ICIMOD

giz

On behalf of

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

Department of Forest and Park Services
Ministry of Agriculture and Forests
Royal Government of Bhutan

Printed at United Printing Press, unitedpressthimphu@gmail.com

FOREST MANAGEMENT PLAN FOR RONGMANCHU FOREST MANAGEMENT UNIT, LHUENTSE DZONGKHAG

ROYAL GOVERNMENT OF BHUTAN
MINISTRY OF AGRICULTURE AND FORESTS
DEPARTMENT OF FORESTS AND PARK SERVICES
DIVISIONAL FOREST OFFICE, MONGAR

FOREST MANAGEMENT PLAN FOR RONGMANCHU FOREST MANAGEMENT UNIT, LHUENTSE DZONGKHAG

Plan Period: 1st January 2018 - 31st December 2027

Prepared by:
Tashi Wangdi, Sr. Forest Ranger
Divisional Forest Officer, Mongar &
Tashi Norbu Waiba, Sr. Forestry Officer
Forest Resources Management Division, Thmphu

FOREST MANAGEMENT PLAN FOR RONGMANCHU FOREST MANAGEMENT UNIT, LHUENTSE DZONGKHAG

Plan Period: 1st January 2018 - 31st December 2027

Prepared by:
Tashi Wangdi, Sr. Forest Ranger
Divisional Forest Officer, Mongar &
Tashi Norbu Waiba, Sr. Forestry Officer
Forest Resources Management Division, Thmphu

AUTHORITY FOR PREPARATION, REVISION AND APPROVAL

PERIOD OF THE PLAN

This plan is valid for the period of 10 years from 1st January 2018 – 31st December 2027.

AUTHORITY FOR PREPARATION, REVIEW AND APPROVAL

The authority for preparation of this plan was given to the Divisional Forest Office (DFO), Mongar, Department of Forest and Park Services.

PROVISION FOR REVISIONS AND CHANGES

The Head of the DoFPS has the authority to revise and approve Plan, if major changes occur in the Forest Management Unit (FMU), or if new information becomes available that may have significant bearing on the implementation of the plan, or if huge challenges arise and need to relook at the management plan. The CFO, Mongar may prepare revisions and changes to the plan for submission to the Director, DoFPS for approval.

APPROVAL

This plan was examined by a wide section of user groups, clients and organisations. The final revision of the plan was reviewed and technically cleared by CFO, FRMD and an environmental clearance was obtained from National Environment Commission Secretariat. It was then submitted to the Director, DoFPS who after further review and amendment forwarded with his recommendation for approval to the Secretary, MoAF. The Secretary, MoAF, further reviewed and submitted the plan to the Minister, MoAF for his approval for implementation.

Submitted for Approval

Chief Forest Officer
Forest Resources Management Division

Recommended for Approval

Director
Department of Forests and Park Services

Secretary
Ministry of Agriculture and Forests

APPROVED

Hon'ble Minister
Ministry of Agriculture and Forests
Date: .....

རྒྱལ་ཡོངས་མཐའ་འཁོར་གནས་སྐྱོངས་ལྷན་ཚོགས།
དཔལ་ལྡན་འབྲུག་གཞུང་།

National Environment Commission
Royal Government of Bhutan

NECS/EACD/Dzo-Lhuntse/3597/2018/1070 **December 12, 2018**

ENVIRONMENTAL CLEARANCE

In accordance with Section 34.1 of the Environmental Assessment Act 2000 this Environmental Clearance (EC) is hereby issued to Department of Forests and Park Services for the operation and management of Rongmanchu Forest Management Unit (FMU) measuring an area of 6401 hectares under Lhuntse Dzongkhag with the following terms and conditions:

I. General

The holder shall:

1. comply with provisions of the National Environment Protection Act 2007, Environmental Assessment Act 2000 and its Regulation 2016, Waste Prevention & Management Act of Bhutan 2009 and its Regulation 2012 (Amendment 2016), The Water Act of Bhutan 2011 and its Regulation 2014;
2. ensure that the operation and management of FMU is in line with Environmental Impact Assessment and Management Plan submitted for EC;
3. ensure that the annual timber extraction from FMU does not exceed its Annual Allowable Cut stated in the Management Plan;
4. ensure that no extraction of timber is carried out at the critical watershed;
5. ensure that local communities, properties and any religious, cultural, historic and ecologically important sites are not adversely affected by the operation and management of FMU;
6. restore the damage to any public or private properties caused by the operation and management of FMU;
7. inform NECS and any other relevant authorities of any unanticipated or unforeseen chance-find of any precious metals or minerals or articles, that have economic, cultural, religious, archeological, and/or ecological importance; and
8. erect a signboard at the take-off point of the main entry of the FMU stating the name of the FMU and contact address.

II. Environmental standards

The holder shall comply with the Environmental Standards 2010.

III. Import and use of secondhand equipment and ODS

The holder shall:

1. not import and use secondhand equipment and machineries; and
2. ensure that import and use ODS are in line with the Revised Regulation on the Control of ODS 2008.

Received # 1513 dtd 26/12/2018

NEC, PO Box 466, Thimphu, Bhutan
Tel: (975-2) 323384/325856/324323/326993 Fax: (975-2) 323385
www.nec.gov.bt

IV. Protection and management of water resources

The holder shall:

1. ensure that operation and management of FMU does not disrupt the water flow and pollute the water bodies; and
2. ensure that 30 meter or 100 feet buffer is maintained from the water resources at all times.

V. Waste prevention and management

The holder shall manage wastes generated from the project (labour camps, offices etc.) with the application of 4R (Reduce, Reuse, Recycle, Responsibility) principle and other environmentally friendly methods of waste management.

VI. Management of excavated materials and run-off

The holder shall:

1. dispose excess excavated materials generated during construction of access road and operation and management of FMU only at the pre-identified approved dumpsite; and
2. put appropriate measures for management of surface run-off to avoid erosion and landslides.

VII. Implementation plan

The holder shall prepare a detailed implementation plan focusing on the implementation of terms and conditions of this EC and submit to NECS within three (03) Months from the date of issue of this EC as per the reporting format attached herewith.

VIII. Monitoring and reporting

The holder shall ensure that the effective day-to-day monitoring of the EC terms and conditions are carried out by the environmental unit or designated environment focal person.

IX. Renewal and modification

The holder shall:

1. ensure that renewal of this EC is processed at least three months prior to its expiry along with a copy of EC and a report on the implementation of its terms and conditions failing which the applicant shall liable for penalty as per the RECOP 2016; and
2. obtain prior approval from NECS for any modification to the existing proposal/application.

Reservation

1. The NECS may stop the activity or impose additional terms and conditions, as may be deemed necessary; and
2. The EC shall be subject to periodic review and modifications as per Article 25 of the EA Act 2000, without any liability on the part of the Royal Government.

The holder may adopt best practices in executing these terms and conditions to avoid adverse environmental impacts.

Failure to comply with any of the above terms and conditions shall constitute an offence and the proponent shall be liable in accordance to the Environmental Assessment Act 2000 and/or existing environmental laws.

Validity:
This EC is issued with validity from **December 12, 2018** until **December 11, 2023** for the operation and management of Rongmanchu FMU.

Karma C. Nyedrup
OFFICIATING SECRETARY

To
Chief Forestry Officer
Forest Renounces Management Division
Department of Forests and Park Services
Ministry of Agriculture and Forests
Thimphu

Copy to;
1. Dasho Dzongdag, Chairman, Dzongkhag Environment Committee, Lhuntse for kind information.
2. Officiating Environment Officer, Dzongkhag Administration, Lhuntse for necessary action.
3. Guard File, (NECS/EACD/Dzo-Lhuntse/3597/2018/) EACD, NECS for record.

Compliance Report

1. General Information

1.1. Name of the activity (including nature/type of the project)

.....

.....

1.2. Location (including survey No./Plot No and project area, if applicable).....

.....

.....

1.3. Environmental Focal Person & Contact details.....

.....

.....

1.4. Number of employees (regular/casual, national and non-national):.....

.....

.....

1.5. Year of Commencement.....

1.6. EC reference No. and its validity.....

.....

1.7. Date of reporting.....

2. Description of the compliance to EC terms and conditions

Sl No	Terms and Condition of the EC	Action/activities undertaken/implemented to achieve compliance including evidence, wherever applicable	Remarks

3. **Any other initiatives undertaken other than stipulated in the EC**

.....

.....

.....

.....

4. **Emission/discharge test, if applicable**

Sl No 1	Parameters as in Environmental Standards, 2010					Emission test result carried out by the project proponent (Attach the test report)					Date and time of monitoring. Specify methodology of test	Remarks
	Industrial effluent discharge	*Ambient air quality*	*Industrial emissions*	*Work place emission*	*Noise level*	*Industrial effluent discharge*	*Ambient air quality*	*Industrial emissions*	*Work place emission*	*Noise level*		
1												
2												
3												
4												
5												

5. **Details of attachment (Documents that needs to be attached while providing information as required under point number 2, 3 and 4)**.....

.....

.....

.....

Reported by:

(Signature)
Name:
Designation:
Company:

Detailed Implementation Plan

Sl No	Specify terms and conditions of the EC	Activities/actions that will be undertaken to implement the terms and conditions	Time frame required	Responsibility

ACKNOWLEDGEMENT

The planner would like extend gratitude to Mrs. Kezang Yangdon, Deputy Chief and Mr. Ugyen Penjor, Sr. FO of FRMD, Thimphu for training field staff on handling equipments for carrying out forest management inventory in the Rongmanchu FMU. Thanks also goes to the FRMD official who compiled the forest inventory data and Mrs. Kezang Yangdon for analysing and producing the inventory results for annual allowable cut calculation.

My deep gratitude goes to all the field staff of Territorial Division and Natural Resources Development Corporation Limited (NRDCL), who participated tirelessly for months to carry out forest management inventory with me. This lot of people have done the toughest job. Without their hard work and great contribution, this plan would have remained incomplete.

I would like to thank the CFO Territorial Division and Regional Manager (RM), Natural Resources Development Corporation Limited (NRDCL). Zhonggar Division, NRDCL and people from Tshekhar and Minjee Geogs for rendering assistance during the field visit and field work.

LIST OF ABBREVIATIONS

%	Percentage
AAC	Annual Allowable Cut
CFO	Chief Forest Officer
cm	Centimeter
DBH	Diameter at Breast Height
DFO	Divisional Forest Office
DoFPS	Department of Forests and Park Services
EIA	Environmental Impact Assessment
FMP	Forest Management Plan
FMU	Forest Management Unit
FMCB	Forest Management Code of Bhutan
FNCRR 2017	Forest and Nature Conservation Rules and Regulations 2017
FRMD	Forest Resources Management Division
GIS	Geographic Information System
Ha	Hectare
Km	Kilometer
m	Meter
m3	Cubic meter
masl	Meter Above Sea Level
MC	Mixed Conifer
mm	Millimetre
MoAF	Ministry of Agriculture and Forests
NRDCL	Natural Resources Development Corporation Limited
NTFP	Non-Timber Forest Products
Nu	Ngultrum
NWFP	Non-wood Forest Products
PFM	Participatory Forest Management
PRA	Participatory Rural Appraisal
RGoB	Royal Government of Bhutan
RM	Regional Manager
RNR	Renewable Natural Resources
RRA	Rapid Rural Appraisal
sp(p)	Species (pl)

SRF	State Reserve Forests
UIC	Unit In-charge
UM	Unit Manager
UWICER	Ugyen Wangchuk Institute for Conservation and Environmental Research
WC	Working Circle
WWMP	Warm Watershed Management Project

EXECUTIVE SUMMARY

This is the second plan for Rongmanchu FMU. The plan structure is as per the guidelines reflected in the Forest Management Code of Bhutan. It comprises of three parts:

PART 1: GENERAL DESCRIPTION AND THE CURRENT SITUATION

PART 2: FURTURE MANAGEMENT

PART 3: IMPLEMENTATION OF THE PLAN

PART 1: GENERAL DESCRIPTION AND THE CURRENT SITUATION

» Rongmanchu FMU is located in Lhuentse Dzongkhag. It is situated within 91°11'E to 91°17'E longitude and 27°29'N to 27°35'N latitude. The altitude ranges from 965 m to 3865 masl. The FMU became operational in 2007. The total area of RFMU is 6401 ha.

» Forest types found in the FMU are Chir Pine, Cool Broadleaved Forest, Blue Pine Forest (Bhutan Pine and Fir Forest. A range of fauna or their sign were observed or have been reported in the area of which four are on the list of totally protected animals in the Forest and Nature Conservation Act of Bhutan 1995.

» The AAC of the last Management Plan was set at **4577 m³**, including the AAC for local use. As per the data collected from Rongmanchu FMU at Budur, Lhunetse, the commercial volume harvested for the last nine years is **34898.77 m³** and the rural volume supplied is **1706.47 m³** in standing volume. This shows that commercial extraction is undercut by **4751.23 m³** and rural extraction undercut by **4413.53 m³** against total AAC of ten years.

» A total of **14.4 km** of forest road was constructed in FMU during the last plan period. The road network benefitted the local people of Budur, Kupingesa, Wambur and Lagay.

PART 2: FURTURE MANAGEMENT

» The goal of the Management Plan are:

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

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

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

iv. 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.

» The Rongmanchu FMU was organised into three Working Corcle viz. Protection, Production and Non-Production Working circles for the smooth implementation of the Plan. Commercial harvesting will be carried out in the Production Working Circle.

» Management based on Forest Functions
Management based on different forest functions will also be adopted as per the prescriptions in the Plan. Following forest functions and the management options with restriction have been described in detail.

Table 1: Code of function group and functions

Code	Function Group (in bold) and Functions
S	**Soil Protection and Conservation**
SC	Soil Conservation
SP	Soil Protection
W	**Water and Watershed Conservation**
WRR	Riparian Reserve Protection
WSh	Watershed Conservation
WLS	Local Water Supply Protection
Soc	**Social Function**
SocL	Social (Local Use Only)
SocRS	Religious Site Protection
RB	**Road Buffer**

To facilitate better organisation of management activities during the implementation of the Plan and better field orientation within the FMU, the area has been sub-divided into Blocks and Compartments.

» **Silviculture Systems**

» The prescribed silviculture system for the commercial harvesting is the Patch Clear-cut System with artificial regeneration. Group opening of 0.25 ha will be created in the stand allowing optimum quantity of light to reach the forest floor and creating conducive micro climatic conditions for seed germination and establishment of seedlings. Criteria for opening the groups and laying out annual coupes are given in detail in the plan.

For rural marking Single Tree Selection System will be applied.

» **Environmental Assessment**

A team from DFO Mongar in consultation with NRDCL carried out detailed EIA and its findings are incorporated in preparing the Forest Management Plan. Checklist of Environment Parameters for Forestry projects as per NEC guidelines and Forest Management Code of Bhutan has been followed and the following activities were taken

into consideration in this Management Plan.

i. FMU Planning and Zoning
ii. Road Construction and Maintenance
iii. Harvesting and Extraction
iv. Regeneration and Post-harvesting Treatment
v. Riparian Zone Protection
vi. Biodiversity Conservation within the FMU
vii. Local use forest area

» AAC for Rongmanchu FMU.

Table 2: Annual Allowable Cut in standing volume

Stratum (Working areas)	Net operable area (ha)	Rotation (years)	RME standing volume (m^3/ha)	AAC (m^3/yr)	Actual AAC (m^3/yr)	Clear cut equivalent area
Broadleaf, Mixed conifer and Chirpine	4307.55	130	99.40	3293.61	3200	32.19
Total	4307.55	130	99.40	3293.61	3200	31.99

» Allocation of AAC

Table 3: Annual Allowable Cut allotment

Standing Volume (m^3)	Allotment
2700	Commercial production for NRDCL
500	Rural production for local use only

Limits of harvesting area for commercial timbers in this plan period (2nd Plan period)

The harvesting of commercial timbers by NRDCL must be limited till Compartment Khepachu II & III only for the current plan period and under any circumstances the harvesting should not be diverted to other compartments unless approved by the Director, DoFPS.

PART 3: IMPLEMENTATION OF THE PLAN

» The CFO, Mongar assisted by UIC and other supporting staff will be the implementing agency. Determining of cutting cycles, annual coupes, harvesting, reforestation, road construction, etc. will be done as per prescriptions in this plan. Annual planning will be

facilitated through Operational Planning. Record keeping and Monitoring will be done by the CFO on annual basis as per the format. FRMD will evaluate at an interval of 5 years.

» FMU Level Management Committee chaired by the CFO, Mongar has been established to assist in objective setting and ensuring the smooth implementation of the plan. The committee comprises of the stakeholders of the FMU and each member has equal say in recommendation for management and implementation of the FMU. Plan activities to achieve the FMU objectives will be discussed in the FMU Level Management Committee.

» Unforeseen circumstances may warrant deviation from plan prescriptions and in such event the CFO Mongar must obtain prior written approval from the Head of the Department. The reasons for the deviations entered into the Management Plan during the next scheduled revision.

