measured Periodic Annual Increment of Gross Volume per Ha.

Inventory Unit : Rudongla
Stratum : Bluepine working circle
Area (ha) : 1058.1
Period : 05/08/04 to 29/10/04

Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 16
Estimate of Total : 9.609
t (0.975, 15) : 2.131
Sampling Error% for Estimate (at P=0.95) : 54.88

Estimated Parameter : AVERAGE PERIODIC ANNUAL INCREMENT OF GROSS VOLUME PER HA (m^3/(ha*yr))

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.00	0.00	0.00	0.00	0.02	0.00	0.06	0.00	0.00	0.04	0.00	0.00	0.00	0.12	1.21
Pinus	0.55	1.30	1.71	1.52	0.29	0.35	0.25	0.06	0.12	0.14	0.12	0.35	1.16	7.92	82.46
Tsuga	0.00	0.10	0.32	0.27	0.05	0.10	0.06	0.07	0.05	0.11	0.00	0.06	0.37	1.57	16.33
Fir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	0.55	1.40	2.03	1.79	0.36	0.45	0.37	0.13	0.17	0.29	0.12	0.41	1.53	9.61	100.00
Acer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total	0.55	1.40	2.03	1.79	0.36	0.45	0.37	0.13	0.17	0.29	0.12	0.41	1.53	9.61	100.00
%	5.69	14.59	21.13	18.67	3.72	4.65	3.85	1.38	1.75	3.06	1.29	4.30	15.91	100.00	

Additional Statistics for Main Table 24.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE PERIODIC ANNUAL INCREMENT OF GROSS VOLUME PER HA (m^3/(ha*yr))
Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Bluepine working circle
Area (ha) : 1058.10200000
Stratum Weight : 1.00000000
Number of Sampling Units : 16
Degrees of Freedom : 15
Sampling Intensity : 0.00075607
Finite Population Correction : 0.99924393
t (0.975, 15) : 2.13100000
t (0.950, 15) : 1.75300000

Estimate : 9.60918630
Standard Deviation : 9.90320763
Coefficient of Variation % : 103.05979426
Standard Error : 2.47486579
Sampling Error (P=0.95) : 5.27393900
Sampling Error % : 54.88434542
Reliable Minimum Estimate (P=0.95) : 5.27074657

Main Table 25. Conifer Survivor Trees >= 10 cm Dbh: Total Measured Periodic Annual Increment of Gross Volume.

Inventory Unit : Rudongla
Stratum : Bluepine working circle
Area (ha) : 1058.1
Period : 05/08/04 to 29/10/04

Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 16
Estimate of Total : 10.167
t (0.975, 15) : 2.131
Sampling Error% for Estimate (at P=0.95) : 54.88

Estimated Parameter : TOTAL PERIODIC ANNUAL INCREMENT OF GROSS VOLUME ('000 m^3/yr)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.00	0.00	0.00	0.00	0.02	0.00	0.06	0.00	0.00	0.05	0.00	0.00	0.00	0.12	1.21
Pinus	0.58	1.37	1.81	1.61	0.31	0.37	0.26	0.07	0.13	0.15	0.13	0.37	1.23	8.38	82.46
Tsuga	0.00	0.11	0.34	0.29	0.05	0.10	0.07	0.08	0.05	0.12	0.00	0.07	0.39	1.66	16.33
Fir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other conifer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total conifer	0.58	1.48	2.15	1.90	0.38	0.47	0.39	0.14	0.18	0.31	0.13	0.44	1.62	10.17	100.00
Acer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total	0.58	1.48	2.15	1.90	0.38	0.47	0.39	0.14	0.18	0.31	0.13	0.44	1.62	10.17	100.00
%	5.69	14.59	21.13	18.67	3.72	4.65	3.85	1.38	1.75	3.06	1.29	4.30	15.91	100.00	

Additional Statistics for Main Table 25.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : TOTAL PERIODIC ANNUAL INCREMENT OF GROSS VOLUME ('000 m^3/yr)
Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Bluepine working circle
Area (ha) : 1058.10200000
Stratum Weight : 1.00000000
Number of Sampling Units : 16
Degrees of Freedom : 15
Sampling Intensity : 0.00075607

Finite Population Correction : 0.99924393
t (0.975, 15) : 2.13100000
t (0.950, 15) : 1.75300000
Estimate : 10.16749924
Standard Deviation : 10.47860380
Coefficient of Variation % : 103.05979426
Standard Error : 2.61866044
Sampling Error (P=0.95) : 5.58036540
Sampling Error % : 54.88434542
Reliable Minimum Estimate (P=0.95) : 5.57698749

Main Table 1. Survivor Trees >= 10 cm Dbh: Average Number of Trees per Ha.

Inventory Unit : Rudongla
Stratum : Mixed Conifer WC
Area (ha) : 5127.7
Period : 03/08/04 to 21/12/04

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 68
Estimate of Total : 1207.059
t (0.975, 67) : 1.997
Sampling Error% for Estimate (at P=0.95) : 21.41

Estimated Parameter : AVERAGE NUMBER OF TREES PER HA (/ha)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	8.82	8.82	13.24	2.94	0.88	1.18	1.18	1.18	0.29	0.00	0.00	0.00	2.35	40.88	3.39
Pinus	133.82	102.94	76.47	36.76	6.76	2.06	4.12	0.88	3.24	1.18	1.76	2.35	2.65	375.00	31.07
Tsuga	17.65	17.65	29.41	20.59	3.53	1.76	1.47	1.76	2.65	1.47	3.82	2.35	21.47	125.59	10.40
Fir	16.18	7.35	7.35	16.18	2.06	3.24	2.06	3.53	2.65	2.94	2.06	2.65	11.76	80.00	6.63
other conifer	2.94	4.41	2.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	10.59	0.88
total conifer	179.41	141.18	129.41	76.47	13.24	8.24	8.82	7.35	8.82	5.59	7.65	7.35	38.53	632.06	52.36
Acer	61.76	48.53	25.00	8.82	1.18	0.00	0.29	0.29	1.47	0.29	0.00	0.29	0.88	148.82	12.33
Betula	0.00	2.94	1.47	2.94	0.00	0.29	0.00	0.29	0.00	0.00	0.00	0.00	0.00	7.94	0.66
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	170.59	51.47	20.59	7.35	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250.59	20.76
other broadl.	98.53	50.00	14.71	2.94	1.18	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	167.65	13.89
total broadl.	330.88	152.94	61.76	22.06	2.35	0.88	0.59	0.59	1.47	0.29	0.00	0.29	0.88	575.00	47.64
total	510.29	294.12	191.18	98.53	15.59	9.12	9.41	7.94	10.29	5.88	7.65	7.65	39.41	1207.06	100.00
%	42.28	24.37	15.84	8.16	1.29	0.76	0.78	0.66	0.85	0.49	0.63	0.63	3.27	100.00	

Additional Statistics for Main Table 1.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE NUMBER OF TREES PER HA (/ha)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Mixed Conifer WC
Area (ha) : 5127.69500000
Stratum Weight : 1.00000000
Number of Sampling Units : 68
Degrees of Freedom : 67

Sampling Intensity : 0.00066307

Finite Population Correction : 0.99933693
t (0.975, 67) : 1.99700000
t (0.950, 67) : 1.66800000
Estimate : 1207.05882353
Standard Deviation : 1067.24790280
Coefficient of Variation % : 88.41722392
Standard Error : 129.37990328
Sampling Error (P=0.95) : 258.37166685
Sampling Error % : 21.40506012
Reliable Minimum Estimate (P=0.95) : 991.25314486

Main Table 4. Survivor Trees >= 10 cm Dbh: Average Basal Area per Ha.