» ***Through this new management plan it is recommended to carry out extraction of timbers from the FMU based on market demand. If there is no market demand for the extracted timbers the extraction of timbers from the FMU must be withheld by NRDCL till such time when there is adequate market demand and the extracted timbers could be disposed/sold profitably. In no circumtances shall NRDCL let the extracted timbers rot in the depot as was the case in the first management plan.***

Table 4: Actions required by the plan and responsibility

Actions required by the FMU Plan	Responsibility
Implementation and Review	
The CFO Mongar, as the senior territorial officer will be responsible for the implementation of this Management Plan, assisted by the Unit-In-charge and staff.	CFO
A FMU sub-committee of the Divisional Management Committee, chaired by the CFO, will be established to ensure the smooth implementation of the Management Plan.	CFO
The CFO and UIC will ensure that only the silvicultural systems described for each working circle are used for that working circle, and they are implemented thoroughly and correctly.	CFO & FMU UIC
The Head, FRMD, will ensure that the Plan is reviewed five years after implementation (mid-term review), and at the end of the plan period (end-of-term review)	Head, FRMD
Monitoring and Evaluation	
The CFO will ensure that monitoring is carried out on an annual basis according to the guidelines issued by FRMD	CFO

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.	Head, FRMD
Operational Planning	
A bi-annual Operational Plan will be prepared by the CFO to facilitate the timely implementation of this Management Plan, and completed and submitted to FRMD by 2nd October every year, before the start of operating year.	CFO RM, NRDCL
The budget in the operational plan should be jointly developed by the CFO and RM, NRDCL and agreed by both.	CFO RM, NRDCL
The UIC will determine the location and extent of cable lines in the compartment to be harvested annually in consultation with NRDCL staff as prescribed in the Operational Plan.	FMU UIC
The CFO and the RM, NRDCL will cooperate and coordinate to ensure that the logging operation and log out turn are conducted smoothly and in accordance with local and other demands.	CFO RM, NRDCL
The FMU, UIC will ensure that plantation survival surveys are conducted annually to ensure enough restocking of harvested area.	FMU UIC
Plantation will be carried out by NRDCL.	NRDCL RM
Tending operation must be done as per the norms and standard of nursery and plantation to facilitate good health of seedlings.	NRDCL RM
The FMU UIC will inspect the coupes when harvesting is completed and will issue a Coupe Clearance Certificate only if all aspects of the operation are satisfactory.	FMU UIC
Road survey, design and construction will be carried out by NRDCL.	NRDCL
NRDCL road engineers must follow acceptable standards, designs, estimates and provide supervision during construction to ensure that the standards are met.	NRDCL staff
Regular inspection will be conducted by the FMU staff to detect and report any pest and disease outbreaks to enable earliest possible remedial or preventive measures to be initiated.	FMU staff
Participatory Forest Management	
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 CFO Mongar.	FMU UIC

Timber and non-wood products can be allotted to bonafide local villagers.	FMU UIC, via Operational Plan
The views of stakeholder groups will be incorporated into the operational plans through the inclusion of stakeholder representatives on the FMU sub-committee of the Divisional Management Committee.	CFO

Table of Contents

Lists of Figures

Lists of Tables

PART 1

GENERAL DESCRIPTION AND THE CURRENT SITUATION






1. LOCATION, BACKGROUND, AREA AND STATUS

1.1. Location of Rongamcnhu FMU

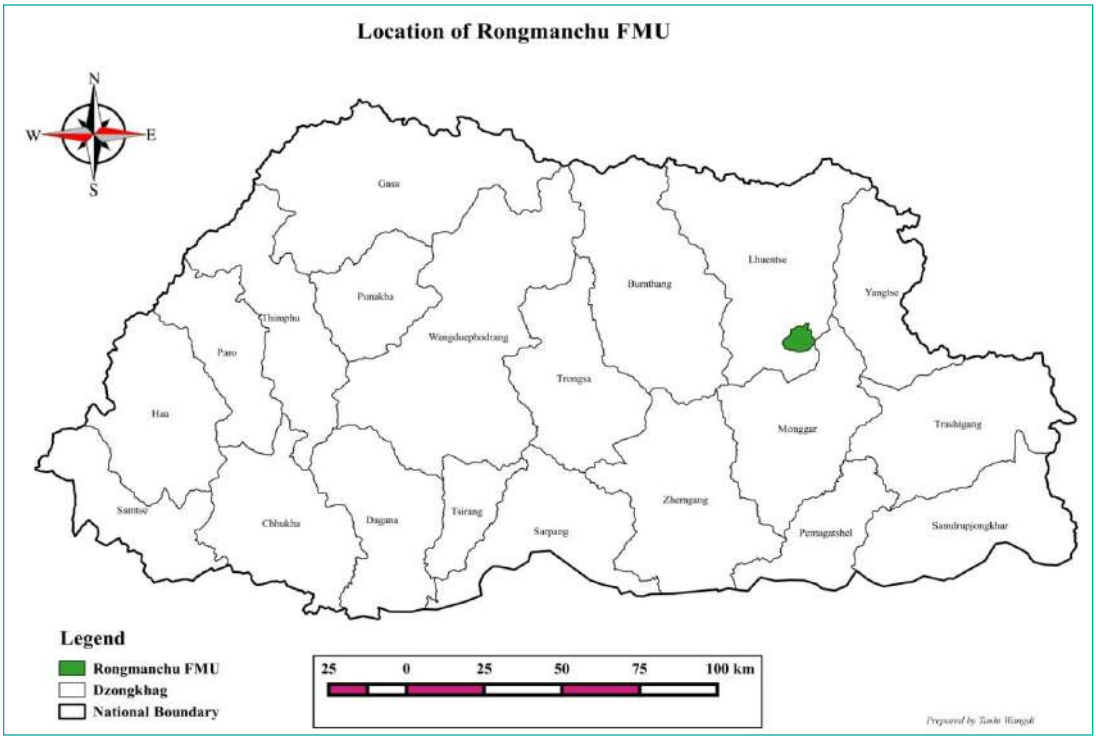


Figure 1: Location of Rongmanchu FMU

Rongmanchu FMU is located in Lhuentse Dzongkhag. It is situated within 91°11'E to 91°17'E longitude and 27°29'N to 27°35'N latitude. The altitude ranges from 965 m to 3865 masl. The Kurichu forms the western boundary and the eastern boundary adjoins the Bumdeling Wildlife Sanctuary. The northern boundary follows the main ridge, south of Bragong descending towards Kurichu on the western part. The sourthern boundary follows the ridge of Tokaphung Gompa on the southern tip towards the Kurichu. Khepachu, Rongmanchu and Khardungchu comprise the three main watersheds of the FMU.

The FMU became operational in 2007. The total area of RFMU is 6403.13 ha.

There are no formal documentation of the historical context of the villages and the adjoining forests that fall within the FMU. Anthropological studies in the region are also lacking. Therefore, the historical background of the FMU was mostly obtained through semi-structured interviews and talking informally with the elderly and key resident of the FMU.

Before the creation of Department of Forests and Park Services in the mid 1950s, villagers in and near the Rongmanchu FMU had unregulated access to the forest in general. Forest areas adjoining villages were mostly treated as common property resource, guided by dome form of traditional rights. Felling of trees for construction and firewood collection was generally

unregulated. Timber removals from the forest have been mostly confined to subsistence use since there were no formal markets for such products around that time.

Many parts of the FMU have a long history of cattle grazing. Almost 500 acres of registered tsadrog falls within the FMU. During the survey, nine different communities including the monk body were identified as having exclusive rights to grazing in the FMU. It was indicated that cattle grazed in accessible parts of the FMU, exceeding the grazing areas for the communities.

Figure 2: Umlingbadep depot, RFMU

Since the commencement of logging in the FMU, selling timber had been a problem. Huge volume of timber remained staked in the Umlingbadep depot for years leading to deterioration of timber quality as well as rotting. The reason believed to have led to not able to sell the timber was depot being located far away from the highway and also production of inferior quality timber compared to other FMUs. Therefore, NRDCL have re-located their depot at Fawan to make timber accessible to consumers.

1.2. Area statement

The following Table and Figure give the detail land use types of the FMU. These figures are obtained from the LUPP land use map, topographic maps, SPOT imagery and wherever necessary field thruthing was done during the course of forest inventory.

Table 5: Area statement by land use

Land use	Area (ha)
Permanent cultivation	334.84
Build up	4.63
Landslide	2.64
Rivers	5.91
Meadow	36.74
Shrubs	304.96
Chir Pine forest	828.40
Mixed-Conifer forest	1314.07
Fir forest	26.74
Broadleaf forest	3543.80
Total	6403.13

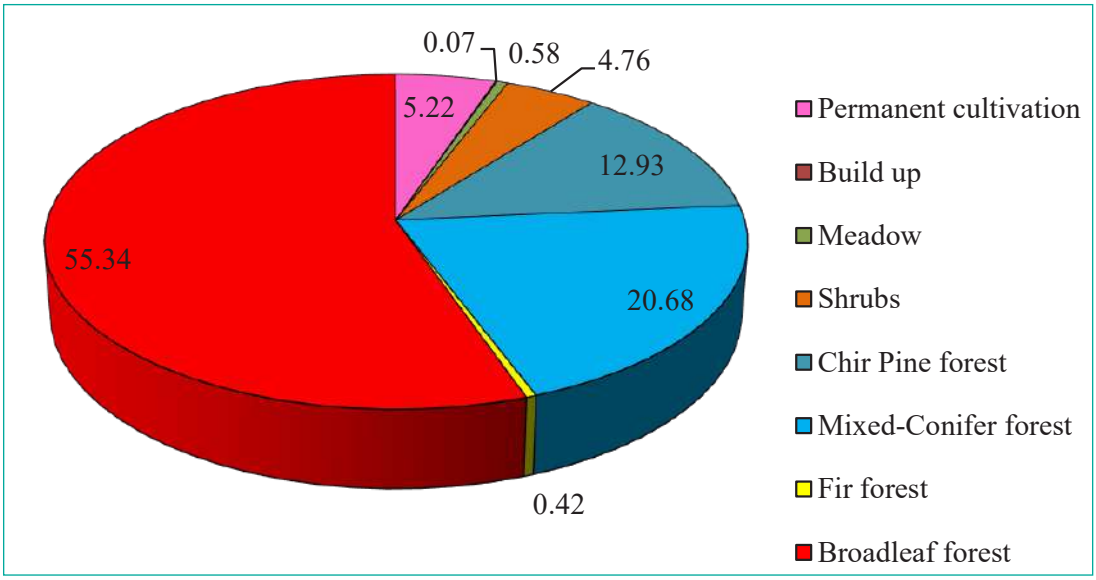


Figure 3: Area statement by land use in percentage

1.3. Forest Condition

An analysis of broadleaf species composition and distribution suggests that the broadleaf forests can be classified under the Mid-Montane Broadleaf Ombrophilous Forest according to Champion and Sethm (1968). The classification also conforms to the Cool Broadleaved forest zonation, according to the vegetation zones proposed by Grieson and Long (1983). These forests are considered to be the most species rich forests between 2000 m and 3000 m elevations. In general none of the species particularly in less disturbed forests accounts for more than 12% of relative importance. Compared to the similar forests zones in the lower elevations, stratification is less developed in these forests. The canopy is mostly closed with thick undergrowth and woody climbers. During inventory, in the humid pockets, luxuriant growth of epiphytes, including orchids and climbers were recorded. Major families represented in these forests are Lauraceae and Fagaceae. They are generally classified under the temperate climax forests with matured stands reaching ages of more than 300 years.

Between altitude of 1000 m and 2000 m, mostly in the southernly aspect, Chir Pine (*Pinus roxburghii*) covers almost 11% of the FMU. The canopy is generally open with crown density less than 50% and grasses pre-dominating the ground flora. Mature trees of 30-35 m in height can be found dotted across the landscape with good understory regeneration of Chir Pine. The main highway also passes along this forest belt resulting in more pressure on these resources compared to the forests that are much further away from the highway. Chir Pine forests have responded well to disturbance and stabilised quite well as a permanent feature in these areas. Chir Pine working is mostly confined to Kupingesa block, where stands can be broadly classified under two conditions mainly stand initiation stage and mature stage.

The Rongmanchu FMU is mostly Cool Broadleaved Temperate Forests. Though the FMU was not under pressure from timber production, the cattle pressure was very high that hinders the area from restocking to its natural form. It was basically hard in getting the valuable species in place for the future sustainability.

Since regeneration is a major problem in the broadleaved forests, intensive artificial regeneration will be adopted with frequent monitoring and better financial support from the NRDCL. These areas will be regenerated with local viable species from the nursery maintained by the NRDCL. Any possible ways to bring the forests into greenery is of utmost importance for the implementing agencies and DoFPS at large.

1.4. Legal Status

1.4.1. Ownership

The Forest and Nature Conservation Act 1995, defines forests as "any land and water body, whether or not under vegetative cover, in which no person has acquired a permanent and transferable rights of uses and occupancy, whether such land is located inside or outside the forest boundary pillars, and includes land registered in a person's name as tsamdo (grazing land) or sokshing (wood lot for collection of leaf litter)". All such areas are considered as State Reserved Forest (SRF). On this basis, extend of SRF within the Rongmanchu FMU is about 5850 ha (91.4%) and the human settlement and cultivated lands is about 551 ha (8.6%). On the ground some farmland boundaries may have encroached on forestland during the course of agriculture expansion. However, the land not registered as private lands are considered legally as SRF.

1.4.2. Rights and Privileges

The rights and privileges of the local communities, with regard to the use of forest area as per the Forest and Nature Conservation Act 1995 and National Forest Policy 1994. The Forest Act permits grazing and collection of firewood, fodder and leaf mould for domestic use, either free or on payment of royalty. Firewood collection is permitted only from dead and fallen trees. Timber trees are issued for bonafide domestic use after the recommendation from the Dzongkhag concern and royalty has been paid. Hunting is totally prohibited within the forest.

1.4.3. Grazing Rights

Figure 4: Cattle grazing inside RFMU

The entire accessible forest land of Rongmanchu FMU is grazed by cattle from the villages within the FMU, adjacent communities and monk bodies of Lhuentse Dratshang who have traditional rights to grazing on areas. The Forest and Nature Conservation Act 1995 gives authority to the DoFPS to regulate and restrict grazing anywhere in the country to prevent environmental damage.

1.4.4. Water Rights

The local population has the rights to use water from the streams and rivers for their domestic purposed, such as home consumption, watering livestock and irrigation of crops. The Kurichu, Rongmanchu, Khepachu and Khardungchu are the main sources of water, besides numerous streams and creeks within the Rongmanchu FMU.

1.4.5. Historical Monuments and Monastries

There are numerous ngeys and monasteries inside the FMU. All these monuments are provided a buffer of 100 m around within the FMU.

One of the amazing sites is the historical ruin of Bangtsho located at an elevation of about 2438 m on a small hillock in the middle of a mountain slope that stretches from the ridge of mountain where Damthang is located.

Figure 5: View of Bangtsho Phodrang

It is said that there were two brothers who belonged to the Bangtsho family in Dungsam (ancient name for Pemagatshel). After an angry dispute between the two brothers, the elder one decided to share the family wealth and property with the younger brother but on condition that the later would go on exile to Umling in Kurilung (ancient name for Lhuentse Dzong).

The younger brother settled in Bangtsho and also ruled the adjoining settlement in Umling and Tshenkhar. This ruler stayed underground, hidden from the internal and external threats, which at that time included perpetual enemies and vested interests from Tibet in the north.

Figure 6: The cone shaped ceiling inside

The roof of the underground building is built of a mixture of earth works and stone slabs. It is cone shaped and very thickly built. The partition walls are built of stones and the stone beams support the walls. One compartment has a small stone shelf and hanger projecting from the walls. The masonry contains not a single piece of wood.

2. SITE FACTORS

2.1. Topography and Slope

The general terrain of the Rongmanchu FMU catchment is moderate with 77% of the commercially available forest area falling between the elevation ranges of 1500 m – 2900 m (Table 6). The remaining area falls between the elevation ranges of 2900 m – 3500 m.

Table 6: Area and percentage of elevation classes

Elevation class (m)	% of plot per class	Area of commercial forest (Ha)
1500 – 1700	4.2	135
1700 – 1900	4.2	135
1900 – 2100	9.5	305
2100 – 2300	9.5	305
2300 – 2500	16.8	541
2500 – 2700	14.7	474
2700 – 2900	17.9	575
2900 – 3100	9.5	305
3100 – 3300	10.5	338
3300 – 3500	3.2	102
Total	100	3215

Source: Inventory data, 2000

Table 6 shows the total operable area with areas above and below 100% slope class. The areas that have been excluded from operable areas such as private lands, registered tsadrogs, buffer and nature conservation areas account for 3175 ha within the FMU. The slope classification as per Table 6 pertains to the operable area by using a 40 m contour with scale 1: 25000 topographic map. By employing such a classification system, 90.1% of the operable area has slopes below 100% and only 9.9% with slopes above 100% of the total operable area. In effect, a total of 3215 ha of forest area is available for sustainable harvesting. The deduction of areas above 100% from the operable areas is also mandated by the Forest and Nature Conservation Act 1995 to safeguard fragile areas from being operated.

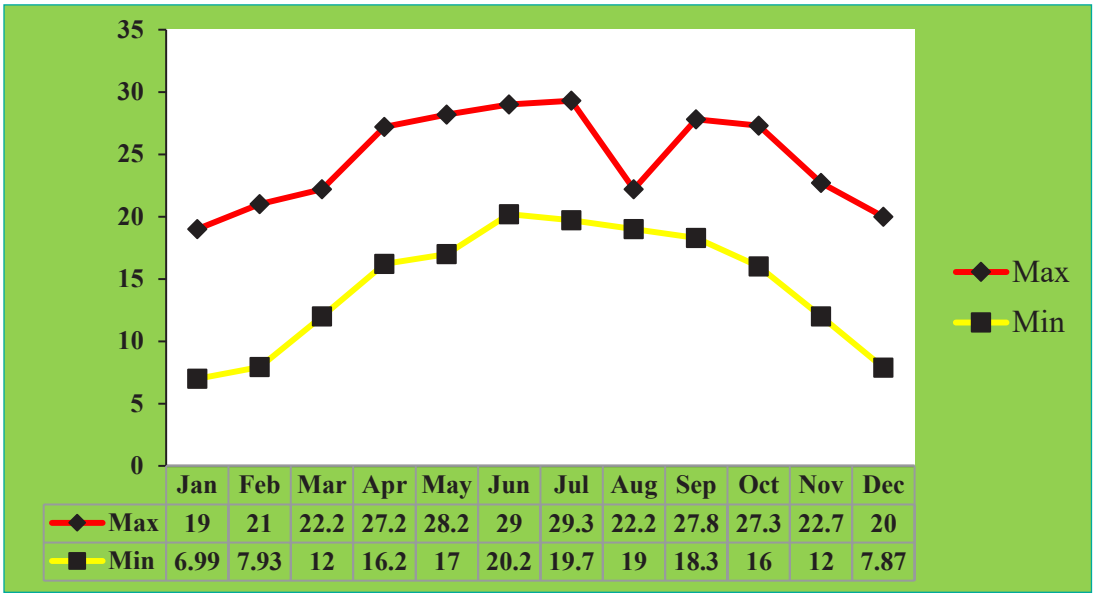
2.2. Climate

The climate data for the region was obtained from the Khoma weather station located at 2000 m under Lhuentse Dzongkhag. The weather station is in close proximity to the north eastern boundary of the FMU. The weather station maintained by the Bhutan Power Corporation. The interpretation of the available data only provides a generalised profile of the climate over the specified period. However with elevations ranging from 1500 m – 3500 m within the FMU, micro climates and several variations in temperature and humidity can be expected all across the FMU at a given period.