Inventory Unit : Rudongla
Stratum : Mixed Conifer WC
Area (ha) : 5127.7
Period : 03/08/04 to 21/12/04

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 68
Estimate of Total : 68.630
t (0.975, 67) : 1.997
Sampling Error% for Estimate (at P=0.95) : 16.63

Estimated Parameter : AVERAGE BASAL AREA PER HA (m^2/ha)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.12	0.20	0.46	0.18	0.07	0.12	0.17	0.21	0.07	0.00	0.00	0.00	1.84	3.42	4.98
Pinus	1.43	2.26	2.87	2.09	0.53	0.22	0.56	0.15	0.67	0.30	0.51	0.83	1.39	13.82	20.13
Tsuga	0.22	0.40	1.09	1.17	0.28	0.19	0.19	0.30	0.56	0.39	1.14	0.82	19.65	26.41	38.49
Fir	0.18	0.16	0.29	0.94	0.16	0.34	0.28	0.63	0.56	0.74	0.61	0.91	6.67	12.47	18.18
other conifer	0.03	0.09	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.47	0.68
total conifer	1.98	3.10	4.81	4.38	1.04	0.88	1.20	1.28	1.86	1.43	2.27	2.56	29.79	56.59	82.46
Acer	0.67	1.05	0.87	0.48	0.09	0.00	0.04	0.05	0.30	0.07	0.00	0.11	0.67	4.39	6.40
Betula	0.00	0.06	0.06	0.15	0.00	0.04	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.35	0.51
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	2.04	1.12	0.72	0.40	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.33	6.31
other broadl.	1.08	1.07	0.52	0.16	0.09	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	2.96	4.32
total broadl.	3.80	3.30	2.17	1.19	0.18	0.09	0.08	0.09	0.30	0.07	0.00	0.11	0.67	12.04	17.54
total	5.78	6.40	6.99	5.57	1.21	0.97	1.28	1.37	2.16	1.50	2.27	2.67	30.46	68.63	100.00
%	8.42	9.33	10.18	8.11	1.77	1.42	1.86	2.00	3.15	2.19	3.31	3.89	44.38	100.00	

Additional Statistics for Main Table 4.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE BASAL AREA PER HA (m^2/ha)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Mixed Conifer WC
Area (ha) : 5127.69500000
Stratum Weight : 1.00000000
Number of Sampling Uni : 68
Degrees of Freedom : 67
Sampling Intensity : 0.00066307
Finite Population Correction : 0.99933693
t (0.975, 67) : 1.99700000
t (0.950, 67) : 1.66800000

Estimate : 68.63000863
Standard Deviation : 47.13361902
Coefficient of Variation % : 68.67785677
Standard Error : 5.71389558
Sampling Error (P=0.95) : 11.41064947
Sampling Error % : 16.62632672
Reliable Minimum Estimate (P=0.95) : 59.09923081

Main Table 5. Survivor Trees >= 10 cm Dbh: Average Gross Volume per Ha.

Inventory Unit : Rudongla
Stratum : Mixed Conifer WC
Area (ha) : 5127.7
Period : 03/08/04 to 21/12/04

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 68
Estimate of Total : 598.583
t (0.975, 67) : 1.997
Sampling Error% for Estimate (at P=0.95) : 18.04

Estimated Parameter : AVERAGE GROSS VOLUME PER HA (m^3/ha)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.49	1.09	3.05	1.22	0.49	0.97	1.44	1.85	0.63	0.00	0.00	0.00	19.43	30.65	5.12
Pinus	5.69	12.34	19.28	16.06	4.24	2.13	5.44	1.56	7.25	3.39	6.88	9.65	15.12	109.02	18.21
Tsuga	0.89	2.13	6.40	7.93	2.16	1.58	1.74	2.49	5.27	3.45	11.62	7.62	204.62	257.90	43.08
Fir	0.88	0.77	2.11	7.37	1.52	3.03	2.97	6.10	5.22	7.39	6.11	9.08	67.12	119.67	19.99
other conifer	0.14	0.51	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.55	3.90	0.65
total conifer	8.09	16.84	31.53	32.58	8.40	7.71	11.59	12.00	18.37	14.23	24.61	26.34	308.84	521.14	87.06
Acer	4.87	7.14	6.31	3.64	0.78	0.00	0.34	0.68	3.11	0.74	0.00	1.21	8.41	37.24	6.22
Betula	0.00	0.35	0.37	1.36	0.00	0.32	0.00	0.46	0.00	0.00	0.00	0.00	0.00	2.85	0.48
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	8.69	5.64	4.35	2.73	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.81	3.64
other broadl.	4.65	5.59	3.19	1.13	0.64	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	15.55	2.60
total broadl.	18.21	18.71	14.23	8.86	1.42	0.72	0.69	1.14	3.11	0.74	0.00	1.21	8.41	77.45	12.94
total	26.29	35.56	45.76	41.44	9.82	8.42	12.28	13.14	21.48	14.97	24.61	27.55	317.26	598.58	100.00
%	4.39	5.94	7.64	6.92	1.64	1.41	2.05	2.20	3.59	2.50	4.11	4.60	53.00	100.00	

Additional Statistics for Main Table 5.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE GROSS VOLUME PER HA (m^3/ha)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Mixed Conifer WC
Area (ha) : 5127.69500000
Stratum Weight : 1.00000000
Number of Sampling Units : 68
Degrees of Freedom : 67
Sampling Intensity : 0.00066307

Finite Population Correction : 0.99933693
t (0.975, 67) : 1.99700000
t (0.950, 67) : 1.66800000
Estimate : 598.58271189
Standard Deviation : 446.03209743
Coefficient of Variation % : 74.51469756
Standard Error : 54.07140129
Sampling Error (P=0.95) : 107.98058837
Sampling Error % : 18.03937638
Reliable Minimum Estimate (P=0.95) : 508.39161454

Main Table 14. Survivor Trees >= 10 cm Dbh: Total Gross Volume.

Inventory Unit : Rudongla
Stratum : Mixed Conifer WC
Area (ha) : 5127.7
Period : 03/08/04 to 21/12/04

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 68
Estimate of Total : 3069.350
t (0.975, 67) : 1.997
Sampling Error% for Estimate (at P=0.95) : 18.04

Estimated Parameter : TOTAL GROSS VOLUME ('000 m^3)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	2.50	5.59	15.64	6.23	2.50	4.96	7.39	9.48	3.23	0.00	0.00	0.00	99.65	157.17	5.12
Pinus	29.20	63.26	98.85	82.35	21.72	10.93	27.87	8.01	37.16	17.39	35.26	49.48	77.55	559.02	18.21
Tsuga	4.56	10.93	32.81	40.68	11.05	8.11	8.91	12.78	27.05	17.69	59.58	39.06	1049.21	1322.41	43.08
Fir	4.52	3.96	10.80	37.79	7.80	15.53	15.25	31.28	26.76	37.90	31.35	46.54	344.16	613.63	19.99
other conifer	0.70	2.62	3.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.08	20.00	0.65
total conifer	41.47	86.37	161.70	167.05	43.07	39.53	59.42	61.55	94.19	72.98	126.19	135.08	1583.65	2672.23	87.06
Acer	24.95	36.62	32.37	18.68	4.01	0.00	1.75	3.49	15.94	3.77	0.00	6.21	43.15	190.95	6.22
Betula	0.00	1.77	1.89	6.96	0.00	1.65	0.00	2.34	0.00	0.00	0.00	0.00	0.00	14.62	0.48
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	44.57	28.90	22.32	14.01	0.00	2.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	111.82	3.64
other broadl.	23.83	28.66	16.37	5.79	3.28	0.00	1.79	0.00	0.00	0.00	0.00	0.00	0.00	79.73	2.60
total broadl.	93.35	95.95	72.95	45.45	7.29	3.67	3.55	5.84	15.94	3.77	0.00	6.21	43.15	397.12	12.94
total	134.82	182.32	234.65	212.51	50.37	43.20	62.96	67.38	110.13	76.75	126.19	141.29	1626.79	3069.35	100.00
%	4.39	5.94	7.64	6.92	1.64	1.41	2.05	2.20	3.59	2.50	4.11	4.60	53.00	100.00	

Additional Statistics for Main Table 14.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : TOTAL GROSS VOLUME ('000 m^3)
Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Mixed Conifer WC
Area (ha) : 5127.69500000
Stratum Weight : 1.00000000
Number of Sampling Units : 68
Degrees of Freedom : 67
Sampling Intensity : 0.00066307
Finite Population Correction : 0.99933693

t (0.975, 67) : 1.99700000
t (0.950, 67) : 1.66800000
Estimate : 3069.34957884
Standard Deviation : 2287.11655583
Coefficient of Variation % : 74.51469756
Standard Error : 277.26165402
Sampling Error (P=0.95) : 553.69152308
Sampling Error % : 18.03937638
Reliable Minimum Estimate (P=0.95) : 2606.87713993

Main Table 23. Survivor Trees >= 10 cm Dbh: Total Stocked Area.

Inventory Unit : Rudongla
Stratum : Mixed Conifer WC
Area (ha) : 5127.7
Period : 03/08/04 to 21/12/04

Tree Status : Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 68
Estimate of Total : 4976.880
t (0.975, 67) : 1.997
Sampling Error% for Estimate (at P=0.95) : 4.25

Estimated Parameter : TOTAL STOCKED AREA (ha)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	15.62	25.78	51.74	29.00	10.78	11.47	20.28	30.26	9.57	0.00	0.00	0.00	102.87	307.37	6.18
Pinus	108.41	221.03	266.13	167.58	74.66	23.06	159.79	14.17	141.58	27.55	54.52	65.90	103.41	1427.79	28.69
Tsuga	20.20	29.86	63.58	73.55	18.65	15.92	9.26	35.34	53.15	43.93	89.07	53.81	1041.65	1547.98	31.10
Fir	11.33	7.84	17.01	50.38	15.22	18.93	24.81	55.20	35.69	46.55	37.18	55.72	383.09	758.94	15.25
other conifer	12.53	48.01	9.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.93	80.53	1.62
total conifer	168.09	332.52	407.52	320.51	119.30	69.38	214.14	134.97	239.99	118.02	180.77	175.43	1641.95	4122.60	82.84
Acer	41.97	89.23	77.82	63.55	9.08	0.00	16.15	1.34	25.76	2.01	0.00	20.72	26.77	374.38	7.52
Betula	0.00	3.22	3.83	10.80	0.00	1.60	0.00	16.19	0.00	0.00	0.00	0.00	0.00	35.64	0.72
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	102.32	62.35	36.88	17.03	0.00	7.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	225.84	4.54
other broadl.	84.52	77.72	34.99	12.19	5.33	0.00	3.67	0.00	0.00	0.00	0.00	0.00	0.00	218.42	4.39
total broadl.	228.81	232.52	153.52	103.57	14.41	8.86	19.82	17.52	25.76	2.01	0.00	20.72	26.77	854.28	17.16
total	396.90	565.04	561.04	424.08	133.71	78.24	233.96	152.49	265.75	120.04	180.77	196.15	1668.72	4976.88	100.00
%	7.97	11.35	11.27	8.52	2.69	1.57	4.70	3.06	5.34	2.41	3.63	3.94	33.53	100.00	

Main Table 24. Conifer Survivor Trees >= 10 cm Dbh: Average Measured Periodic Annual Increment of Gross Volume per Ha.

Inventory Unit : Rudongla
Stratum : Mixed Conifer WC
Area (ha) : 5127.7
Period : 03/08/04 to 21/12/04

Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 68
Estimate of Total : 6.145
t (0.975, 67) : 1.997
Sampling Error% for Estimate (at P=0.95) : 19.31

Estimated Parameter : AVERAGE PERIODIC ANNUAL INCREMENT OF GROSS VOLUME PER HA (m^3/(ha*yr))

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.03	0.05	0.09	0.05	0.01	0.02	0.03	0.03	0.01	0.00	0.00	0.00	0.18	0.50	8.18
Pinus	0.13	0.46	0.62	0.44	0.10	0.04	0.09	0.02	0.10	0.04	0.08	0.10	0.11	2.35	38.26
Tsuga	0.05	0.11	0.26	0.24	0.05	0.03	0.03	0.03	0.07	0.03	0.11	0.07	1.04	2.13	34.59
Fir	0.07	0.05	0.07	0.17	0.03	0.05	0.04	0.06	0.05	0.07	0.05	0.06	0.35	1.10	17.92
other conifer	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.06	1.05
total conifer	0.28	0.68	1.06	0.90	0.19	0.14	0.19	0.15	0.23	0.14	0.24	0.23	1.71	6.15	100.00
Acer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total	0.28	0.68	1.06	0.90	0.19	0.14	0.19	0.15	0.23	0.14	0.24	0.23	1.71	6.15	100.00
%	4.58	11.06	17.18	14.62	3.08	2.29	3.12	2.38	3.75	2.35	3.91	3.82	27.86	100.00	

Additional Statistics for Main Table 24.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : AVERAGE PERIODIC ANNUAL INCREMENT OF GROSS VOLUME PER HA (m^3/(ha*yr))
Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Mixed Conifer WC
Area (ha) : 5127.69500000
Stratum Weight : 1.00000000
Number of Sampling Units : 68
Degrees of Freedom : 67

Sampling Intensity : 0.00066307
Finite Population Correction : 0.99933693
t (0.975, 67) : 1.99700000
t (0.950, 67) : 1.66800000
Estimate : 6.14515328
Standard Deviation : 4.90199221
Coefficient of Variation % : 79.77005596
Standard Error : 0.59425676
Sampling Error (P=0.95) : 1.18673074
Sampling Error % : 19.31165409
Reliable Minimum Estimate (P=0.95) : 5.15393301

Main Table 25. Conifer Survivor Trees >= 10 cm Dbh: Total Measured Periodic Annual Increment of Gross Volume.