2.2.1. Temperature

With the available weather information for over a period of last ten years, the following tables and figures were generated to indicate a general trend of the weather patterns in the locality. Ideally for forest ecological and management purposes, long term meteorological data would

be preferred but given the limitations, this plan will utilise the available data and resources. As a result, the interpretation of this data, particularly for long term ecological purposes should be viewed with some level of caution.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	19	21	22.2	27.2	28.2	29	29.3	22.2	27.8	27.3	22.7	20
Min	6.99	7.93	12	16.2	17	20.2	19.7	19	18.3	16	12	7.87

Figure 7: Annual average temperature

2.2.2. Precipitation and Humidity

The highest average rainfall was recorded in the month of August over the period with a rainfall of 152.49 mm as a result of late monsoon showers in the past years. However in comparison to data obtained from other stations in the region, particularly from Lingmethang, the average rainfall recorded at Khoma seems to be generally lower. Because of ridges extend and the intensity of rainfall varies quite considerably on slope with different aspects. As a result the north facing slopes are generally much more humid, supporting dense broadleaf forests than the south facing slopes which is normally associated with pines and shrubs. The

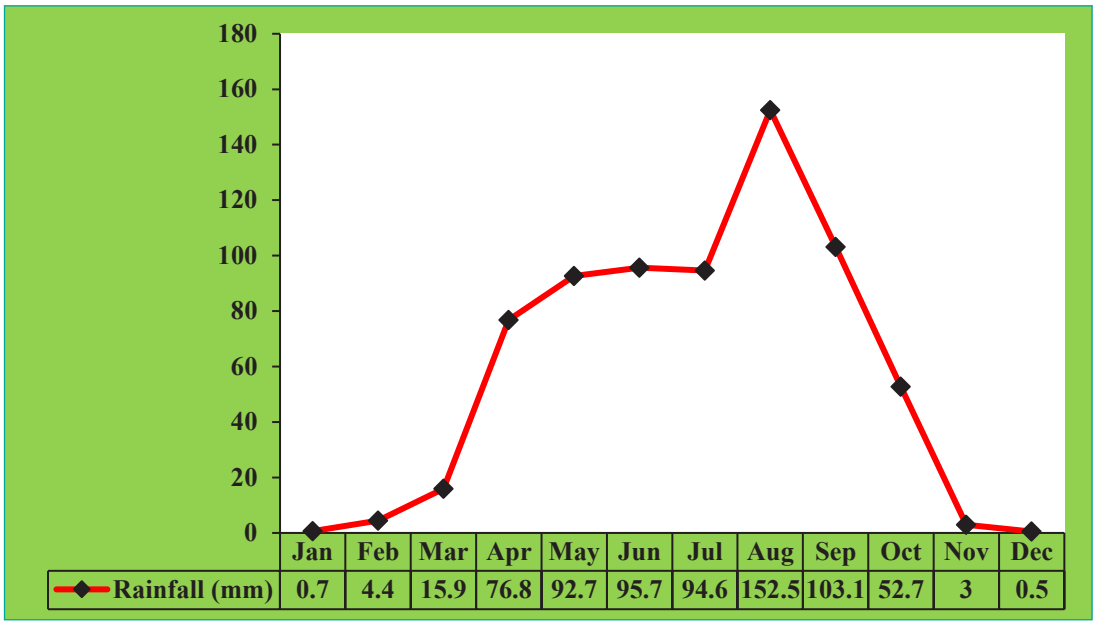


Figure 8: Annual average rainfall

driest months are normally the winter months which are also the most fire prone month. In general relative humidity (Figure 9) seems to be on the higher side even during the cold winter months when the rainfall is very scanty. Corresponding with the highest average rainfall, the month of August was also recorded with the highest humid conditions. With such a fairly stable humid condition over the year, we can expect better net biomass production or growth compared to similar forest types in the Himalayan region.

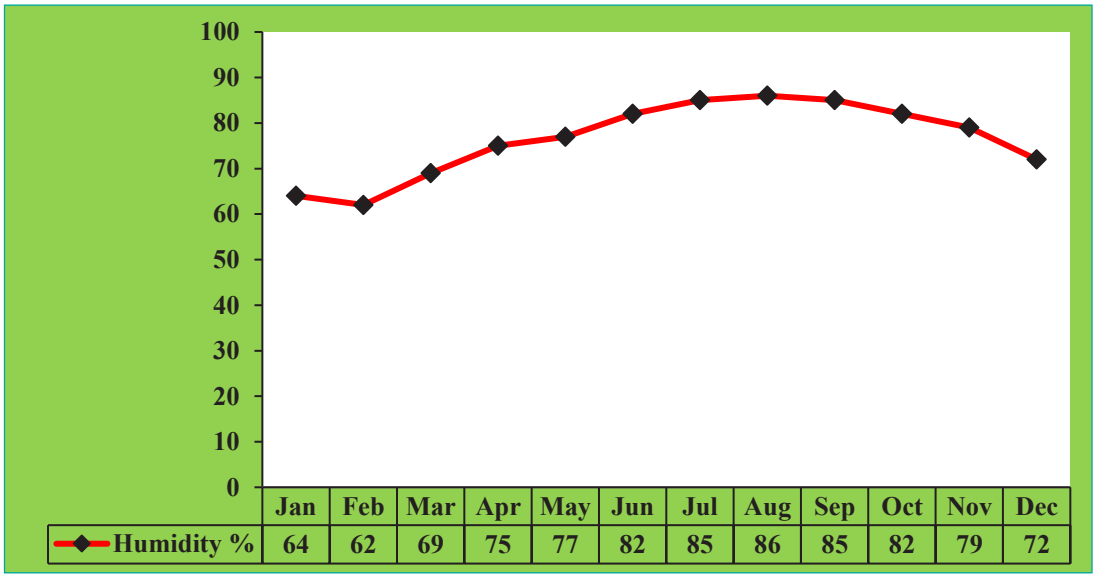


Figure 9: Annual average humidity percent

2.3. Geology

No detailed geological surveys have been carried out for eastern Bhutan. However, according to Grierson and Long (1983), most of Bhutan is composed of a complex system of folded and metamorphosed rocks of pre-Cambrain and early-Paleozoic age, largely quartzite and gneiss, and dissected by faults running east-west. Sedimentary rocks are scarce. The predominant parent rock in the region comprises rock units derived from the Daling formation (Samchi/ Shumar) of pre-Cambrain age.

2.4. Hydrology

The Rongmanchu FMU comprises watersheds of three major streams namely, Rongamnchu, Khepachu and Khardung Chu. All three streams drain into the Kurichu which flows across the western boundary of the FMU in north-south direction. Considering that the FMU encompasses the watersheds of all three streams, the management of the forest resources within the FMU will have to pay close attention to harvesting and road building operations. Close to the headwaters of the Dungkhar chu, the villagers have a strong traditional belief of an existence of an underground lake, popularly known as "Eib Tsho" (also see Socio economic report, 2001). However scientific validations have not been carried out but given its local importance and their belief system, this management plan has made adequate provisions for its protection by providing a system of buffer around the designated area.

3. VARIABLE SITE FACTORS

3.1. Population and Demography

There are 10 villages which fall within Rongmanchu FMU namely, Budur, Kupingesa, Wambur, Khablang, Goney, Lagay, Umling, Bangtsho, Bumling and Gorgan.

There are 181 households within, 29 households just outside and 173 households within 3 km from the boundary of the Rongmanchu FMU.

3.2. Farming and Agriculture

Agriculture is the main basis for the livelihood of the people living within the FMU. The crops grown by the people are maize, rice, potato, sweet buckwheat and wheat. Some vegetable are grown for home consumption and for sale in the Lhuentse vegetable market. Potatoes are grown as a cash crop and sold either locally or through auction in Samdrup Jongkhar. Fruit trees are planted on a limited scale.

The income of the people within the FMU is by selling agriculture and livestock products.

Table 7: No of household with different categories of land holdings

Sl. No	Village	Dry land	Wetland	Tseri	Pangshng	Sokshing	Landless
1	Wambur	68	48	68	68	68	0
2	Bangtsho	10	1	10	10	6	0
3	Umling	19	19	19	19	19	0
4	Budur	29	26	29	7	25	0
5	Kupingesa	30	27	30	5	25	0
6	Jalang/Bragong/ Jabung	29	27	20	5	20	1
7	Lekshogang	16	27	5	6	7	1
8	Minji	18	18	18	0	4	2

Table 7 furnishes the details of different categories of land use owned or used by various households under different villages. Almost all the households of Wambur village own a land of varying sizes under all the listed land use categories.

Although wealth ranking across the villages was not carried out, the information furnished under Table 7 gives a broad indication of rural prosperity and the level of access to various land uses. The future management section of this management plan will look at the implications of land distribution and uses more closely from the point of forest resource allocation and sustainable management.

3.3. Traditional Use of Forest

The community within and outside the FMU are using forest resources for their livelihood. The relationship between the people and forest is very strong. They use forest resources to construct their houses, collect firewood, fodder, graze their cattle, fruits and vegetables, leaf litters, make farm implements, fencing materials, medicinal plants, etc.

3.4. Grazing

The information about pattern of grazing, number of cattle and grazing land were acquired from semi-structured interview during the field visit. Grazing is evident in most areas of the FMU and is going to be one of the main pressures in the FMU owing to more population of freed cattle (tshedar tokas). The heaviest grazing pressure is in forest

Figure 10: Cattle grazing inside plantation area

areas close to the settlements, despite the availability of pastures and grazing grounds for the animals.

The high number of cattle within the FMU indicates that there is a widespread dependence on the SRF for grazing. Although some of the cattle population are accounted by migratory cattle, the cumulative effect on forest regeneration as a result of selective browsing both by resident and migratory cattle can lead to severe impairment of artificial as well as natural regeneration capacity of the forests in the long term. Future management prescriptions and options should take into account the dynamics and the appropriate regulation of cattle grazing in the forest.

3.5. Forest Fire

Forest fire are relatively uncommon, particularly in the Rongmanchu and Kupingesa block owing to its more north facing aspect and dominance of moist broadleaf forest than the Khepachu block, where the vegetation is mostly dominated by pine trees.

During the last management plan, the incidence of forest fire was two. One fire broke out in Minjee Geog in 2010 and the other in Tshenkhar Geog in 2015.

Given the drier conditions, Khepachu block will be more prone to forest fires. The young stands of Chir pine in the lower elevations around the Gorgan village will need to be protected from indiscriminate forest fire.

Table 8: Table 8: Forest fire incidence in the FMU

Year	Geog	Location	Area burnt (Ha)
2010	Minjee	Tsertserma	275.19
2015	Tshenkhar	Gorgan	12.00
Total			**187.19**

3.6. Pest and Diseases

There are no official records of any significant pest and disease outbreak in and around the FMU in the first Forest Management Plan (2007-2017). However gypsy moth and pine defoliator have been reported in similar forest types in the adjoining Dzongkhags before the first management plan. Most likely, due to the diversity of tree species and irregular age structure, the damage from such pests does not seem to affect the forest on a large scale. The casual agents of diseases in coniferous trees and angiosperms span the same array of organisms and abiotic stresses but the relative importance of various groups, in these forests differ markedly. Under conifer environment, few bacterial diseases are known, due to the generally acidic pH of the soil. Therefore, most diseases of conifer are caused by fungi and the group of parasitic plants like the mistletoes. These obligate parasites are known to distort and divert tree growth to their own benefit and gradually kill the trees in the longer term.

However, it is equally important to recognise that these saprophytic and parasitic fungi have co-evolved with their pine hosts and often exist in a delicate balance. Just as the saprophytic and symbiotic fungi play essential roles in the forest, so the pathogens manage many ecosystem interactions.

3.7. Non-Wood Forest Products (NWFP)

On the use and sustainability of non-wood forest products, a comprehensive study was not carried out within and in the surrounding of the FMU. However, like in many other rural communities in the region, NWFPs play an important role in sustaining the livelihoods of the local people in many ways. Villages within and around the FMUs have a long tradition and history of collecting wild mushrooms, ferns, *Elatostema sp.* (dambur), natural plant dyes, bamboos and canes and few other plant material for medicinal purposes. Besides, the forests are also an important source of farm manure and fodder for domestic cattle.

The socio-economic report for the area listed bamboo and cane as the two main NWFPs used by the villagers for various uses, ranging from housing and fencing material to household items. As of now, due to marketing opportunities and access, these materials are used on a subsistence level and thereby over harvesting of these resources do not take place for the time being.

More than 90% of all the households under Minjee and Tshenkhar Geogs depend on the forest for firewood. In particular, villages in Tshenkhar Geog are more dependent on the FMU resources than Minjee owing to proximity and accessibility.

Forest and Nature Conservation Rules and Regulation 2017 (FNCRR 2017) provide legal basis for their use and management of forest resources by local communities.

4. ECOLOGY

Bhutan and especially Eastern Bhutan, comprises an important part of the so-called East Himalayan biodiversity "hot spot" (Salter, 1995) globally, it is one of the few places with an exceptional concentration of species and endemism. This rich biodiversity is due to the wide variation in altitude, slope and aspect within a short latitudinal range, a varied climate and Bhutan's location at the interface of the Indo-Malayan and Paleartic Realms, where essentially different groups of species have evolved (Salter, 1995).

Three of Bhutan's nine "protected areas", namely Bumdeling (A = 1485 km^2), Sakteng (A = 755 km^3) and Khaling (A = 334 km^3) Wildlife Sanctuaries are located in Eastern Bhutan, as they are parts of the Phrumsangla and the Royal Manas National Parks. The Bumdeling Wildlife Sanctuary abuts the boundary of the Rongmanchu FMU and separates it physically, but not biogeographically from the Dongdechu FMU in Trashiyantse Dzongkahg.

4.1. Floral Association

There is no detail classification of the vegetation in Bhutan been carried out. However, the work of Champion and Seth (1968) on the classification of forests in India included the Himalayas. This could be applied to many of the forest types in Eastern Bhutan. It classified the country into three zones:

» A northern belt above 4000 masl with no forest cover, only alpine ground shrubs and grasslands

» A central belt between 2000 – 4000 masl containing the major temperate coniferous and broadleaved forest types and

» Southern belt between 200 – 2000 masl elevations comparing sub-tropical vegetation.

On these bases, the Rongmanchu FMU falls mainly within the central belt and the upper part of the Southern belt.

4.2. Fauna

A preliminary wildlife survey (Yonzon *et al*, 1998) in the FMU revealed the most commonly occurring mammals in the region. The survey was based on track identification and counts and casual reporting by the residents. It was carried out by Dr. Pralad Yonzon, Wildlife consultant for the then Third Forestry Development Project. The survey covered both the districts of Trashiyangtse and Lhuentse, particularly across the Traditional Dongla Track, which covers the habitats of both Dongdechu and Rongmanchu FMUs. In addition the multi-resource forest inventory carried out for the FMU, by employing a systematic grid which also recorded wildlife presence/absence data at various locations of the plot (Inventory report, 2000). The most commonly occurring mammals in the area include wild boar, common leopard, Assamese macaque, capped langur, sambar, goral, wild dogs, barking deer, musk deer and black bear. During the inventory, the crew noted various signs and sightings of these mammals over the entire inventory period and the corresponding data collected via commonly identifiable signs such as tracks, pug marks, scats, actual sighting and browsing/ground disturbance signs. Since the data did not indicate the number of different species observed over a certain area, density measures for different populations were not possible for this stage of planning. However, the FMU monitoring and evaluation programme will take into account periodic monitoring and assessment of wildlife population of the FMU over longer period of time.

Table 9: Wildlife inventory plots

Species	Plots	Area (Ha)
Goral (*Nemorhaedus goral*)	1	3.7
Barking deer (*Muntiacus muntjak*)	16	59
Sambar Deer (*Cervus unicolor*)	16	59.9
Wild boar (*Sus scrofa*)	19	71.5
Himalayan black beer (*Selenarctos tibetanus)*	4	15
Total	**56**	**209.1**

Figure 11: Pellets of Red Panda

Given the severe limitation of the inventory crew in small mammal and avifauval identification skills, the inventory data did not include any information on the distribution and presence/absence data for small mammals and was reported in the north west of the broad-leaved forest area (McDougal and Tshering, 1998).

However, Table 10 is an attempt to list the wild animals and Table 11 the bird and small mammal species, previously recorded or is known to exist in these forest types.

Table 10: List of wild animals recorded in the FMU

Sl. No	Common name	Sl. No	Common name
1	Yellow throated marten	7	Bamboo rat
2	Red panda	8	Voles
3	Orange bellied Himalayan squirrel	9	Mouse hares
4	Mole rat	10	Five stripped squirrel
5	Field mouse	11	Hoarybellied Himalayan squirrel
6	Porcupine		

Table 11: List of birds and small mammals recorded in the FMU

Bird Species				Small mammal species	
1	Leaf warbler	12	Bar winged flycatcher	1	Yellow throated marten
2	Grey-winged black bird	13	Sapphire flycatcher	2	Red panda
3	Green-backed tit	14	Himalayan bulbul	3	Orange bellied Himalayan squirrel
4	Wood snipe	15	Drongo	4	Mole rat

5	White-throated laughing thrush	16	House sparrow	5	Field mouse
6	Great pied hornbill	17	Common crow	6	Porcupine
7	Great babbler	18	Raven	7	Bamboo rat
8	Mountain bulbul	19	Pigion	8	Voles
9	Rufous wood pecker	20	Kite	9	Mouse hares
10	Grey tree pie	21	Mountain hawk eagle	10	Five stripped squirrel
11	Red-vented bulbul	22	Chesnut brested patridges	11	Hoarybellied Himalayan squirrel

In general about 75 species of birds were observed (Yonzon, 1998).

Some of the birds and mammals found in eastern Bhutan are reported to be endemic threatened or vulnerable, or of other conservation concern (Salter, 1995; Dick & Yonten, 1966). Of these, Salter mentions 32 bird species of conservation concern. Similarly, Dick and Yonten list 10 bird species in moist temperate broad-leaved forests which are likely to decline with increased forest disturbance. Five bird species of conservation concern mentioned in both the reports were:

» Nepal fulvetta (*Alcippe nipalensis*)

» Long-tailed sibia (*Heterophasia picaoides*)

» Yellow-vented warbler (*Phylloscopus cantator*)

» Striated bulbul (*Pycnonotus striatus*)

» Hoary-throated barwing (*Actinodura nipalensis*)

4.3. Avifauna

The list of birds was prepared during the first general inventory. The list of the birds was prepared using the previous management plan as well as sighted during transect exercise, cable and road survey during the preparation of this management plan. Therefore, most of the visitors of other seasons and migrant birds could have been missed out.

5. SOCIO-ECONOMICS

5.1. Sources of Income and Expenditure

The people living within the FMU are mostly subsistence farmers. The forest road serves the purpose of transporting their cash crops such as potatoes and oranges to markets of Lhuentse and Phuentsholing.