Inventory Unit : Rudongla
Stratum : Mixed Conifer WC
Area (ha) : 5127.7
Period : 03/08/04 to 21/12/04

Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

Number of Strata : 1
Number of Sampling Units : 68
Estimate of Total : 31.510
t (0.975, 67) : 1.997
Sampling Error% for Estimate (at P=0.95) : 19.31

Estimated Parameter : TOTAL PERIODIC ANNUAL INCREMENT OF GROSS VOLUME ('000 m^3/yr)

	Dbh class (cm)														
Species Group	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	total	%
spruce	0.15	0.24	0.48	0.23	0.06	0.11	0.14	0.16	0.05	0.00	0.00	0.00	0.95	2.58	8.18
Pinus	0.65	2.36	3.19	2.27	0.53	0.23	0.48	0.11	0.54	0.22	0.40	0.52	0.57	12.06	38.26
Tsuga	0.26	0.55	1.34	1.22	0.24	0.15	0.18	0.17	0.36	0.17	0.58	0.36	5.32	10.90	34.59
Fir	0.35	0.24	0.34	0.88	0.13	0.23	0.18	0.31	0.24	0.36	0.25	0.32	1.81	5.65	17.92
other conifer	0.03	0.10	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.33	1.05
total conifer	1.44	3.49	5.41	4.61	0.97	0.72	0.98	0.75	1.18	0.74	1.23	1.20	8.78	31.51	100.00
Acer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Betula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quercus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhododendron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
other broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total broadl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total	1.44	3.49	5.41	4.61	0.97	0.72	0.98	0.75	1.18	0.74	1.23	1.20	8.78	31.51	100.00
%	4.58	11.06	17.18	14.62	3.08	2.29	3.12	2.38	3.75	2.35	3.91	3.82	27.86	100.00	

Additional Statistics for Main Table 25.

INVENTORY UNIT : Rudongla
Size of Sampling Unit (ha) : 0.05000000
Number of Strata : 1

ESTIMATED PARAMETER : TOTAL PERIODIC ANNUAL INCREMENT OF GROSS VOLUME ('000 m^3/yr)
Tree Status : Conifer Survivor
Timber Quality : All (Dbh 10+ cm)

STRATUM : Mixed Conifer WC
Area (ha) : 5127.69500000
Stratum Weight : 1.00000000
Number of Sampling Units : 68
Degrees of Freedom : 67

Sampling Intensity : 0.00066307
Finite Population Correction : 0.99933693
t (0.975, 67) : 1.99700000
t (0.950, 67) : 1.66800000
Estimate : 31.51047175
Standard Deviation : 25.13592094
Coefficient of Variation % : 79.77005596
Standard Error : 3.04716740
Sampling Error (P=0.95) : 6.08519330
Sampling Error % : 19.31165409
Reliable Minimum Estimate (P=0.95) : 26.42779652

Annexure 3: Compartment Description and Prescriptions[7]

Block: Doyungchhu - Compartment: I

Altitude	2700-3600m
Aspect	West & Northwest
Slope	10-25^0
Terrain	Moderate
Total area	402.38 ha
Protection	159.94ha
Non-production area	199.50ha
Production area	202.88ha

Forest Description

The upper 40 % of the compartment consists of mixed conifer forest and the stands in this area are matured. The entire compartment is used as grazing ground and has open areas at few locations. The lower ridges (60% of the compartment) are covered mostly by thick young stands of blue pine. It was observed that moderate grazing pressure didn't have significant impact on conifer seedlings. Lower part of this compartment was operated under selection felling in the past for local use.

Prescription for Future Management

Group Selection System for mixed conifer and the dense blue pine stands needs to be thinned to improve the forest stocking. Grazing in this compartment needs to be regulated.

Block: Doyungchhu - Compartment: IIa

Altitude	2700m-3600m
Aspect	West & Northwest
Slope	10-250
Terrain	Gentle
Total area	415.31ha
Protection	186.34ha
Non-production area	206.28ha
Production area	209.03ha

Forest Description

The compartment has good stock of middle-aged blue pine stands and mixed conifer forests. Nearly 5% of the compartment is blank. The compartment is used as grazing ground.

Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System. Plantation needs to be carried out in the blank areas. Grazing in this

7 *Functions like Riparian reserve, Soil protection, wildlife protection and Non-forest area overlaps*

compartment needs to be regulated.

Block: Doyungchhu - Compartment: IIb

Altitude	2700m-3600m
Aspect	North & West
Slope	10-25^0
Terrain	Gentle slope
Total area	346.43ha
Protection	137.30ha
Non-production area	138.13ha
Production area	208.30

Forest Description

The area is covered by almost 95% forest. The area is well stocked with bluepine and mixed conifer forests. *Abies densa* forms a dominant conifer in the upper coniferous belt of the FMU, in altitudes between 2800 and 3700 m. the regeneration of fir is poor but it was observed that nurse log and wet moss microsite were found to be the favourable for seedlings establishment. About 5% of the compartment is alpine meadows and is open. Regeneration is good in the bluepine areas.

Prescription for Future Management

The area needs to be operated under Group Selection System. Blank areas needs to be planted with suitable local species taking into account specific micro site.

Block: Doyung - Compartment: III

Altitude	2900-4000m
Aspect	North & Northeast
Slope	15-25^0
Terrain	Moderate
Total area	822.62
Protection	380.65ha
Non-production area	406.40ha
Production area	416.22ha

Forest Description

About 5% of the compartment is covered by alpine grassland. Nearly 95% of the compartment is covered mostly by mixed conifer forests. The area has good composition of both middle aged and matured stands of mixed conifer forest. The characteristic conifer species found in the zone are *Picea spinulosa, Tsuga dumosa* and *Abies densa* in association with broadleaf species like *Betula utilis, Acer campbellii* and *Quercus semicarpifolia*. The lower part is dominated by spruce.

Prescription for Future Management

The area has potential to be operated under Group Selection System for mixed

conifer and Selection System for Fir forest. Plantation needs to be carried out in open areas in the lower part of the compartment.

Block: Doyungchhu - Compartment: IVa

Altitude	2900m-4000m
Aspect	Northwest & West
Slope	15-25^0
Terrain	Gentle slope and steep towards south
Total area	312.25ha
Protection	196.90ha
Non-production area	236.09ha
Production area	76.15ha

Forest Description

About 40% of the compartment is alpine grassland. The middle part has matured mixed conifer and the lower part has young blue pine stands.

Prescription for Future Management

The upper part of the area will be protected. The middle part of the compartment will be harvested under Group Selection System.

Block: Doyungchhu - Compartment: IVb

Altitude	3300m-4200m
Aspect	West & Northwest
Slope	20-35^0
Terrain	Steep
Total area	235.86ha
Protection	152.96ha
Non-production area	195.22ha
Production area	40.65ha

Forest Description

50% of the area is covered by alpine grasslands. The lower ridges are covered by mixed conifer forest while the in the upper part of the compartment mature stands of fir forest is found in patches.

Prescription for Future Management

The area has potential for commercial extraction under Group Selection System in the lower part of the compartment. The upper part of this compartment will be protected for wildlife conservation.

Block: Doyungchhu - Compartment: V a

Altitude	3600m-4200m
Aspect	North

Slope	10-35^0
Terrain	Gentle to Steep
Total area	350.62ha
Protection	241.65ha
Non-production area	310.86ha
Production area	39.75ha

Forest Description

More than 60% of this compartment is covered by alpine meadows and is steep in the upper part, while rest of the area is covered by matured stand of mixed conifer and fir forest. There are two prominent lakes within this compartment.

Prescription for Future Management

The upper part will be protected while the lower part will be operated under Group Selection Selection for the improvement of the stock.

Block: Doyungchhu - Compartment: Vb

Altitude	3600m-4200m
Aspect	West & East
Slope	15-25^0
Terrain	Gentle
Total area	173.3ha
Protection	89.43ha
Non-production area	108.10ha
Production area	65.21ha

Forest Description

Nearly 50% of this compartment is under forests cover and rest of the area is under grassland. Matured stands mixed conifer and fir forest cover the lower part of this compartment. There is one prominent lake in the middle of this compartment. Fir regeneration is poor due to competition with the understory species like Rhododendron and *Yushania microphylla*. These two species can be found on most of the management blocks. On these sites there is often no or only little advanced regeneration of fir, a fact which has to be considered in harvesting operations.

Prescription for Future Management

The mature stand of mixed conifer needs to be oprated under Group Selection System and fir under selection system supplemented by plantation in open areas to check soil erosion.

Block: Doyungchhu - Compartment: Vc

Altitude	3600m-4200m
Aspect	North & Southeast
Slope	10-25^0

Terrain	Gentle to steep.
Total area	332.43ha
Protection	153.20ha
Non-production area	245.05ha
Production area	87.40ha

Frest Description

About 50% of this compartment comprises of middle-aged mixed conifer stands while rest of the area is covered by alpine meadows. There is one prominent lake within this compartment and the stream flows through the middle of this compartment.

Prescription for Future Management

The lower part of this compartment has potential to operate under Group Selection System while the upper part will be protected for wildlife conservation.

Block: Benzabi - Compartment: Ia

Altitude	2700m-3600m
Aspect	Northwest
Slope	15-25^0
Terrain	Gentle
Total area	301.28ha
Protection	70.10ha
Non-production area	209.18ha
Production area	92.02ha

Forest Description

More than 60% of the area, towards the lower part is settlement or cultivation. Nearly 20% of the area away from the settlement is covered by young stands of blue pine. Large part of this compartment is covered by alpine grasslands in the upper part. The upper part of this compartment is used as grazing land by the locals. The local communities utilized the forests in their locality based on traditional rights and their local knowledge.

Prescription for Future Management

Thinning operatiions in young blue pine stands needs to be carried out while rest of the area may be used as grazing ground. Grazing in this compartment needs to be regulated and plantation needs to be carried out to control erosion.

Block: Benzabi - Compartment: Ib

Altitude	2700m-3600m
Aspect	North & Northwest
Slope	10-35^0
Terrain	Gentle to steep
Total area	697.14ha

Protection	343.05ha
Non-production area	428.76ha
Production area	268.39ha

Forest Description

About 60% of compartment has pure young blue pine stands with profuse natural regeneration. Large part of this compartment is covered by blank areas. The bank areas may be due to past practices of shifting cultivation. The compartment is also used as grazing ground by the locals.

Prescription for Future Management

Blue pine thinning operations needs to be carried out while the upper part has potential for commercial harvesting under Group Selection System. Grazing needs to be regulated.

Block: Benzabi - Compartment: IIa

Altitude	3000m-3900m
Aspect	East & Northwest
Slope	$10\text{-}25^0$
Terrain	Gentle
Total area	507.5ha
Protection	195.77ha
Non-production area	243.66ha
Production area	263.84ha

Forest Description

The lower part of the compartment has young and pure blue pine stands with profuse natural regeneration. About 25% of the compartment is blank. Most of the pure blue pine stands are young in the lower part of the compartment while towards the upper part is covered by middle aged stands.

Prescription for Future Management

The upper part of the compartment has potential to be operated under Group Selection System. Thinning operations needs to be carried out in the lower region. Plantation needs to be carried out in the blank areas.

Block: Benzabi - Compartment: IIb

Altitude	3000m-3900m
Aspect	Northwest & East
Slope	$10\text{-}25^0$
Terrain	Gentle
Total area	582.93ha
Protection	120.32ha

Non-production area	127.14ha
Production area	455.79ha

Forest Description

The entire compartment is covered by young to middle-aged stands of bluepine and mixed conifer.

Prescription for Future Management

The compartment has potential to be operated under Group Selection System. Thinning is required in the thick stands of bluepine.

Block: Benzabi - Compartment: III

Altitude	3300m-4000m
Aspect	East
Slope	$10\text{-}25^0$
Terrain	Relatively gentle
Total area	848.61ha
Protection	848.61ha
Non-production area	417.90ha
Production area	430.71ha

Forest Description

More than 70% of the compartment is covered by good stock of bluepine and mixed conifer forest. Fir forests cover the higher ridges. Fir die-back phenomena like in western Bhutan were not observed in the FMU. The upper most part of the compartment is covered by alpine grasslands.

Prescription for Future Management

The stands of bluepine and mixed conifer needs to be operated under Group Selection System while the matured stands of fir needs to be oprated under Selection System

Block: Benzabi - Compartment: IVa

Altitude	3300m-3800m
Aspect	$10\text{-}25^0$
Slope	North & South
Terrain	Gentle
Total area	451.08ha
Protection	106.20ha
Non-production area	109.88ha
Production area	341.21ha

Forest Description

100% of the compartment is covered by good stock of mixed conifer forest. The

upper ridge is covered by fir forest. Fir forest in the upper watersheds plays very important protection function. A thick layer of moss with rhododendron, sub-alpine bamboo, other shrubs and herbs characterizes the undergrowth. The regeneration is good in the mixed conifer zone.

Prescription for Future Management
The mixed conifer zone area will be operated under Group Selection System. The fir zone will be operated under Selection System.

Block: Benzabi - Compartment: IVb

Altitude	3200m-3900m
Aspect	10-25^0
Slope	North & Southwest
Terrain	Gentle
Total area	605.06ha
Protection	103.70ha
Non-production area	114.59ha
Production area	490.48ha

Forest Description
More than 90% of the compartment has good stock of middle-aged blue pine and mixed conifer stands. The forest covers extensive areas where the graduation is very gradual and is mixed with oak and blue pine, or upper hill mixed with spruce and hemlock. The upper ridges are covered by mature stands of fir forests.

Prescription for Future Management
The mixed conifer and bluepine stands will be operated under group selection system while fir forest will be operated under Secection System.

Block: Ugyencholing - Compartment: Ia

Altitude	2500m-3300m
Aspect	East & Southeast
Slope	10-15^0
Terrain	Relatively flat
Total area	531.05ha
Protection	147.83ha
Non-production area	260.07ha
Production area	270.98ha

Forest Description
The area has mostly young stands of bluepine and the regeneration is profuse. The lower part of the compartment is under settlements and agriculture. The area is also used as grazing ground by the local people

Prescription for Future Management
The young stands are not suitable for commercial harvesting. The area can be used

to meet the local requirements. However, thinning operations needs to be carried out in the thick stands of bluepine. Grazing needs to be regulated in this area.

Block: Ugyencholing - Compartment: Ib

Altitude	2400m-3000m
Aspect	South & Southwest
Slope	$0\text{-}25^0$
Terrain	Gentle
Total area	463.47ha
Protection	197.85ha
Non-production area	320.48ha
Production area	142.99ha

Forest Description

Part of the compartment is under cultivation and settlement. The area has several open patches of alpine meadows used as grazing ground by the local people. The remaining area is covered by young stands of bluepine.

Prescription for Future Management

The dense blue pine stands needs to be thinned to improve the forest stocking. Grazing needs to be regulated.

Block: Ugyencholing - Compartment: Ic

Altitude	2500m-3000m
Aspect	Southeast & Northwest
Slope	$0\text{-}15^0$
Terrain	Relatively gentle
Total area	241.84ha
Protection	107.98ha
Non-production area	195.23ha
Production area	46.60ha

Forest Description

The area is almost under cultivation and settlement. The historic Ugyen Choling Monastry is located within this compartment. Patches of bluepine stands are scattered throughout the compartment. About 5% of the compartment is covered by thick stands of bluepine

Prescription for Future Management

The area is unsuitable for commercial harvesting but part of the area can be used to meet local requirements. Grazing needs to be regulated.