It is a big concern of the local people as their crops are frequently destroyed by wild pigs and as a consequence there is rising human wildlife conflict. The FNCA 1995 and FNCRR 2017 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 it was found necessary to prevent destruction of his property, livestock, or crops and further proven that the wild animals in the category was killed in his own agriculture field.

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

6. CURRENT TIMBER DEMAND AND SUPPLY

The demand of timber in the FMU was assessed by studying the past supply trend. The people living within and in the periphery of the FMU have been using forest resources for fulfilling their daily needs. The rural allotments were given in the form of drashing, shingle, cham, tsim, dangchung, and firewood. The trees are marked on Single Tree Selection System.

6.1. Supply of commercial timber, firewood and woodchips from the FMU

The supply of commercial timber, firewood and woodchips from Rongmanchu FMU from 2008 - 2016 is given in the Table 12.

Table 12: Details of commercial supply

Year	Standing volume (m3)	Log volume (m3)	Firewood (m3)	Woodchips (m3)
2007	0	0	0	0
2008	3448.78	1013.15	366.00	0.00
2009	4091.77	1169.43	409.28	58.00
2010	4229.80	933.73	714.19	44.00
2011	7286.90	2325.07	561.69	28.00
2012	4360.67	1638.27	58.00	48.00
2013	3591.73	1348.69	88.00	0.00
2014	4406.82	1684.73	78.00	0.00
2015	2842.28	1052.91	84.00	0.00
2016	640.20	256.08	658.24	0.00
TOTAL	**34898.77**	**11422.06**	**3017.40**	**178.00**

Source: FMU Office, Rongmanchu

6.2. Supply of Rural Timber and Firewood from FMU

All the people living within the FMU collect timber and firewood from nearby forest. It is utilised for construction of new houses, repair, renovation and extension of rural houses, shed for livestock, farm guard shed, watch tower, toilet and machinery sheds. Besides, it

is also used for agricultural implements such as domestic furniture, flag poles and fencing poles. The supply of rural timber and firewood from Rongmanchu FMU during the period from 2008 to 2016 is given in the Table 13.

Table 13: Details of rural supply

Year	Drashing (m^3)	Cham (m^3)	Tshim (m^3)	Flagpost and Dangchung (m^3)	Fencing post (m^3)	Firewood (m^3)	Total (m^3)
2007	11.2			3.9		8	23.1
2008	86.4	1.2	0.9	10.2	1.2	84	183.9
2009	118.4	15.6	0.24	26.4	5.7	24	190.34
2010	9.6	0	0	19.8	14.1	40	83.5
2011	244.8	0.6	0.9	6.6	15.3	108	376.2
2012	121.6	0	0	3.12	5.25	40	169.97
2013	100.8	0	0	14.1	1.5	60	176.4
2014	52.8	18	0	13.2	0	88	172
2015	44.8	0	0	16.8	12.24	92	165.84
2016	9.6	0	0	32.88	58.74	64	165.22
Total	**800**	**35.4**	**2.04**	**147**	**114.03**	**608**	**1706.47**

Source: FMU Office, Rongmanchu

Besides the sale of timber by Natural Resources Development Corporation Limited (NRDCL) through open auction, timber and firewood are also directly supplied by the Territorial Division (TD). The rural subsidised timber for house construction, repair, renovation, extension and other purposes form a major portion of the timber supplied through TD. Supply from 2008 to 2015 fluctuated between 133.61 m^3 and 320.57 m^3 attributable to the periodicity of entitlement of subsidised timber every 25 years for new construction and once in a block period of 12 years for repair or renovation and extension.

7. SILVICULTURE ASSESSMENT

7.1. Past Silvicultural Treatment

Prior to first forest management plan of the FMU and commercial harvesting, trees were marked on Single Tree Selection System for rural allotment. It was during the first forest management plan implementation (2007-2017), the Patch Clear Cutting System was prescribed based on forest type and mode of regeneration. The silviculture system was introduced based on the recommendation made by the RNRRDC (then RNRRD) Yusipang during the 8th Five Year Plan.

The Patch Clear Cutting System is considered as an appropriate silvicultural system for managing the forests in the FMU to induce natural regeneration. Single Tree Selection System was prescribed in local use forests areas for rural marking.

7.2. Forest Types

Chir Pine Forest is a xerophytic forest type occurring at low elevations of 900 – 2100 m on shallow soils and southerly aspects in drier (rainfall 1000 – 1500 mm/year), deeper valleys. These sites are characterised by an extended dry season during which fires are common. Chir Pine (*Pinus roxburghii*) is relatively resistant to these annual and semi-annual fires except in the seedling stages. Naturally regenerating seedlings are highly resistant to grazing. It is often the only tree species present. More fire-susceptible shrub species are limited to moist depressions and near watercourses.

Cool Broad-leaved Forest occurs on moist steep slopes above the Warm Broad-leaved Zone and the most medic portion of the Chir Pine zone. This zone comprises two distinct sub-zones which grade into one another, depending on aspect and rainfall; a drier Evergreen Oak Forest and a Cool Moist Broad-leaved Forest.

Evergreen Oak Forest occurs at an elevation of 2000 – 2800 m in areas where precipitation ranges from 2000 – 3000 mm/ year. It is dominated by oaks and chestnuts of the genera *Quercus* and *Castanopsis* respectively. *C. Hystrix* and *C. Tribulodes* are dominant at lower elevations, while *Q, lamellosa* becomes the most common species as elevation increases.

Blue Pine Forest is the temperate equivalent of the Chir Pine zone, occupying mid-elevations (2100 – 3000 m) of dry interior valleys where precipitation varies from 700 – 1200 mm/year. Unlike Chir Pine, Blue Pine (*Pinus wallichiana*) and Bhutanese Blue Pine (*P. Bhutanica*) are very susceptible to fire. These pines often form almost pure stands, with a diverse understorey of xerophytic shrubs and with *Quercus griffithii* the only associated tree species. Blue Pine is a common pioneer species appearing after disturbance in the Cool Moist Broad-leaved and lower Spruce and Hemlock zones and often attains its highest growth rates in the latter two. In the Rongmanchu FMU, this type is almost entirely represented by ***P. Bhutanica***.

Table 14: Area covered by different forest types

Forest Type	Total Forest (ha)	% of FMU area
Broadleaf	3543.80	58.89
Mixed Conifer	1314.07	21.84
Fir	26.74	0.44
Chir Pine	828.40	13.77
Shrub	304.96	5.07
Total	6017.79	100

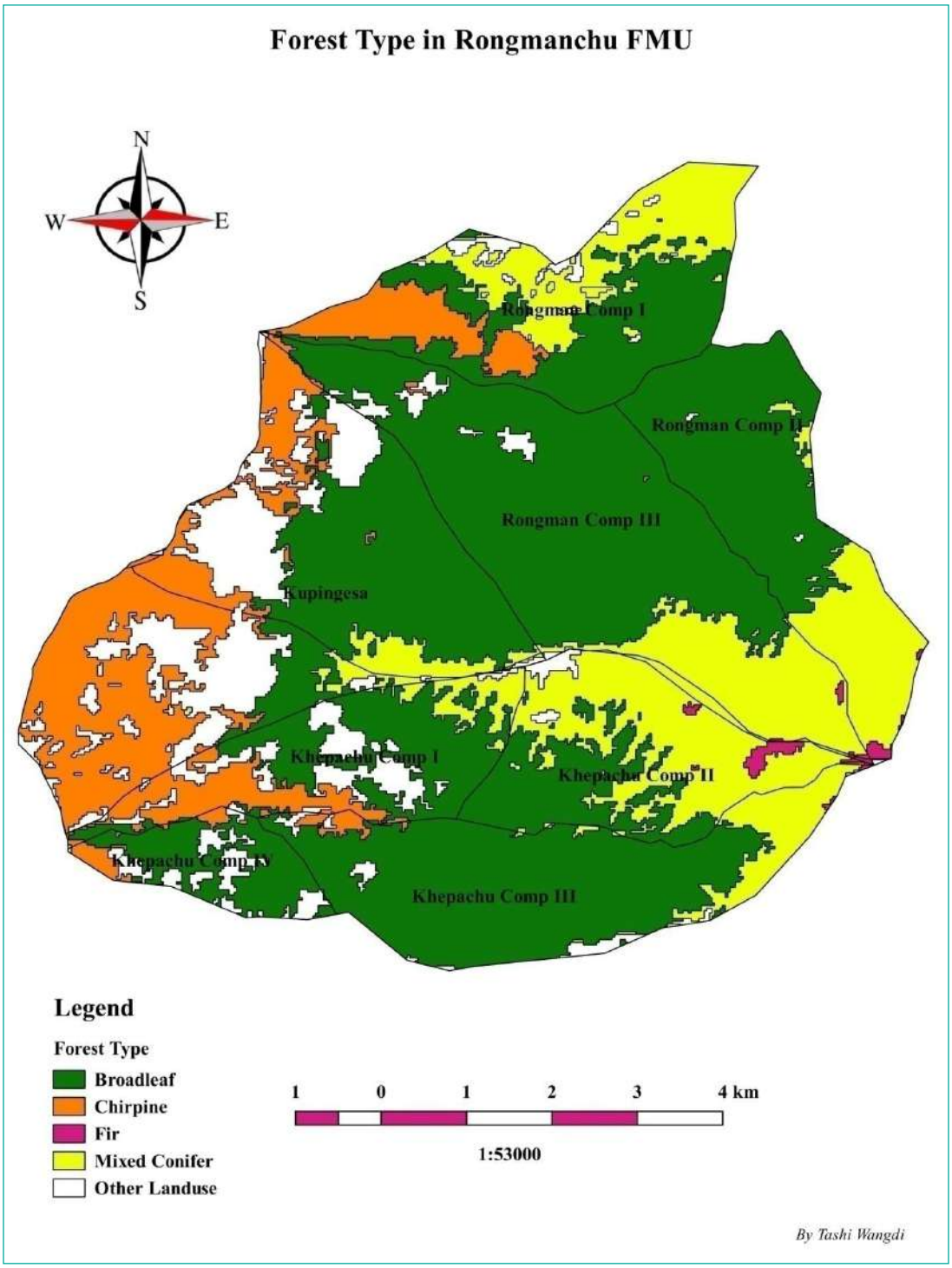


Figure 12: Forest type map in RFMU

Fir Forest is the highest elevation forest zone in Bhutan, ranging from 3200 – 3800 m, in areas receiving greater than 1300 mm/year precipitation. The defining fir species (*Abies densa*) occurs in almost-pure, very dense stands along the higher ridge tops, mixing with birth, hemlock and spruce only in the lower elevations of the range.

8. ORGANISATION AND ADMINISTRATION

8.1. Organisation

The Rongmanchu FMU is under the jurisdiction of Mongar Territorial Division and it is directly administered by the CFO. The CFO will be supported by the Unit In-charge (UIC), who will supervise the FMU operations. Operational Plans (Ops) will be prepared by the UIC with assistance from the CFO, Mongar. All activities within the FMU will be administered by the CFO, Mongar

8.2. 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 staff. During the process of felling, the chainsaw should be equipped with full functioning chain breaks and feller should ensure to keep two tree lengths apart while felling. The danger of felling timbers and overhead cable lines is inevitable and care should be taken while staking. The staking should be done to a standard height in the same direction. First aid box and necessary field gears needs to be provided to the workers during the operation.

8.3. Record Keeping

The FMU 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 (FMCB 2004). The activities may include area or number of cable lines harvested annually to achieve Annual Allowable Cut (AAC), timber volume accrued from operated cable lines, forest road construction and sanitation or epidemic felling among others. The records have to be maintained both for standing and log volume.

9. INFRASTRUCTURE, TRANSPORT AND EQUIPMENTS

9.1. Roads

A total of 14.4 km of fair weather forest road have been constructed in the FMU, 7 km under the aegis of the Third Forestry Development Project before the commencement of the FMU operation and 7.4 km by the NRDCL after the FMU has been operational. Some sections of the forest road are in immediate need of maintenance and side drains are blocked in some places. Nevertheless, the FMU road has immensely benefitted villagers of Budur, Kupingesa, Wambur and Lagay.

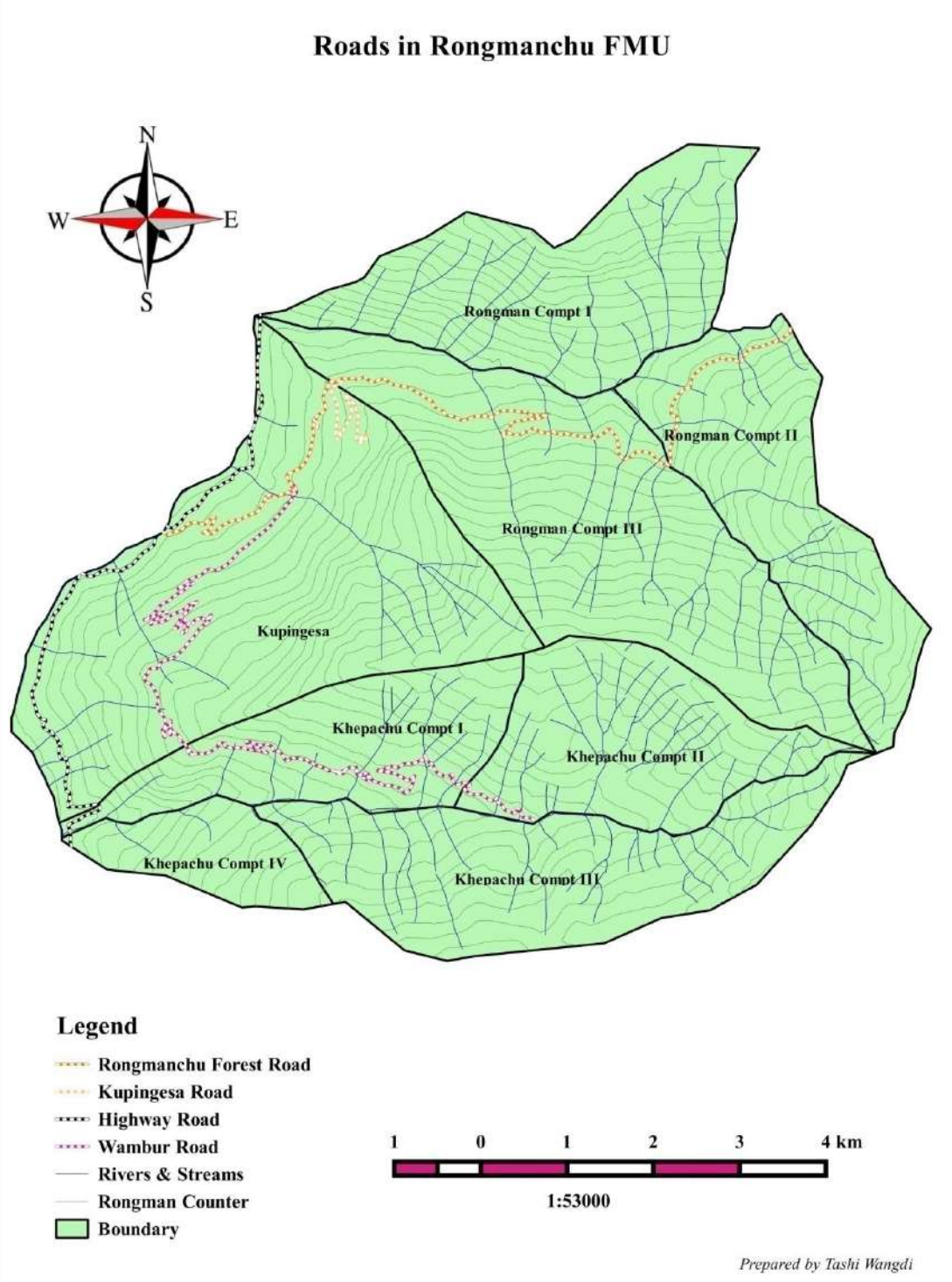


Figure 13: Roads in RFMU

10. EVALUATION OF FIRST PLAN

First Management Plan was prepared by Mr. Dechen Dorji, the Management Planner in FRMD. The review of the previous plan is imperative to identify areas that are in need of management interventions and comment on objectives that were set in the Plan. The entire FMU was not only been used as grazing ground by the people residing within and adjacent to the FMU, but also to meet an array of forest resources since long time.

10.1. Review of Goals and Objectives

The overall goal of the first management plan was to manage the FMU on a sustained yield basis for the production of timber, firewood and other forest products and for watershed and environmental protection.

The broad goal to mange on a multiple use and sustained yield basis is usually considered as the long term objective of management and should be met in the long run. It was observed that forest cover around the water source have been protected well and no felling or harvesting was allowed in the first management plan period. Much of the vegetation cover in the FMU is largely intact due to improved harvesting technology. As per the record maintained by the FMU office, a total of **35,975.24 m^3** (Table 12 & 13 shows detail) was cut in the FMU over the last nine years with artificial planting of **76736** seedlings carried out in the harvested area (Table 15).

The clearcut area includes the area of forest cleared for forest road construction also.

Table 15: Area and annual timber harvested and artificial regeneration done

Year	Standing volume (m^3)	Clear cut area (Ha)	Corridor Clear cut area (Ha)	Total Clear cut area (Ha)	Area planted (ha)	No. of seedling planted
2008	3448.78	5.25	5.16	10.41		
2009	4091.77	5.75	9.11	14.86		
2010	4229.80	8.05	3.30	11.35	6.25	10000
2011	7286.90	6.38	5.21	11.59	6.38	10208
2012	4360.67	7.75	2.43	10.18	7.75	12400
2013	3591.73	7.35	0.63	7.98	5.75	9200
2014	4406.82	5.25	4.60	9.85	5.25	8400
2015	2842.28	6.4	4.09	10.49	6.4	10240
2016	640.20	3.00	4.13	7.13	10.18	16288
TOTAL	**34898.77**	**55.18**	**38.66**	**93.84**	**47.96**	**76736**

Source: FMU Office, Rongmanchu

Profuse weed growth and very poor regeneration of principle species were observed in the harvested area. The regeneration should otherwise have been >70% as per the Management Plan. This is attributed to grazing pressure which needs to be monitored to achieve established regeneration. Initially artificial regeneration was not carried out monitoring the natural regeneration for three years as prescribed by the first management plan. But in 2010 an order from the DOFPS on taking up plantation immediately in following plantation season in the broadleaf forest owing to failure of natural regeneration. The FMU had taken up artificial regeneration in the same year.

The survival percentage of the plantation was found out to be 12.3% when a study was carried out by the planner with assistance from UWICER, Bumthang. During the final evaluation by the team from DoFPS the plantation survival rate was assessed and it was found out to be 19%.