Block: Ugyencholing - Compartment: IIa

Altitude	2700m-3200m
Aspect	East & Southwest
Slope	15-25^0
Terrain	Gentle
Total area	483.41ha
Protection	200.14ha
Non-production area	283.73ha
Production area	199.68ha

Forest Description

About 40% of the area is under cultivation. Part of well stocked area is under Sambayung Community Forest. Remaining area is covered by young to middle-aged bluepine and spruce stands. Several bank areas are scattered throughout the compartment. The area is also used as grazing ground by the local people.

Prescription for Future Management

The remaining area has potential to operate under Group Selection System. Plantation is required in the blank areas and grazing needs to be regulated in this area.

Block: Ugyencholing - Compartment: IIb

Altitude	2700m-3600m
Aspect	South & Southwest
Slope	10-15^0
Terrain	Gentle
Total area	499.66ha
Protection	74.99ha
Non-production area	90.37ha
Production area	409.30ha

Forest Description

90% of the compartment is covered by middle aged bluepine and mixed conifer. The lower part is mostly covered by thich bluepine stands.

Prescription for Future Management

The area is suitable for commercial harvesting under Group Selection System. Thinning operations needs to be carried out in thick young stands of bluepine for the improvement of future stock.

Block: Ugyencholing - Compartment: IIIa

Altitude	3000m-3600m
Aspect	North & West
Slope	10-25^0
Terrain	Gentle
Total area	727.87ha
Protection	229.58ha
Non-production area	270.77ha
Production area	409.30ha

Forest Description

The majority of the area is covered by middle-aged to matured stands of bluepine and mixed conifer species. Nearly 20% of the area is blank.

Prescription for Future Management

The area is suitable for commercial harvesting under Group Selection System. Thinning operations needs to be carried out in thick young stands of bluepine for the improvement of future stock.

Block: Ugyencholing - Compartment: IIIb

Altitude	**3000m-3600m**
Aspect	North & Northwest
Slope	10-25^0
Terrain	Relatively gentle but steep towards west
Total area	218.65ha
Protection	96.11ha
Non-production area	96.11ha
Production area	122.55ha

Forest Description

About 90% of this compartment is under matured fir and mixed conifer forests. Towards the lower part there are some blank areas

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Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System.

Block: Ugyencholing - Compartment: IVa

Altitude	3500m-4000m
Aspect	West & Northwest
Slope	10-25^0
Terrain	Gentle to steep

Total area	206.3ha
Protection	78.97ha
Non-production area	79.06ha
Production area	127.24ha

Forest Description

The area comprises of about 95% middle-aged to matured fir and mixed conifer forests. Towards the lower region there are young stands of spruce and bluepine.

Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System for mixed conifer and Selection System for fir.

Block: Ugyencholing - Compartment: IVb

Altitude	3500m-4000m
Aspect	North & Northeast
Slope	10-25^0
Terrain	Gentle
Total area	291.77ha
Protection	63.39ha
Non-production area	71.23ha
Production area	220.50ha

Forest Description

The area is well stocked with middle-aged blue pine and mixed conifer stands. The higher ridges are covered by fir forest.

Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System for mixed conifer and Selection System for fir. Thinning operation needs to be carried out to improve the remaining growing stock.

Block: Jinergang - Compartment: Ia

Altitude	2800m-3600m
Aspect	Southwest & Northeast
Slope	20-35^0
Terrain	Steep
Total area	183.95ha
Protection	120.17ha
Non-production area	20.16ha
Production area	63.78ha

Forest Description

The area is well stocked with middle-aged blue pine and mixed conifer stands. The higher ridges are covered by fir forest.

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Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System for mixed conifer and Selection System for fir. Thinning operation needs to be carried out to improve the remaining growing stock. Thinning operation needs to be carried out to improve the remaining growing stock.

Block: Jinergang - Compartment: Ib

Altitude	3000m-3600m
Aspect	Southeast & Northwest
Slope	15-25^0
Terrain	Moderate
Total area	208.86ha
Protection	130.82ha
Non-production area	134.62ha
Production area	72.24ha

Forest Description

The area has 100% middle-aged blue pine stands and mixed conifer species. The mixed conifer forest in the upper part is taken over by fir forest.

Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System for mixed conifer and Selection System for fir. Thinning operation needs to be carried out to improve the remaining growing stock. Thinning operation needs to be carried out to improve the remaining growing stock.

Block: Jinergang - Compartment: Ic

Altitude	2700m-3800m
Aspect	Southeast & Southwest
Slope	10-25^0
Terrain	Gentle to steep
Total area	235.88ha
Protection	130.15ha
Non-production area	132.68ha
Production area	103.21ha

Forest Description

The sub-compartment has 100% middle-aged blue pine stands and mixed conifer species. The mixed conifer forest in the upper part is taken over by fir forest. There are few patches of open areas in this sub-compartment.

Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System for mixed conifer and Selection System for fir. Thinning operation needs to be carried out to improve the remaining growing stock. Thinning operation needs to be carried out in thick stands of bluepine to improve the remaining growing stock.

Block: Jinergang - Compartment: II

Altitude	2700m-3800m
Aspect	West & Southwest
Slope	10-25^0
Terrain	Gentle to steep
Total area	607.79ha
Protection	236.80ha
Non-production area	260.86ha
Production area	346.94ha

Forest Description

The sub-compartment has 100% middle-aged blue pine stands and mixed conifer species. The mixed conifer forest in the upper part is taken over by fir forest. There are few patches of open areas in this sub-compartment.

Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System for mixed conifer and Selection System for fir. Thinning operation needs to be carried out to improve the remaining growing stock. Thinning operation needs to be carried out in thick stands of bluepine to improve the remaining growing stock.

Block: Jinergang - Compartment: III

Altitude	2500m-3300m
Aspect	North & Northwest
Slope	15 -25^0
Terrain	Gentle
Total area	528.87ha
Protection	215.18ha
Non-production area	254.56ha
Production area	274.31ha

Forest Description

The compartment has 100% middle-aged blue pine stands and mixed conifer species. The mixed conifer forest in the upper part is taken over by fir forest. There are few patches of open areas in this sub-compartment.

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Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System for mixed conifer and Selection System for fir. Thinning operation needs to be carried out to improve the remaining growing stock. Thinning operation needs to be carried out in thick stands of bluepine to improve the remaining growing stock.

Block: Jinergang - Compartment: IV

Altitude	2500m-3300m
Aspect	Northwest & Southeast
Slope	10-25^0
Terrain	Gentle to Steep
Total area	599.97ha
Protection	225.42ha
Non-production area	302.53ha
Production area	297.45ha

Forest Description

More than 70% of the compartment is covered by young to middle-aged blue pine and mixed conifer species. The compartment is dissected by several blank areas.

Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System for mixed conifer and Selection System for fir. Thinning operation needs to be carried out to improve the remaining growing stock. Thinning operation needs to be carried out in thick stands of bluepine to improve the remaining growing stock. Blank areas needs to be planted with suitable local species considering specific microsite.