For the betterment of plantation survival in the FMU the following activities are recommended to be taken up:

1. Increase the number of barbed wire fencing to protect plantation from browsing and trampling by cattle and wildlife
2. Currently the NRDCL staffs are not able to carry out plantation maintenances entailed by the plantation norms and standard because the fund released from their head office is at wage rate Nu.165.00 in lieu of Nu.215.00. Therefore, they merge two maintenance budgets to enable doing good maintenance work once or twice in a year which as per norms demands to do three times. It is recommended that NRDCL should release fund as per the wage rate approved by the Government to enable staff in the field to execute work smoothly as per norms.
3. The saplings produced from the FMU is either browsed or not hardened off. Therefore, the FMU must emphasise on producing good quality saplings. High quality tree seedlings ensure high survival rate of seedlings. Good quality seedlings are better able to endure transplanting shock and difficult post-planting conditions. The hardiness quality of seedlings lead to increased survival rates, faster early growth and reduced establishment costs.

The AAC of the last management plan was set at **4577 m^3**, including the AAC for local use. As per the data collected from Rongmanchu FMU at Budur, Lhuentse, the total commercial volume harvested for the last nine years is **34898.77 m^3** (Table 12) and rural volume is **1706.47 m^3** (Table 13) in standing volume. This shows that extraction has not exceeded the total volume of the AAC for both the commercial and the local use. The entire extractions have been carried out in Rongman Block.

Rongmanchu FMU shares boundary with Bumdeling Wildlife Sanctuary which ensures that the FMU has connectivity with an external protected area. The protection working circle and interlines also provide safe refuge and passage for movement of wild animals in the FMU,

since there has not been reduction in the connectivity of the FMU with protected areas.

Improvement in the harvesting operations in cable lines after the mid-term evaluation in the FMU was observed. The cable corridors have become narrower but it could still be seen that some corridors have large openings which is due to the large crown width of the broadleaf trees. It was observed that it is difficult to keep corridors width less than 4 meters in most cases as the crown width of many broadleaf trees are more than 4 meters. There has also been marked improvement in the extraction of lops and tops from operated cable lines even though there are still some quantities of lops and tops lying in the cable lines which should have been removed.

10.2. Review of Harvesting Activities

The harvesting is done with a fixed skyline and gravity cable line system till date. It is believed to considerably reduce construction of forest and disturbance on soil and natural regeneration. However, some of the issues observed while evaluating the previous plan are as follows:

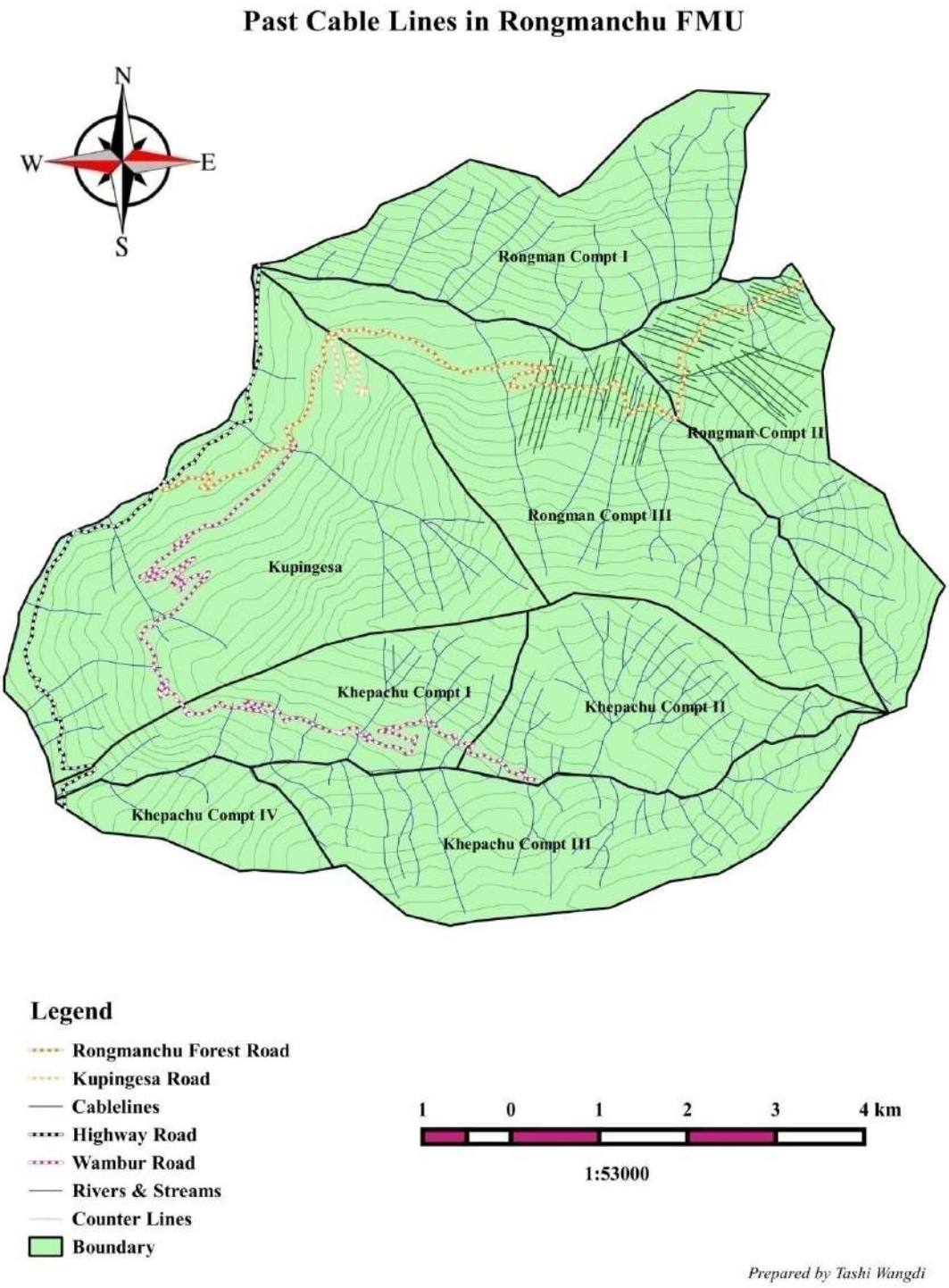


Figure 14: Past cable lines in RFMU

» NRDCL has not been able to sell most of the hardwood timber from their timber depot in the FMU and there are about **45,652.76 cft** (**1292 m^3**) unsold logs balance in the depot. The old logs have deteriorated in quality and, therefore, NRDCL started converting these old logs into sawn form for disposal through their retail outlet.

Through this new management plan it is recommended to carry out extraction of timbers from the FMU based on market demand. If there is no market demand for the extracted timbers the extraction of timbers must be withheld by NRDCL till such time when there is adequate market demand and the extracted timbers could be disposed/sold profitably. In no circumtances shall NRDCL let the extracted rot in the depot as was the case in the first management plan.

Figure 15: Unsold timber at Umlingbadep depot

» There has been marked improvement in the removal of lops and tops from cable lines compared to the past.

» NRDCL identified and opened a new timber depot at Fawan which is near the Lhuntse highway. It is a practical move as it may help in faster disposal of timber owing to its proximity to the national highway. Since the site is much drier due to its location in a dry (Chirpine) area compared to the old depot, the rate of timber deterioration may also slow down.

» As recommended in the mid-term evaluation report, NRDCL have started planting the harvested areas immediately after logging operations and they are also maintaining the plantations as required.

» Plastic or poly-pot after planting the seedlings was littered inside the plantations. NRDCL and Territorial Division need to look into it and manage waste properly in the FMU in future.

» NRDCL have created plantations in the harvested patch openings in cable lines. Some

of the corridors between the two patch openings are wider than 4 m and it needs to be planted too in future.

» NRDCL have also installed signage along the cable lines and forest road which helped in identification of cable lines and plantations, etc.

» Data management has improved with the FMU staff maintaining information on rural and commercial timber through tree marking list, registers, etc. Mongar Division has also codified a standard file system for the FMUs in order to maintain uniformity in management of information/data by FMUs.

» NRDCL forest nursery is now well maintained and the FMU has ready stock of Champ, Walnut, *Exbucklandia* sp., and *Nyssa* sp. for plantation during this planting season.

» During the field visit, it was pointed out that there is confusion about the boundary between Bumdeling Wildlife Sanctuary (BWS) and Rongmanchu FMU. There appears to be some over lapping in areas of BWS and Rongmanchu FMU and NRDCL have already invested and constructed 1.8 Km road in the area which has gone inside the park area.

» Team was informed by NRDCL that they are establishing retail timber outlet in Autsho to meet the timber demand of people in the area.

» The FMU still faces staff shortage. At present, there are four territorial staff and NRDCL has only three staff in the FMU.

In general, the objectives of the management plan were found to have been achieved.

10.3. Review on Road Building Activities

During the last management plan 14.4 km of forest road was constructed from Budur to Soksopachu. The road network mostly concentrated in Kupingesa and Rongman Block, as operation of logging activities have taken plan only in Rongman Block, Compartment II and III.

The road has benefitted local people of Budur, Kupingesa, Wambur and Lagay village. The forest road was maintained well throughout the FMU but some sections of the forest road required immediate maintenance.

Table 16: Shows the status of road in the FMU

Block/Compartment	Year	Road constructed (Km)
Kupingesa	1998	7
Rongman Compartment III	2008	2
Rongman Compartment III	2009	2
Rongman Compartment II	2010	1.8
Rongman Compartment II	2013	1.6
Total		**14.4**

10.4. Review of Reforestation

Figure 16: Natural regeneration

The plantations were carried out in patch opening along the cable corridors by the NRDCL. The plantations fenced with 4 strands of barbed wire. During the assessment of seedling survival rate was only 299 seedlings per hectare. When the survival rate was compared with the standard number of seedlings planted per hectare (n = 1600 seedlings/ha), the survival rate comes to 19% only which is very low. As per the standard and norms of nursery and plantation by SFED 2016, the plantation is a failure because it demands survival percentage >70% to be called a successful plantation.

For the improvement of the plantation survival the recommendations provided above in 10.1 may be adopted.

Grazing pressure was evident from the poor survival of established regeneration in the operated areas. Therefore, the people should be educated with the knowledge of improving the pasturelands, rearing more productive and improved breeds to reduce grazing pressure in the future.

PART 2

FUTURE MANAGEMENT






PART 2: THE FUTURE MANAGEMENT

11. INTRODUCTION

The Royal Government of Bhutan's policy is to retain at least 60% of the country under forest cover. Productive forests are to be managed under a system of multiple objective and sustained yield principles. The FNCA 1995 provides the legitimacy to ensure that all sustainable harvesting operations in the country are carried out in strict accordance with an approved forest management plan prepared by the focal agency of the Department of Forests, namely the Forest Resource Management Division (FRMD) and any other agency, assigned with the responsibility by the Ministry of Agriculture and Forests.

With the increasing emphasis on private sector development and the corresponding growth in the sector, Lhuentse Dzongkhag in particular and the region in general are experiencing a surge in the demand for construction timber. However due to low wood processing capability and the lack of experienced workers in such a field, commercial demand for hardwood is not very significant in the region and also across the country. The problem is further compounded by the severe shortage of conifer timber in the region.

Taking into account, the dynamics of such a supply and demand scenario, the resource management prescribed by this plan should reflect the current and future trend in the timber market as a result of changing socio economic conditions and availability of FMU, the underlying principle of sustainability will always be the central focus of this management plan.

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 of Bhutan, 2011 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. 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

The overall goal of this management plan is to :

Manage the forest resources within Rongmanchu Forest Management Unit on the multiple

use, sustained yield basis for the production of timber, firewood and other forest products; and for conservation of watershed, wildlife and environment.

11.3. Objectives

The objectives of Rongmanchu Forest Management Unit were framed based on different management circles identified to ease the implementation of the plan. The three Management Circles identified are (Figure 17) Protection, Production and Non-Production Management Circles. This allows different areas to be managed and evaluated separately. However, there are instances where different management circles share similar objectives. The objectives of each Management circles are listed below.With proper record keeping, vigilant monitoring and evaluation and appropriate budget considerations by NRDCL it is expected that all the following objectives can be met easily.

Protection Management Circle

- To conserve the water catchment functions by keeping buffer zones and not harvesting timber;
- To protect the forest from fire and illegal activities through involvement of local people;
- To allow low-impact collection of Non-Wood Forest Products through some regulations;
- To conserve and protect wildlife habitats and biodiversityby not interfering any human interventions while managing FMU;
- To raise awareness on biodiversity and the natural forest to local communities and stakeholders;
- To respect the sanctity of religious places and to protect historical sites through FMU management.

Non-Production Management Circle

- To manage and regulate grazing for livestock through involvement of local communities;
- To conserve and protect biological diversity by regulating function maps of FMU;
- To conserve the water catchment areas by keeping buffer zone and not harvesting timber;
- To maintain the forest condition by following the plan prescriptions of management plan;
- To meet the local demand for NWFPs on sustainable basis.

Production Management Circle

- To meet local requirement, as a priority, for timber, fuelwood and other forest products on a sustainable basis;
- To manage the FMU for commercial timber production on a sustainable basis;
- To enhance and improve forest condition and productivity to meet national needs;

» To create local employment opportunities through forestry activities;

» To protect the forest from pest and diseases, fire, illegal activities and from grazing in regenerating areas.

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 such as soil conservation, watershed conservation and supply of clean, corbondioxide sequestration, 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, slope, 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 UIC with first hand information on the location of different forest functions in order to enable him/her to specify the required management prescriptions and to control their implementation.

The concept of forest function planning as applied in Bhutan is described by Shindele and Dhital (1997). This reference provides background and detail to the concept and this plan will only describe the application of forest functions to the Rongmanchu Forest Management Unit. The most important result of forest function planning is the forest function maps. These maps form the bridge between planning and implementation. The forest function prescriptions are the basic tools of the FMU In-charge for field implementation of this Management Plan.

11.4.2. The main objectives of Forest Function Mapping are:

» To define different environmental and social functions of the forest and depict them on the maps.

» 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 UIC 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.

11.4.3. 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 17: Different Forest Function Used in the Management Plan.

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

11.4.4. Mapping Forest Functions

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

Table 18: 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 30 m 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/goenpas, gneys and other religious sites.
	SocLC: Areas which are used by local population for the collection of wood and NWFP.
Road Buffer	**RB**: 200 m uphill and 100 m downhill for motorable public road, 30 m uphill and 10 m downhill for unstable forest road.

11.4.5. 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 19: 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 does 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 Management Inventory

Inventory Design of Rongmanchu Forest Management Unit

Forest Management inventory of Rongmanchu FMU was conducted during the fiscal year 2016-2017 for the preparation of this Management Plan. The standard FMU inventory technique was used, data being collected in the SUMSUNG GALAXY TAB for trees >10 cm DBH (OB). A total of 398 plots were laid throughout the FMU areas with spacing of 400 m x 400 m, thus a plot representing an area of 16 ha. All 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. Further it was also intended to provide an overview of the general characteristics of the natural forest and indication of timber quality.

12.2. Forest Management Inventory Result

The summary of the inventory results is shown in the table below;

Table 20: Forest Management Inventory result for Rongmanchu estimates with sampling error at 90% confidence level

Result Type	Measures	Absolute Error	T-value at 90%	SE/MoE for Tot tree count	SE%	Lower value	Upper value
Total tree volume	1213065.79	111202.94	1.64	182372.83	15.03	1030692.96	1395438.62
Mean tree volume	189.45	54.9100	1.64	90.05	47.53	99.40	279.50
Total tree count	921388.72	43462.14	1.64	71277.91	7.74	850110.81	992666.63
Mean tree count	143.90	6.79	1.64	11.14	7.74	132.76	155.03
Total tree basal area	123771.99	8394.72	1.64	13767.34	11.12	110004.65	137539.34
Mean tree basal area	19.33	1.31	1.64	2.15	11.11	17.18	21.48

13. AREA ORGANISATION

13.1. Spatial Organization

Formation of Management Circles is very important in planning process for better field orientation and organization of management activities during Management Plan implementation. The Management Circle is further divided into Blocks and Compartments. The blocks have been demarcated according to natural features such as perennial river and terrain. Rongmanchu FMU has been divided into 3 blocks i.e. Rongman, Kupingesa and Khepachu. The boundaries of the compartments are also based on identifiable topographic features such as streams, rivers, ridges, etc.

Table 21: Blocks and Compartments with their corresponding area (ha).