Block: Jinergang - Compartment: Va

Altitude	2500m-3200m
Aspect	Southwest & Northeast
Slope	10 -25^0
Terrain	Gentle
Total area	329.15ha
Protection	135.79ha
Non-production area	145.97ha
Production area	183.19ha

Forest Description

The sub-compartment comprises of young blue pine stands with dense stocking. In the upper region spruce is mixed with blue pine. There are several young stands of spruce and bluepine in the area. Part of the compartment is under cultivation and is also used as grazing ground.

Prescription for Future Management

The area will be operated based on Group Selection System. Thinning operation needs to be carried out in thick stands of bluepine to improve the remaining growing stock. Grazing needs to be regulated.

Block: Jinergang - Compartment: Vb

Altitude	2500m-3300m
Aspect	Southwest
Slope	10-25^0
Terrain	Relatively gentle
Total area	250.82ha
Protection	84.62ha
Non-production area	98.33ha
Production area	152.49ha

Forest Description

More than 70% of this sub-compartment comprises of young blue pine stands with dense stocking. The upper part of the area is covered by middle aged mixed conifer species. About 20% of this sub-compartment is under agriculture and settlement. The area is also used as grazing ground by the inhabitants.

Prescription for Future Management

The area will be operated based on Group Selection System. Thinning operation needs to be carried out in thick stands of bluepine to improve the remaining growing stock. Grazing needs to be regulated.

Block: Jinergang - Compartment: VIa

Altitude	2800m-3600m
Aspect	North & Northeast
Slope	10-25^0
Terrain	Relatively gentle
Total area	285.35ha
Protection	86.42ha
Non-production area	87.49ha
Production area	197.86ha

Forest Description

The sub-compartment comprises of middle-aged blue pine stands with dense stocking. The higher part of the compartment is covered by mixed conifer species and fir forest.

Prescription for Future Management

The area will be operated based on Group Selection System for mixed conifer and bluepine and Selection System for fir forests. Thinning operation needs to be

carried out in thick stands of bluepine to improve the remaining growing stock.

Block: Jinergang - Compartment: VIb

Altitude	**3000m-3800m**
Aspect	Southwest & Northeast
Slope	0-25^0
Terrain	Gentle
Total area	147.64ha
Protection	31.27ha
Non-production area	31.27ha
Production area	116.37ha

Forest Description

The sub-compartment comprises of middle-aged mixed conifer species. At higher elevation mature stand of fir forest is found.

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Prescription for Future Management

The area will be operated based on Group Selection System for mixed conifer and Selection System for fir forests.

Block: Jinergang - Compartment: VIc

Altitude	3200m-3900m
Aspect	Southwest & Northeast
Slope	10-25^0
Terrain	Gentle
Total area	259.44ha
Protection	103.36ha
Non-production area	103.56ha
Production area	155.89ha

Forest Description

The sub-compartment comprises of middle to matured stands of mixed conifer species and fir forest with dense stocking.

Prescription for Future Management

The area has good potential for commercial harvesting under Group Selection System for mixed conifer and Selection System for fir. Thinning operation needs to be carried out to improve the remaining growing stock. Thinning operation needs to be carried out in thick stands of bluepine to improve the remaining growing stock.

Annexure 4: Road Standards

The road standards developed in the east by TFDP will be implemented for design, drainage and construction of all forest roads in Rodungla FMU.

Road Design

- Road lengths and density should be minimized, consistent with access requirements to reduce environmental impacts and enhance access economics.
- Where possible locate roads in areas with low side slopes, the maximum side slopes allowed in all areas except rock is 100%.
- Roads must be constructed in such a way that no earth works or soil spill into water courses or watercourse buffer areas. Care should also be taken to ensure that no earth works or soil is allowed to spill onto agricultural land, near houses or main roads.
- Roads should be planned in such a way as to balance cut and fill to minimize transport of construction materials.
- Roads should not be constructed in steep and unstable areas where there is the possibility of landslide. A thorough survey of any area suspected of being unstable should be undertaken prior to construction.
- Roads should be kept as narrow as possible to reduce damage to the environment and to reduce costs.
- Where possible, box cuts should be avoided, however they are acceptable for short distances (up to 300 m), if they reduce the length of the road, reduce environmental damage and are properly drained.
- Minimum radius formed by curves or corners should be 15m and should where possible fit the topography of the land.
- Roads should be located on elevated areas where possible to minimize side cutting, width of clearing and drainage problems.
- Side cutting should be carried out leaving a stepped batter, each step no more than 3m in vertical height and no more than 100% gradient with a 1.5m horizontal step.
- Convex road surface should be maintained at all times with the centre line 30cm higher than the edges.
- Stabilize and revegetate cut and fill slopes with shrubs, grasses and legumes as soon as possible after construction.
- Ensure proper maintenance of roads and enforce road use restrictions during critical weather conditions such as monsoon seasons.

Drainage

- Road planning should ensure that roads are located in such a way as to minimize stream river crossings and avoid areas which are prone to floods during monsoon.

- In areas where side slopes of 70% or greater extend for a distance of 100m or more above the proposed road catch drains should be constructed to divert surface water into culverts. Side drains or table drains should be at least 40cm deep and 65cm wide and should drain into culverts of sufficient size and frequency.
- All culverts must have stone or concrete aprons at their exit points to prevent erosion by water. These aprons should be of suitable width and design to prevent any erosion, taking place and should extend down the slope for at least the length of the spill. They should divert the water back into the stream if the water came from a stream.
- Culverts of appropriate diameter (not less than 30cm) should be placed at regular intervals along the road. The following table gives the minimum spacing required according to road gradient. Should the roadside drain be composed of erodable material then the distance between the culverts must by reduced by 50%.

Road Gradient %	**Distance Between Culverts (m)**
4	110
5-8	90
9-10	80
11-15	60

- Culverts should be laid at 2 to 5 % gradient across the road to enable water to flow but should not exceed 6 % as damage from erosion will result. Culverts pipes (Hume pipe) should be buried a minimum of 700mm below the surface of the road.
- In areas of high seasonal rainfall, catch drains should be constructed above the road to collect surface runoff and prevent it reaching the road.
- Drains should not be allowed to directly enter a watercourse but should be diverted into surrounding vegetation at least 50m before a watercourse.
- Sumps or silt traps should be places in drains every 50m in erodable soils and must be cleaned regularly.

Road Construction

- All timbers above 30cm diameter must be felled and removed from the road alignment, the remaining timber should be cut and burnt (no organic material should be used as fill).
- Primary excavation should be done in such a manner as to remove the topsoil and place it on the downward slope of the road. This will allow vegetation to regenerate and stabilise the slopes.
- Where side slopes of 70% or more extend more than 100m down hill no side casting of spoil should be allowed. In this situation end haul methods must be used.

- Forest roads should only be constructed on stable soil types where there is no possibility of slippage.
- All road construction on side slopes of over 50% or difficult terrain, such as boulder fields, must be carried out using excavators.
- Batter and fill slopes should not exceed 100%.
- Where road construction is carried out on side slopes of over 90% rock or concrete wall should be built to support both batter and fill (this is not required in solid rocks).
- On side slopes of over 70% all of the load carrying surface of the road must be built on stable ground. The road should not be supported by fill.
- The adverse gradient should not exceed 10%. However, grades of up to 12% will be allowed for distances of up to 300m if this substantially reduces road length. Following this incline a minimum distance of 100m of grades of 10% or less must be maintained.
- The favourable gradient should not exceed 12%. However, grades of up to 15% for distances of up to 300m will be allowed if this substantially reduces road length. These grades should be followed by grades of less than 10% for distances of 100m or more.