Block	Compartment	Area (ha)
Khepachu	I	539.31
	II	602.41
	III	807.55
	IV	228.95
Total		2178.24
Kupingsa	None	1562.31
Rongman	I	793.41
	II	666.64
	III	1202.31
Total		**2662.58**
Grand Total		**6403.13**

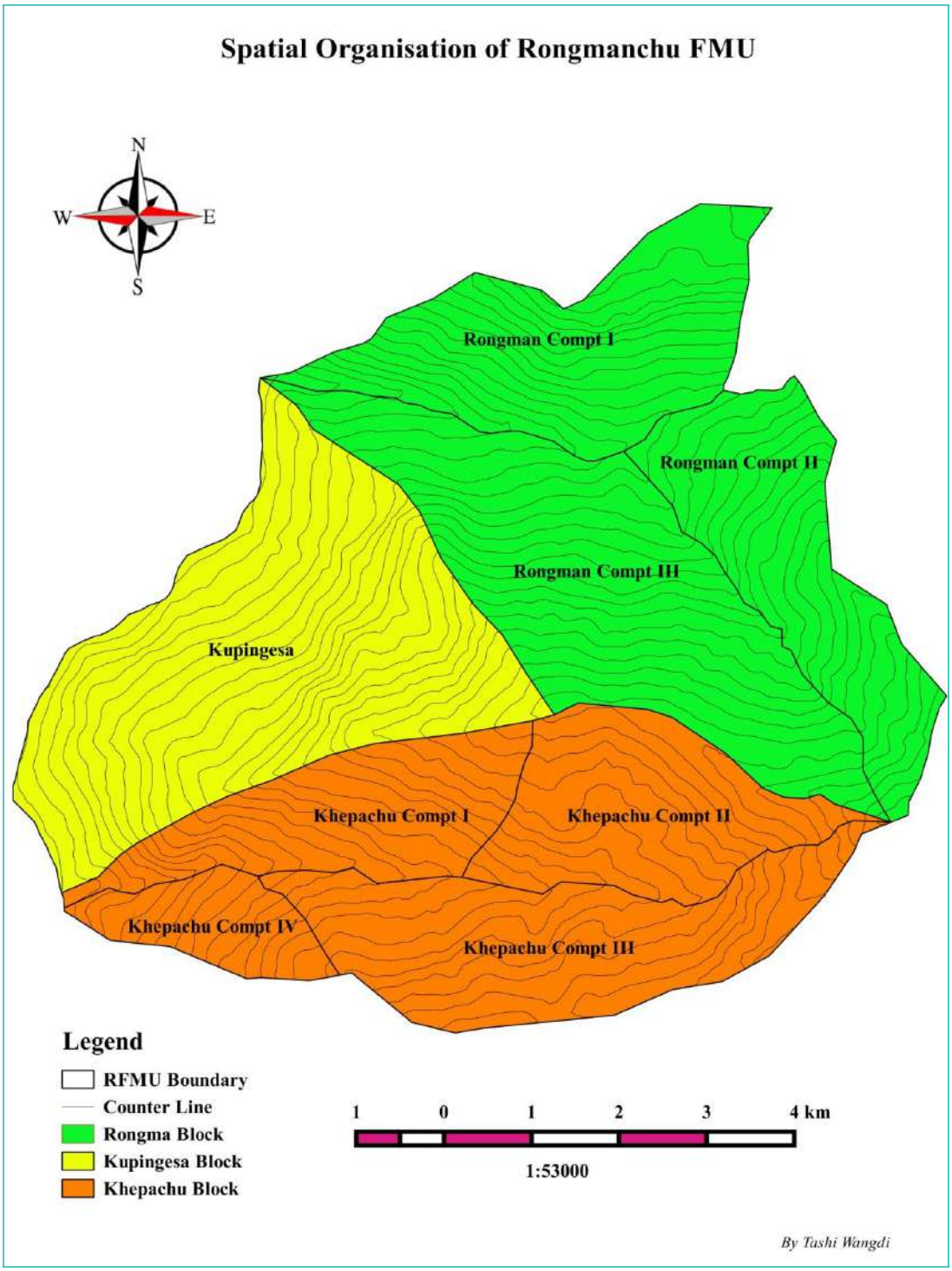


Figure 17: Map showing spatial organization in RFMU

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.

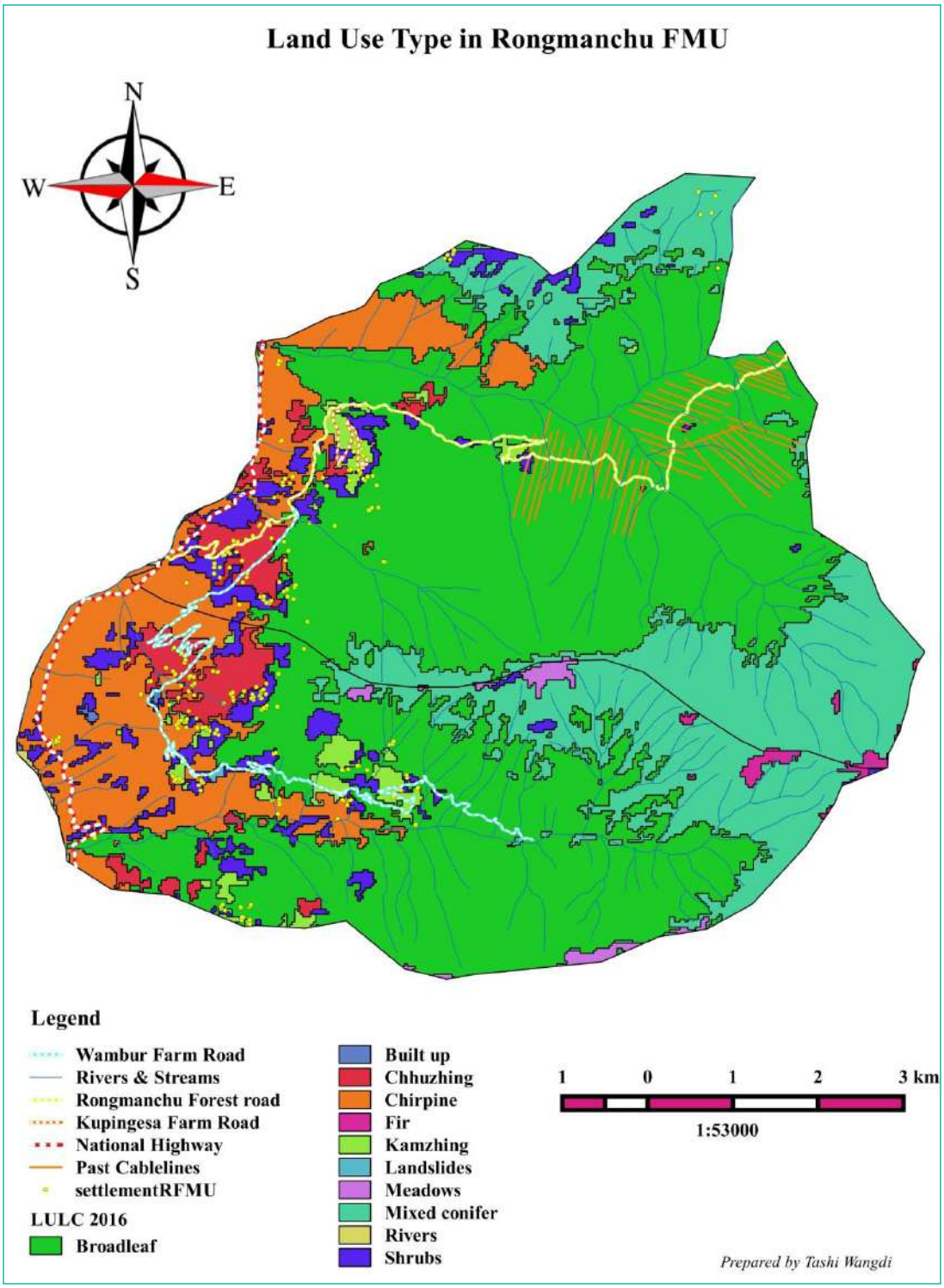


Figure 18: Map showing Land use type in RFMU

Table 22: Areas covered by different land use

Land use	Area (ha)
Permanent cultivation	334.84
Build up	4.63
Landslide	2.64
Rivers	5.91
Meadow	36.74
Shrubs	304.96
Chir Pine forest	828.40
Mixed-Conifer forest	1314.07
Fir forest	26.74
Broadleaf forest	3543.80
Total	**6403.13**

13.3. Organization into Management and Working Circles

Function mapping was used to delineate three broad Management Circles for Rongmanchu FMU. The three broad Management Circles for the FMU are Protection, Production and Non-Production working circles. Table below gives the detail of the area statement for the working circles:

Table 23: Area statement under different management circle

Protection Management Circle	Production Management Circle	Non-Production Management Circle
1556.97 ha	4307.55 ha	538.60ha

13.3.1. Protection Management Circle

The Protection Management Circle is the sum of all protection functions metioned below. The total area under Protection Management circle is 1556.97 ha.These functions are derived by following the restriction placed by the forest management code of Bhutan 2004.

» **Wildlife protection:**

This function includes all habitat and other areas where rare or endangered mammals and birds occur and where the protection of these animals gains highest priority.

Objective:

1. To conserve the habitat pf protected wild animals and corridors for their movement and
2. To prevent the protected animals from human disturbance.

Legal restrictions: According to section 22(a) of the FNCA 1995 altogether 23 wild animals are totally protected in Bhutan.

» **Soil protection**

Soil protection includes all areas which are extremely sensitive to soil erosion, land and snow slides. These areas inclue in particular very steep slopes, rocky and stony areas, water logged gleys and already eroded areas. Unstable slopes above or near important objects such as villages, settlements, individual house, roads, agricultural land, etc. are defined for protection reasons as Soil Protection too.

Objective:

1. To prevent damagecaused to the environment and infrastructure by land slides, snowslides, falling stones and other physical impacts and
2. To protect the soil from erosion and to sustain soil fertility.

Legal restrictions: According to section 14 a (iii) of the FNCA1995 "no permits shall be issued to fell and to take any timber where the slope is greater then 45 degrees (100%) unless authorized under an approved management plan or by the Head of the Department."

» **Riparian reserve protection**

Riparian areas occur along the banks of rivers and streams, and around the perimeter of lakes and wetlands. They include the water body itself, areas subject to periodic inundation and flooding, areas with high water tables and immediate adjacent uplands. Streamside vegetation stabilizes stream banks, regulates stream temperatures through shading, and supplies a continual source of coarse woody debris to stabilize stream channels and diversify aquatic habitat. The majority of fish food organisms come from overhanging trees and shrubs, while the nutrients from organic materials that fall or wash into the stream are the basis of aquatic ecosystem productivity.

Riparian areas often contain the highest plant and animal diversity, and some of the highest valued non-timber forest resources in the forest landscape. They provide critical habitats, home ranges and travel corridors for many mammal and bird species, and maintain ecologically-important vertical and horizontal linkages throughout the forest landscape.

Objective:

1. To minimize or prevent negative impacts due to forest resource use on stream channel stability, water quality, and aquatic ecosystem productivity and diversity;
2. To protect and sustain plant diversity associated with riparian areas; and
3. To allow sustainable and environmentally-sound forest uses consistent with objective (1) & (2) above.

Legal restrictions: According to secton 14 a (ii) of the Forest and Nature Conservation Act (1995) "no permits shall be issued to fell and take timber within 100 feet (30 m) of the bank or edge of any river, stream, water course and or water source.

» **Religious site protection**

Religious sites are lhakhangs/goenpas and gneys and all other places used by people to practice religion.

Through out the country, monasteries, gneys, meditation houses and other religious objects are distributed and many of them are located in forested areas. To respect the sanctity of these holy places and in order, not to disturb people in their religious practice, no forestry operations should take place in the immediate vicinity of religious sites.

Objective:

1. Not to disturb people in their religious practice and to respect the sanctity of these places.

Legal restrictions: None.

» **Local water supply protection**

Buffer zones have to be defined for all areas in the immediate vicinity of water resources used for the local water supply and includes the water-body itself and swampy or waterlogged catchment areas.

Objective:

» To prevent negative impacts due to forest resource use on water quality and stream channel stability

» To prevent damage to water and irrigation channels.

Legal restrictions: According to section 14a (ii) of FNCA 1995 "no permits shall be issued to fell and take timber within 100 feet (30 m) of the bank or edge of any river, stream, water course and or water source."

» **Road buffer**

A road buffer is the zone along a road where the implementation of forest activities may have direct negative impact on the road itself or on the security of the traffic.

Objective:

1. To protect the road from rock fall, land and snow slides, surface runoff of precipitation and erosion and to safeguard traffic.

Legal restrictions: According to section 14 a (i) of the Forest and Nature Conservation Act (1995) "no permit to fell or to take any timber within 600 feet (200 m) uphill and 300 feet (100 m) downhill should be issued along motorable roads *except for forest roads.*"

In these areas commercial activities are not allowed. The total area under Protection Working Circle is 2014 ha. In total the protection area alone account close to 31% of the total FMU area. These areas have been designated as protection area and will not be subject to any form of commercial production activities. Although the designation of these protected areas are not as a result of comprehensive environmental studies, they however are representative forest types of significant size. The combination of sites that are protected within (buffer and steep sites) and outside the productive areas provide a matrix and continuous sites that could have the potential to maintain integrity and function of these ecosystems at the local scale.

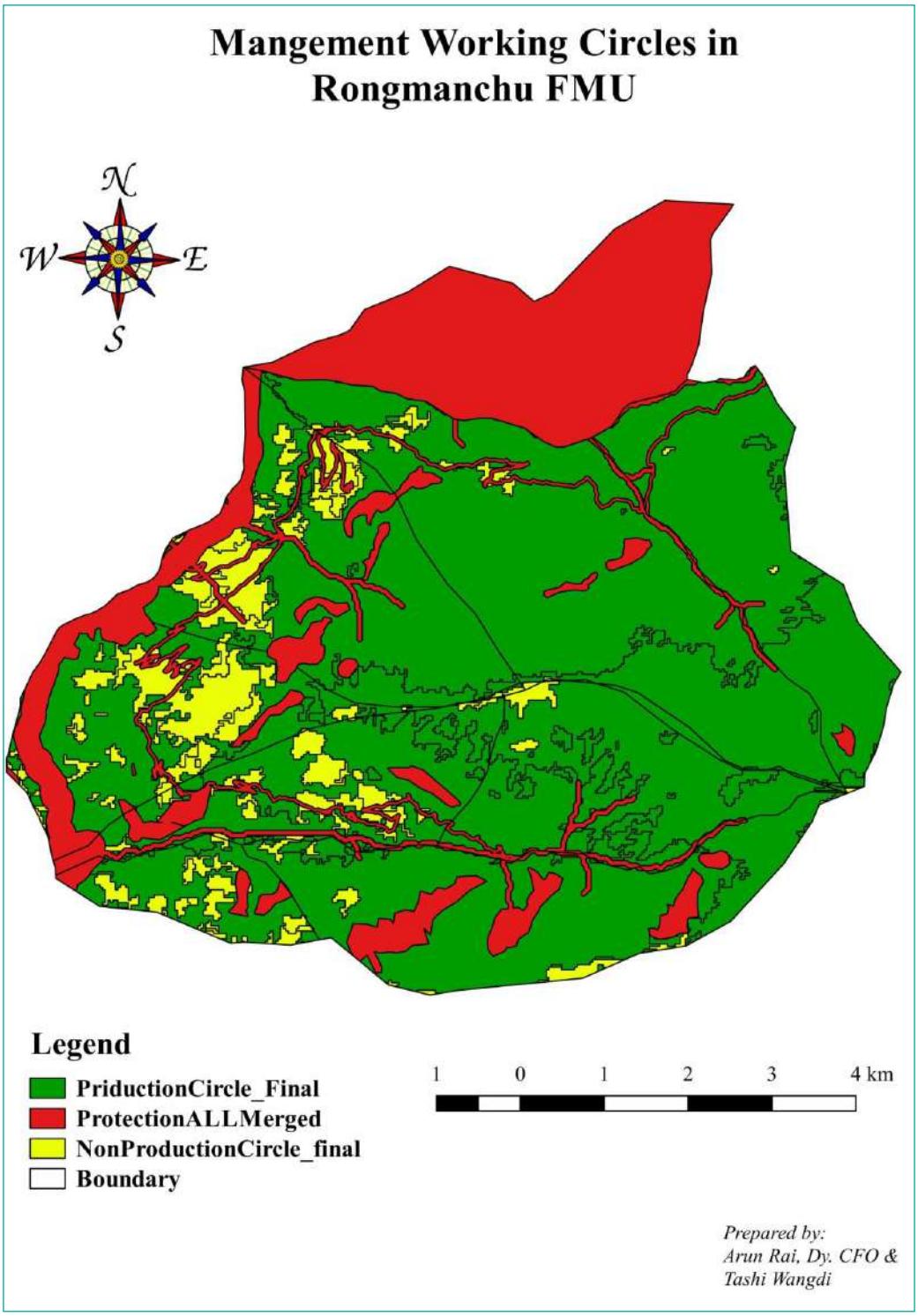


Figure 19: Management circles in RFMU

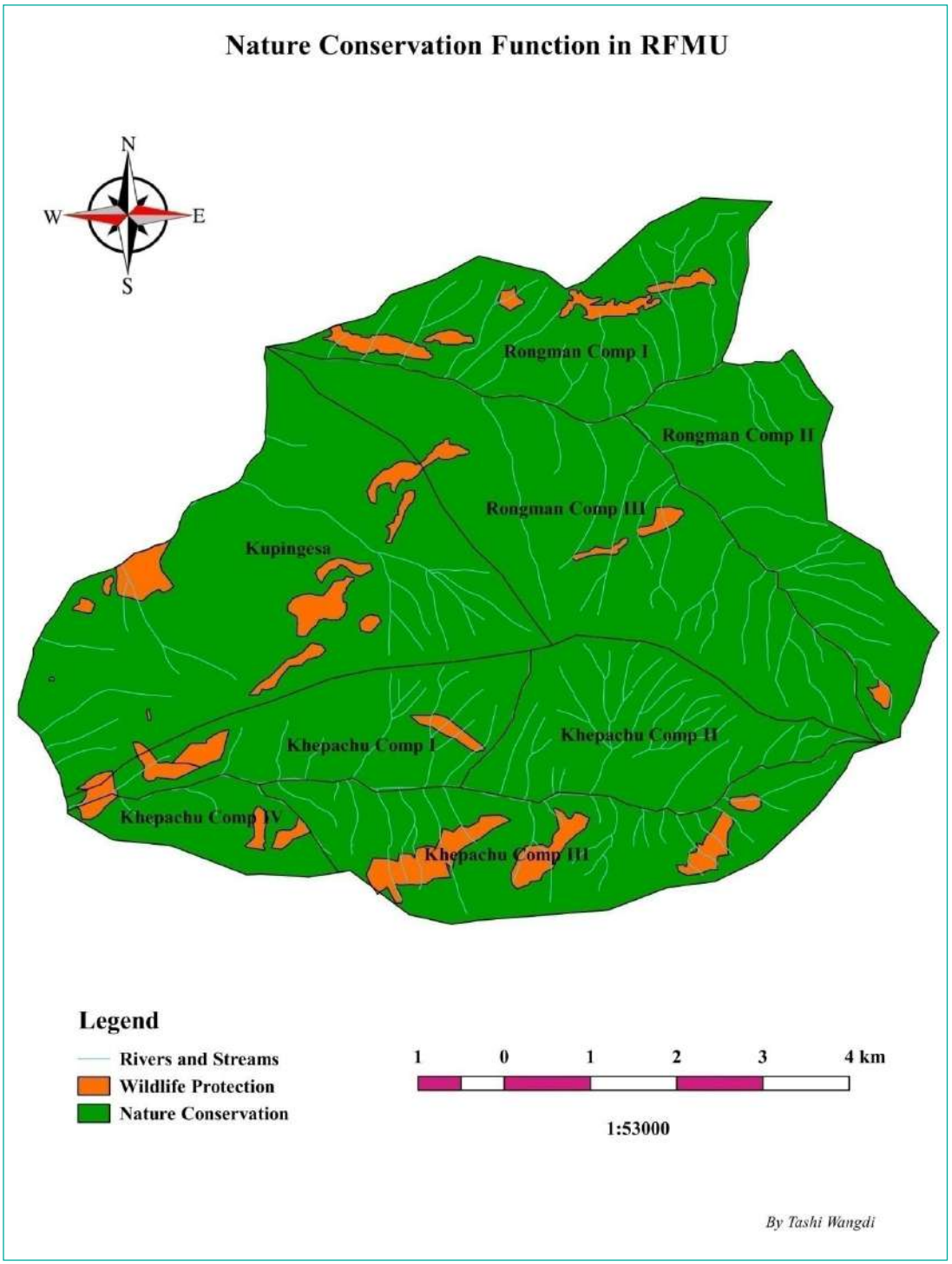


Figure 20: Nature conservation function in RFMU

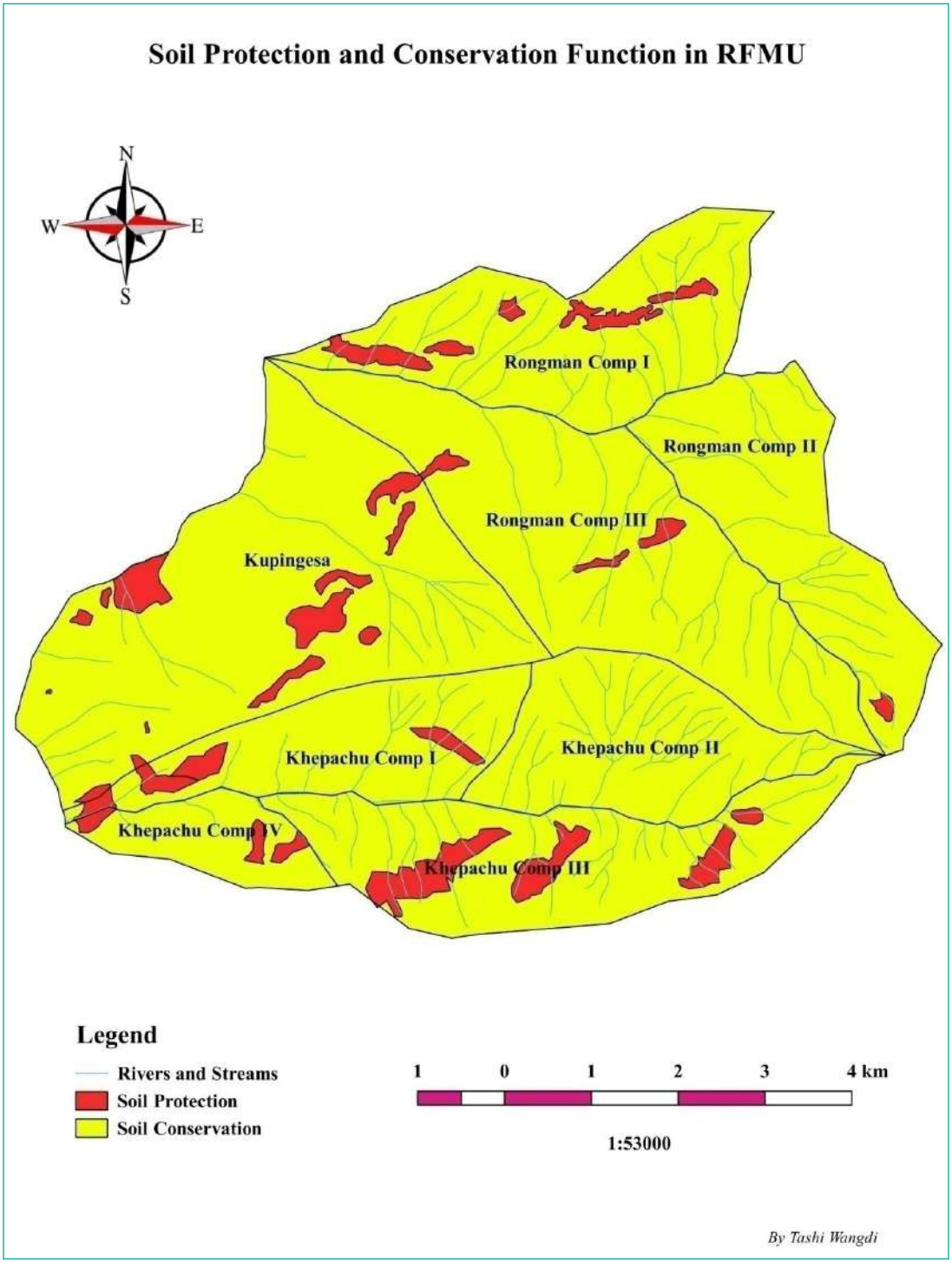


Figure 21: Soil protection function in RFMU

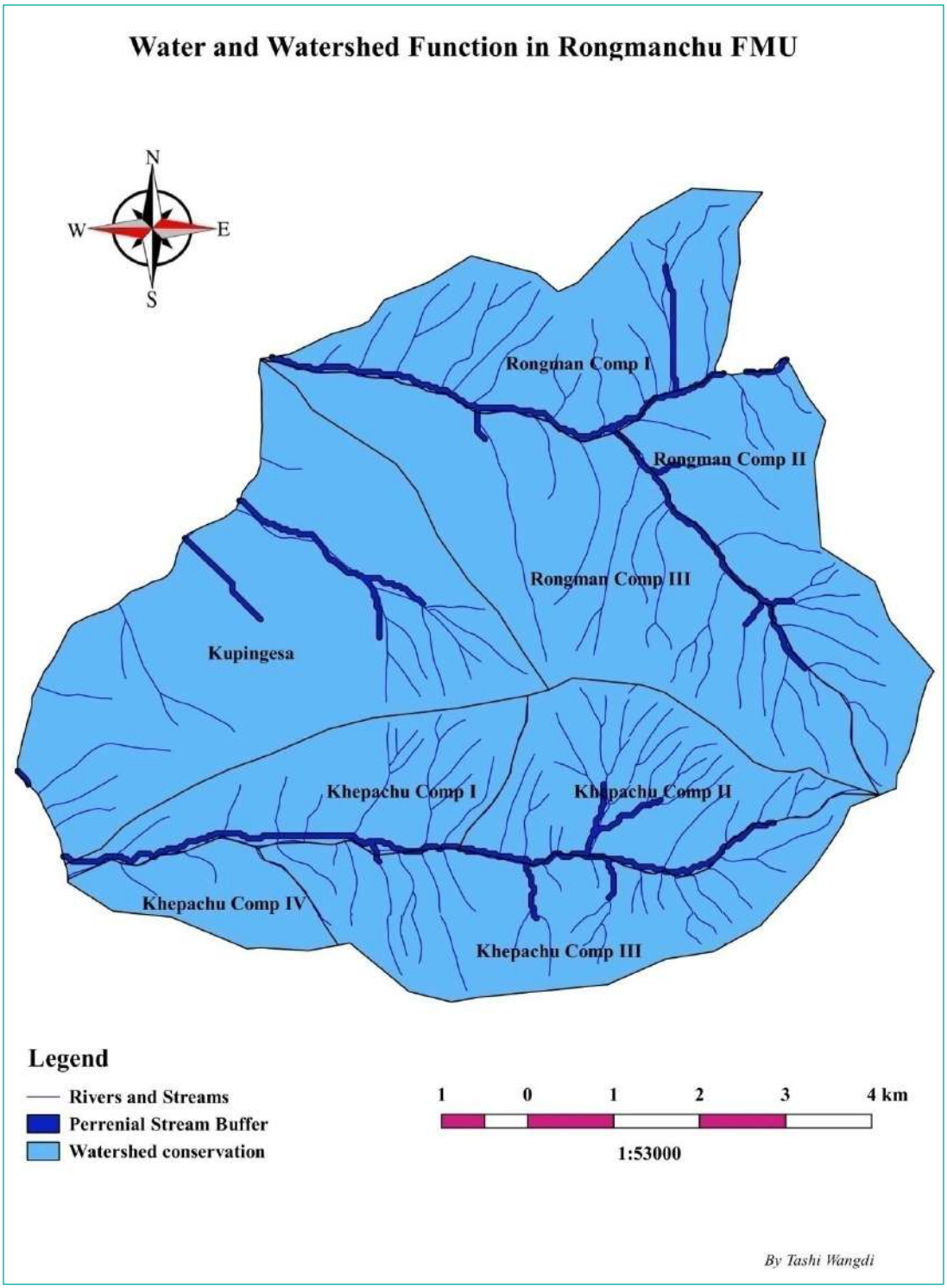


Figure 22: Water and watershed function in RFMU

Table 24: The principle objectives of 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 from 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

13.3.2. Production Management Circle

Forest within this Management circle will be managed to maintain forest cover to safeguard important water catchments and ensure sustainable production of timber based on the annual allowable cut prescribed for this unit. The total area under Production working circle is **4307.50 ha.**

The aim is to allow sustainable harvesting both commercial and non-commercial of the forest resources, while at the same time improving the regeneration potential of the forests. The principle objectives of management are:

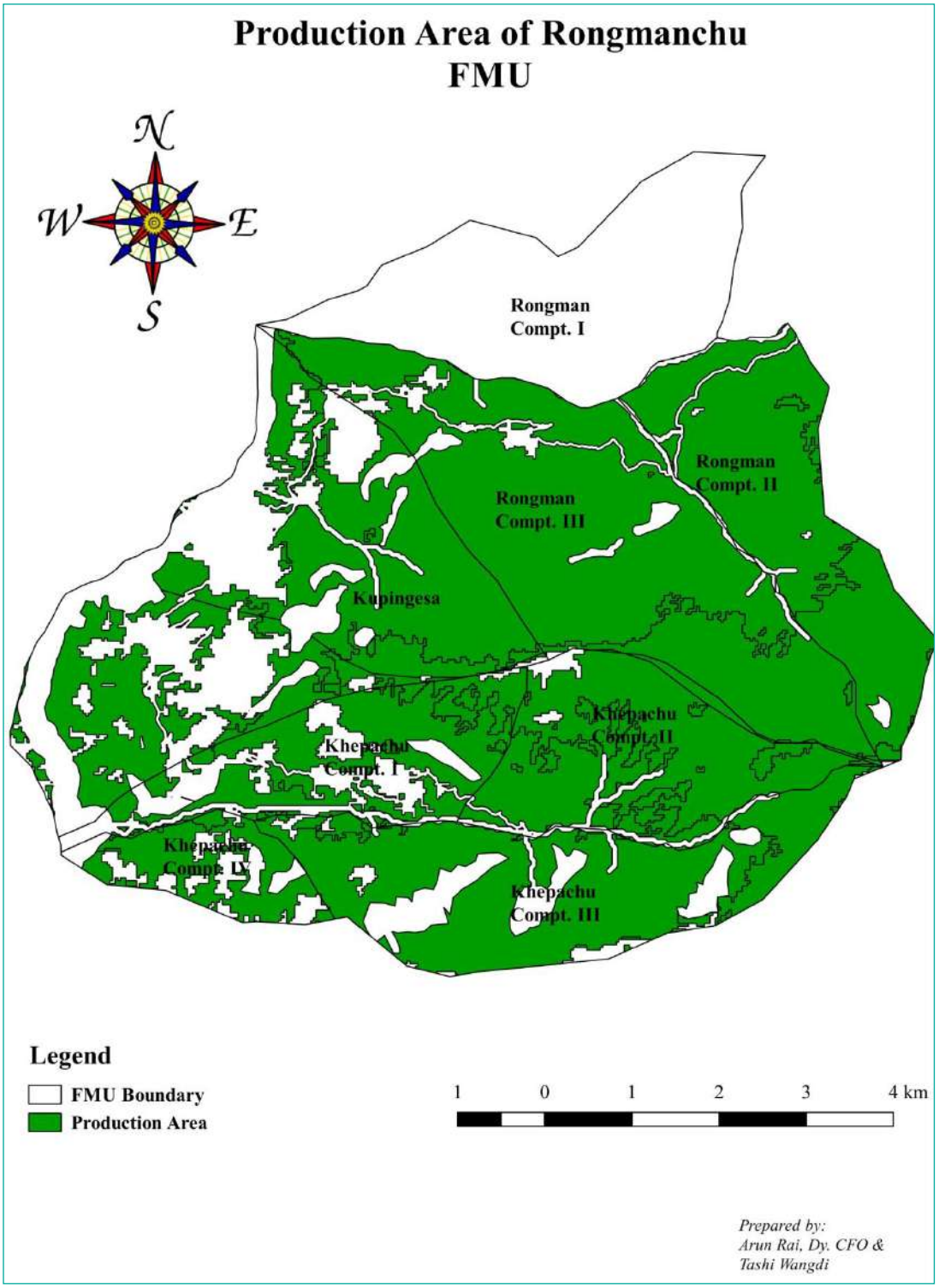


Figure 23: Production Areas in RFMU

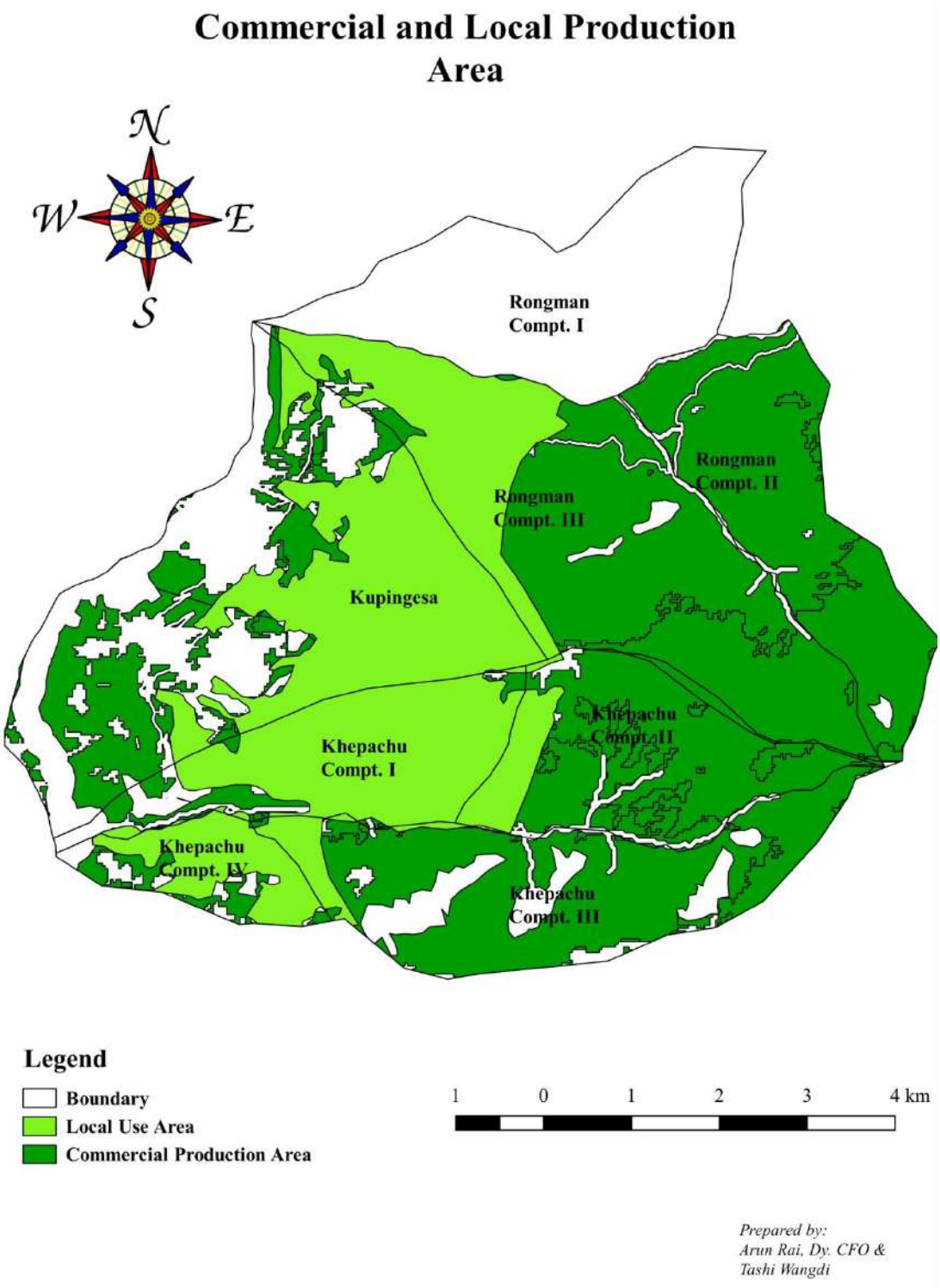


Figure 24: Rural and Commercial Production Area in RFMU

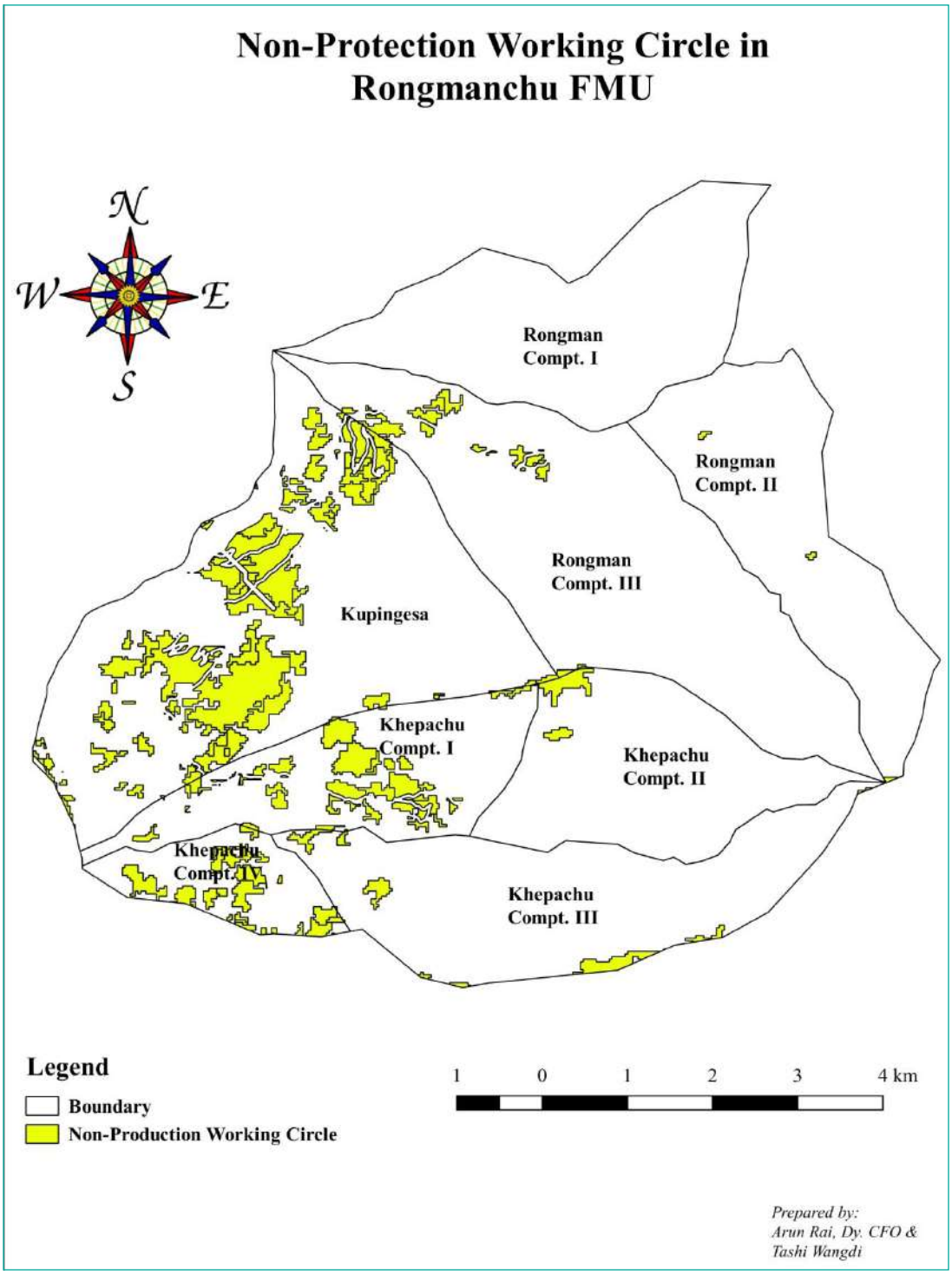


Figure 25: Non-Prodcution Management Circle Map

Table 25: Production Management Circle.