Annexure 5: Tree Marking Guidelines

Marking guidelines for the group selection system

The group selection system aims secure natural regeneration by imitating nature in the creation of small opening in the forest stand; thus allowing light to reach the forest floor and creating favorable microclimatic condition for seed germination and seedling establishment. It is important to avoid damage to the remaining stand by selecting only trees that will fall into the opening and ensuring that accurate felling is carried out.

- Small groups spaced at specified interval will be harvested removing all tress over 10cm DBH.
- The group will be located along extraction lines
- The distance between the extraction lines will be no less than 60m.
- The distance between the groups, along the extraction lines, will be less than 50m.
- The shape of the harvested groups can be irregular, according to the site and terrain conditions.
- Existing opening in the stand having already established regeneration should be used as a nucleus for marking the groups.
- Signs of existing wind fall in the stand should form the basis of the opening. In such a case, opening boundaries should correspond to changes in soil moisture that is often the cause of the windfall.
- Wind firm tress must surround the selection groups. This could be achieved by leaving intermediate height trees along the edge of the opening.

- The trees will be marked for harvesting along the extraction corridors.
- The extraction corridors must be as narrow as possible; 2-4m in the fir stands and no wider than 4m in the Spruce and mixed stands.
- The maximum size of the groups will be on an average less than 0.15 hectares depending on the sites characteristics and stand condition.
- Diseased, dead and malformed tress will be marked on the priority basis and should be used as a nucleus for creating as opening.
- Boundaries of opening should, where possible corresponds to change in slope. An opening should not end in the middle of a steep slope since tree will slide into the remaining stand during logging.
- Care must be taken in choosing the boundary of the opening. Trees, which can be expected to fall into the opening, should be marked while trees leaning out of the proposed opening must be left standing so as to minimize damage to the remaining stand.
- Trees damaged during harvesting will be cut and removed in the subsequent cleaning operations.
- Fruiting trees and some hollow trees which will have less economical value will not be harvested; it will be left for preserving biodiversity.

Marking guidelines for the single-tree selection system

Felling under the single-tree selection system should be done in accordance with the following guidelines:

- Trees marked for harvesting will be evenly distributed throughout the stand.
- Diseased, malformed, dead and decaying trees will be marked on a priority basis; especially these are hampering the better ones (unless objectives of biodiversity conservation dictate otherwise). These trees can be marked even if below the set diameter limit of 50cm. however, care should be taken that no large openings are created in the stand by marking these trees.
- Trees of exploitable size should be marked, particularly if defective or lacking in vigor; mature and over-mature trees over 50cm DBH outside bark to be marked.
- No more than one third of the stand volume should be marked for harvesting.
- In mixed stands, an even and suitable distribution of species should be left standing.
- Fruiting trees and some hollow trees which will have less economical value will not be harvested; it will be left for preserving biodiversity.

Marking Guidelines forBlue Pine under Seed Tree System

- The seed tree system is used in pure pine stands or missed stands consisting of mixture of pine and Spruce with pine predominating.

- The Seed Tree System will be used in the above stands only on suitable sites.
- The system will not be used on steep and exposed, South or South -West sites.
- In mixed stands an equal distribution of pine and Spruce will be left standing
- Slope characteristics, wind firmness and aesthetic value will be considered.
- About 20 to 25 trees per hectare (i.e. approximately 22 to 26 meters apart) will be left standing.
- Diseased, malformed and dying trees will be cut on priority basis.
- Trees left standing will not be oldest or tallest in the stand. Over mature trees will be cut on priority basis.
- Trees left standing will be of good health and form to ensure good seed source.
- The shape of the area chosen for the seed tree can be irregular.
- Maximum size of a contiguous area harvested using this system should not exceed one hectare.
- Fruiting trees and some hollow trees which will have less economical value will not be harvested; it will be left for preserving biodiversity.

Marking Guidelines for Thinning in Blue Pine Stands

Thinning will be carried out in immature stands. The objective of thinning is to increase growth and quality of stands and at the same time provide small dimension. Healthy, vigorous trees will be released by cutting

Considering the fact that there is a great variation in the age, density and condition of the immature stands care has to be taken not to cause damage to the thinned stands. The primary aim is to achieve even spacing of the remaining tress in the stand.

- The stand for thinning will be identified from the forest type maps and verified in the field.
- The stands identified for thinning, if falling within the harvestable limits of cable cranes, will be subjected to thinning.
- Observation and monitoring of dwarf mistletoe infestation on Blue pine; trees infected with mistletoe should be given first priority for felling. Complete burning is needed.
- Mark for thinning 20% of standing volume.
- Marking of trees for thinning will depend on the number of stem per hectare, age or size class, and the spatial distribution.
- Only low thinning will be done in most of the stands, where only dead, dying, suppressed, diseased and defective trees will be marked first.
- In stands less than 10m average height the target spacing should be approx. 4.5x4.5m or about 500 tress per hectare.

- In stand with pole crop (average height 10-20m) the spacing of tress after the thinning should be no more than 5-6m, or approx. 300-400 trees per hectare.
- In stands which at present have less than desired tree density and spacing; only trees that grow in clusters, very close together and competing for light and nutrient can be removed. Diseased trees, especially those infected with mistletoe can be removed.
- Care must be taken not to create large opening in the thinned stands.
- Diseased, malformed and suppressed trees will be thinned on a priority basis.

Marking for Rural Uses

It is necessary that the marking for rural use whether for timber or fuel wood, should be done under standard Silvicultural system.
Firewood marking when necessary should be done under Single Tree Selection System from Local Use (only) forest area.
Flag posts, fence posts and poles demand should be met by marking for thinning in the pole crop high density stands thereby subjecting the stands to Silvicultural thinning.

Annexure 6: Record Keeping Forms

Compartment Record Sheet
Block:…….....…….
Compartment:…….....…
Sub-Compartment:…….……..

Year	Harvesting		Tending		Planting		Other	Remarks
	Area (ha)	Vol. (m3)	Area (ha)	Vol. (m3)	Area (ha)	Species		
2013								
2014								
2015								
2016								
2017								
2018								
2019								
2020								
2021								
2022								
2023								

Rural Allotment

Block:…………………………………………

Compartment:…………………………………….Sub-Compartment:……………………..

MC	WC	Date	Name and Address	Permit #	TMB #	Particulars			Volume (m3)			Comments
						Species	Product Type	Amount	Marked	Recovered	Firewood	

Commercial Allotment

Block:…….Compartment:……

Sub-Compartment:……

MC	WC	Year of Activity	Commercial Activities					Volume (m3)				Other Activities	TMB #	Comments (Include detailed description of cable line location in relation to mappable features)
			Cable Lines			Groups/Patches/ Other		Marked		Extracted (FDC)	Firewood (lops/tops)			
			Line #	Length (m)	Azimuth	Total #	Total Area (ha)	# of trees	Vol.					

Stand Tending and Regeneration[8]

Block:……..Compartment:……

Sub-Compartment:……

MC	WC	Cableline #	Year	Stand Tending		Regeneration						Comments or Other Activities
				Activity	Area (ha)	Natural/ Plantation	Species	Year Surveyed	Area (ha)	Survey Results (stems/ha/survival percent)	Resurvey?	

8 *Use for brushing, planting, weeding, and spacing or ground preparation activity*

Annexure 7: Socio-economic Report