Management Objectives	Management Options	Responsibility
To meet local need for timber and other forest produces 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 habitat management.	Field visit & Research.	Territorial Division

13.3.3. Non Wood Forest Products (Overlapping) Management Circle

The Managenment Circle shall overalap with all other Management Circles, including Protection and Non-Production Management circles, which constitutes the entire FMU area. The overall objective of this Working Circle is to manage the NWFPs in Rongmanchu FMU on sustainable basis, and monitor low impact collection.

Management Objectives	Management Options	Responsibility
To meet NWFPs for local needs	Apply management guidelines and involve community for monitoring	Territorial Division
Environmental conservation	Consider environmental values in the planning process	NRDCL/Territorial Division
To maintain and improve the non-forested area	Follow plan prescriptions	NRDCL/ Territorial Division
To regulate grazing by livestock	People's participation through workshops and sensitization	NRDCL/Territorial Division

13.4. Organization into Working Circles

The Production Working Circle includes all areas where harvesting can occur, both commercial and local. For the ease of implementation of this plan no diifferent working circles for different tree species were identified within the production areas of the FMU. Therefore the entire Production area has been delineated as a single working circle in the FMU.

Table 26 Management Objectives and Management Options

Table 26: Management Objectives and Management Options

Management Objectives	Management Options	Responsibility	Monitoring	Silvicultural systems
To meet the local timber needs of the people and other forest resourcs on sustainable basis	1. Ensure allotment of timbers on thinning and selection basis with an objective of improving the stand	1. Territorial Division	Territorial Division	Single tree Selection System
To manage the commercial timber production on sustainable basis.	1. Use appropriate logging and Silviculture method. 2. Ensure cable line layout allows two interlines for logging in future. 3. Operate entire cable line. 4. Encourage cleaning of entire cable lines.	1. Territorial/NRDCL 2. Territorial/NRDCL 3. Territorial/NRDCL 4. NRDCL	1. Territorial 2. Territorial 3. Territorial 4. Territorial	**Clear Patch Cut or Group Selection System** The coupe sizes recommended by RNR-RDC Yusipang serves as Aa guideline to follow for each silvicultural system prescribed for each forest type. Cable lines will be laid to their full capacity. Cable corridors will be not be more than 4 m wide. Group opening will not exceed 0.25 ha on an average. The distance between the cable lines will not be less than 84 m and between groups along cable line will not be less than 50m.
To enhance and improve forest condition and productivity.	1. Ensure that all barren areas are restocked with suitable native species. 2. Use appropriate logging and silvicultural method. 3. Monitor on the attack of pest and disease. 4. Involve local communities.	1. NRDCL/Territorial 2. NRDCL/Territorial 3. Territorial 4. NRDCL/Territorial	1. Territorial 2. Territorial 3. Territorial 4. NRDCL	
To protect the forest from overgrazing, fire, illegal activities	1. Control over grazing, fire, poaching and other illegal activities through community participation and proper fencing.	1. Territorial	1. Territorial	

and from grazing in regeneration areas.				All merchantable trees > 10cm DBH will be felled. Dead, dying, malformed and diseased tree will be felled by priority.
To create local employment.	1. Employ local people. 2. Employ local contractor.	1. NRDCL/Territorial 2. NRDCL	1. NRDCL 2. NRDCL	Opening can be rectangular, square or circle in shapes based on terrain features and stand condition, but should not exceed the prescribed size. Damage to neighbouring tree must be minimized.
To maintain biodiversity within the production area.	1. Low impact Silviculture system.	1. Territorial/NRDCL	1. Territorial	
To conserve the water catchment functions.	1. Minimal intervention. 2. Abide by stream buffer regulation.	1. Territorial/NRDCL 2. NRDCL/Territorial	1. Territorial 2. Territorial	
To continually improve health and safety standards.	1. Provide training to contractors. 2. Provide awareness to local community.	1. NRDCL 2. Territorial	1. Territorial 2. Territorial	
To regenerate the harvested area	1. Plant harvested are immediately in the planting season 2. Maintenance work is carried out adequately to ensure facilitation of seedling nourishment and growth. 3. Tending operation associated to plantation must be carried out as per norms and standards of plantation and nursery 2016.	1. NRDCL	1. Territorial 2. Territorial 3. Territorial	

13.5. Implementing Management Circles

The concept of Forest Function Mapping has been used in this Plan to delineate between forest and different land use in the FMU for implementing sustainable management of forest resources and making resources available and affordable to the public. This will be further supplemented with detailed information collected during Operational Planning through forest inventory and discussions with stakeholders, primarily local communities and NRDCL. But, implementation of correct prescriptions in the field still remains a challenge.

Therefore, the UIC will have to be fully conversant with the FMU information prior to going to the field. Further, the forest function maps may be updated according to the field observations.

14. YIELD REGULATION AND HARVESTING

14.1. Determination of Annual Allowable Cut (AAC)

14.1.1. Introduction

Principle of sustainability is the backbone of forest management which focuses on sustainable utilization of forest resources by present generation and preservation for future generation as well. The concept of Sustained Yield allows harvesting of forest resources by which annual cut and other losses of timber do not exceed the average annual growth. It also assures continuity of harvest without compromising the productivity of the soil. Calculation of Sustained Yield is expressed as AAC.

FMU's are used for multiple-objective purposes, and commercial and rural use forestry activities are only two of a number of functions. The areas for commercial and rural forestry activities are those that are left after areas for other critical functions were identified and mapped out, using GIS, inventory information and field truthing. The functions that take precedence over commercial and rural forestry activities are:

- Road buffers
- Riparian buffers and zones
- Soil protection areas (slopes greater than 100%)
- Biodiversity areas (wildlife conservation and protection)
- Religious site protection
- Agricultural uses
- Meadows for grazing
- Soil Conservation areas
- Local Water Supply Protection

The above areas do not come under timber production.

14.1.2. Increment Based AAC

In principle, it should be possible to sustainably cut the annual increment each year in case of a normal forest. But, some calculation methods rely heavily on increment. Unfortunately,

data on increment is still limited for Rongmanchu 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 AACs are currently unsuitable for Bhutan.

14.1.3. The Most Appropriate AAC Method

A combination of area, volume and rotational age of species is used for the calculation of AAC in Rongmanchu FMU since methodology is simple and easy to use. The method used for calculating the AAC for Rongmanchu FMU is given below:

$$\text{AAC per Working Circle} = \frac{\text{Net Operable Area x Average Standing Volume per Ha}}{\text{Rotation}}$$

14.1.4. AAC calculation for Rongmanchu FMU

Net operable area

The total operable area is identified through forest function mapping using GIS technique. No area has been ducted from the Net operable area for the purpose of calculating AAC.

Table 27: Net operable area of forest type

Forest Type	Gross operable area (Ha)	Net operable are (Ha)
Broadleaf Forest, Mixed conifer and Chirpine Forest	4307.55	4307.55
Total	**4307.55**	**4307.55**

(***Note: To calculate net operable area no area from the gross operable area has been reduced***)

Rotation

The regeneration period is very long in broadleaf forests and also regeneration has been a very serious issue in Rongmanchu FMU. Therefore a 10 year has been added to the rotation of broadleaf forests (120+10).

Average Standing Volume

The mature average standing volume is derived from management forest inventory data statistically analysed using "R". The standing volume at 90% confidence interval is determined.

The AAC, rotation period and RME is given in (Table 28).

Table 28: Annual Allowable Cut calculation

Stratum (Working areas)	Net operable area (ha)	Rotation (years)	RME standing volume (m^3/ha)	AAC (m^3/yr)	Actual AAC (m^3/yr)	Clear cut equivalent area
Broadleaf, Mixed conifer and chirpine Forest	4307.55	130	99.40	3293.62	3200	32.19
Total	**4307.55**	-	-	**3293.62**	**3200**	**32.19**

Looking at the past experience of the FMU having marked trees in interlines for rural allotment owing to un-identified local use area in the 1st Forest Management Plan. In this plan separate area for local use area is identified for meeting rural timber demand for the people residing within the FMU. For commercial production of timber by NRDCL Khepachu Compartment III is kept for this management plan.

Complying with the resolution of the public consultation meeting, rural use area for the public of Wambur and Lagay a part of Khepachu Compartment II is kept. Some part of Khepachu Compartment III is kept for rural allotment for the public of Umling and Bangtsho within the FMU. No local use area was identified for the public of Kupingesa and Budur owing to lack of area with timber resources, hence decided to allot rural timber from limited production area as have done in the 1st plan.

The total AAC for Rongmanchu FMU is fixed at **3200 m^3 standing volume.** The AAC will be reviewed during the mid-term review.

The total commercial AAC allocated for this plan is **2700 m^3** and the total rural AAC allocated for this plan is **500 m^3**. The clear cut equivalent area is **32.19 ha** per year. The area should be used as control for the AAC. Under any circumstances, the total clear cut equivalent area should not be exceeded even if the volume indicated above is not achieved. The AAC for each stratum must be strictly adhered to. The AAC may be varied by +/-10% in individual year but the volume cut in each five-year period must not be more than five times the AAC.

14.2. Recording and accounting for AAC

AAC will be monitored through trees marked and recorded in the Tree Marking Book (TMB) and Tree Marking Register (TMR) separately for both **commercial and local use** in all Working Circles. AAC has been calculated as gross bole volume and this is the measure that should

be totalled on an annual basis from the TMB and TMR. The records of the logs, firewood, woodchips, poles, etc. extracted from the FMU should also be recorded. The supplied volumes of the same should be totalled annually to monitor AAC.

14.3. Allocation of the AAC

The allocation of the AAC has to take into account: the local village rights and needs for timber, fuelwood, poles and the same demands from outside the Dzongkhag. Owing to insufficient participatory work to determine if needs have changed the allocation of timber for local and rural needs are as follows:

500 m3 gross - allocated to local users (local villages, general public, urban population and *ad hoc)*. The volume of posts, poles, etc. from operations in the immature stands will be included in this allocation. The allocation will be done from allocated areas and local use area as delineated on the maps.

2700 m3 gross - allocated to NRDCL for commercial purposes (from production areas only as delineated on the maps).

Ad hoc demands, especially if the demand is for Government uses, shall be met by NRDCL. Rongmanchu FMU does not have so much of demands from outside the FMU and other Dzongkhags. The concept of FMU encompasses the rights of people within the FMU. While, if the system of supplying timber on standing forms to communities outside the FMU and other Dzongkhags is continued, it shall be very difficult to sustain the FMU.

The AAC workout and the demand assessment have been done based on the existing demand trend and the other factors involved in the standard formula determining the AAC. **Therefore, during this plan period the AAC allocation is strictly for the local communities and NRDCL. Demands from people outside FMU and other Dzongkhags should be encouraged to be met from the NRDCL depots at subsidized rates wherever applicable.**

Table 29: Annual Allowable Cut allocation

Stratum	AAC (m^3)
Commercial Production for NRDCL	2700
Rural Production (Local use only)	500
Total	**3200**

NOTE: The AAC and sustainability of the FMU are based on the above considerations. The forest is highly variable, and the above are ***guidelines***, not prescriptions. Cycles for specific sites can be lengthened or shortened, depending on restocking and growth rates.

14.4. Distribution of the cut

The AAC has been calculated by using the most simple and relevant method. However, to provide properly organized and regulated management, economical harvesting and regeneration an orderly and sequential system of harvesting has to be adhered to. This did not happen in many of the FMUs, with an emphasis being given to easily accessible, high yielding stands.

The mixed broadleaf resource covers the largest area of any resource within the FMU. The broadleaf forest MUST be managed more intensively and with a view to increasing the potential for commercial harvesting. The Rongmanchu FMU after been under management for last 10 years has encountered with difficulty in timber disposal and regeneration problem, especially with the commercial species. Keeping this view in mind the AAC thus less would not create timber shortage especially for the broadleaved species. This ten years management plan involves a lot of re-structuring moving away from a logging-centred approach, exploiting the existing old-growth forests; towards a forest development approach, involving thinning, silvicultural development and the involvement of stakeholders to allow for zoning.

To allow harvesting to operate in an orderly fashion for this plan period, blocks, compartments and sub-compartments are kept alike in the first plan and further harvesting operations will occur in this plan period in the Khepachu Compartment III. The Compartments identified have not been operated in the last plan period but provides further extension to access deeper forests.

Once the harvesting in each individual coupe is completed according to the work detailed in the Operational Plan no other cut will be permitted in the area without an agreement and approval of the Director of DoFPS. This is important to maintain the integrity of the spatial and sequential progression of the chosen silvicultural system. It is, however, important to ensure that harvesting is not concentrated in one isolated area but distributed throughout the FMU in each year of the plan duration.

15. SILVICULTURAL SYSTEMS

15.1. Prescribed Silvicultural System in Broadleaf Forests - Patch Cut with Artificial Regeneration

On 17th of January 2005, Silvicultural Systems Consultative Workshop was held at the DoFPS's Conference Hall. During the workshop, the participants agreed to prescribe Patch Cut System with artificial regeneration as the silvicultural system in broadleaf forests in Bhutan.

The following considerations should be made before the application of the silvicultural system.

1. Factors of Locality

Factors of locality include micro-climate, slope aspects, soil, humidity, rainfall, and geology of the locality which affect the growth of the plant. The nutrient of the soil is also very important for regeneration of the area. Biotic factors like grazing should be considered before clear felling.

2. Potential Productivity of the Site

Potential Productivity of the site should be assessed and the silvicultural technique suitably modified to ensure rapid growth of new plants in the clear felled areas. In Bhutan there is a lack of information on potential productivity of sites. It is also imperative that inputs are applied judiciously. In other countries, people have even irrigated as well as applied fertilizers to the site.

3. Species and composition

Clear felling system is suited to light demanding species. The composition of the species can be changed to ensure the best financial results. But there are trees that can't withstand wind throws. So, clear cutting is going to expose them, causing uprooting and other damages. Some species can't stand the frosts during winter. Clear cutting expose them to such adverse condition. Choice for species and composition should be made taking into consideration these characteristics of different species.

» ***Beilschmedia sikkimensis***

Habitat: a large evergreen tree, usually tall with a straight clean cylindrical bole. Found mostly between 1650 m to 2000 m.

Regeneration/silvicultural characteristics: Generally shade tolerant and are easily raised in nurseries. Fruit is an ellipsoidal 1 seeded berry and ripen in June-July.

Increment: Wood is comparatively soft for a broadleaf species. 5-9 rings per inch of radius, giving a mean annual girth increment of 0.7 to 1.26 inches.

» ***Juglans regia***

Habitat: A large deciduous tree with imparipinnate leaves up to 15 inch long, usually with 5-9 leaflets. Bark of young tree is light grey with vertical striations but that of older tree is light or dark grey with deep vertical parallel fissures. Attains a total height of 27 – 40 m with diameter of 2 m or more in the forest. It is mostly found on deep well drained fertile soils often containing boulders.

Regeneration/silvicultural characteristics: It is one of the first trees to lose its leaves in the forests. The leaves start falling during September and the new leaves appear during March-April. The male catkins are green 2-5 inch long and the female flowers also green occur singly or up to four together at the apex of the young shoots. The fruits ripen in September.

Germination is Hypogeous. Seedling growth is moderately fast. Nursery raised seedlings can attain heights of 1-1.5 feet by the end of the first season and similar heights can be reached under natural conditions only within three years. It is a light demander and need to be raised close together to avoid large spreading crowns. It has a large root system and coppices well.

Increment: 6-10 rings per inch of radius with a mean girth increment of 0.42-1.92 inches.

» ***Quercus lamellose***

Habitat: A large evergreen tree with a massive spreading crown if grown in the open. Bole often crooked in the wild but produces a clean straight bole if grown close together and managed. Bark is grey and granular. Under favourable conditions it can attain a height of 30-40 m with girth of 15-20 feet. Leaves up to 18 inch long, elliptical lanceolate acute at both ends, sharply serrate, glabrous above and glaucous beneath.

Regeneration/silvicultural characteristics: Flowers appear in April and May and the acorns ripen in November – December in the second year. Large acorns with its cup almost 3 inches in diameter. Acorns are eaten by many animals. Usually a good seed year is expected once in every three years.

Although shade tolerant in the younger stages, from the sapling stage onwards the tree develops best with full overhead light but requires some side shade to prevent growth of too many side branches.

It is frost and drought tolerant to great extent but very susceptible to fire. Coppices very well.

Natural regeneration is not so good because of long seed year and the acorns are large and consumed by many wild animals.

Increment: 8-12 ring per inch of radius giving a mean annual girth increment of 0.5-0.8 inch. Rings are very compact.

» ***Exbucklandia populnea***

Habitat: It is a medium sized to a tall handsome evergreen tree attaining a height of 18-30 m and a girth of 3-5 m with a cylindrical clear bole of 9-18 m. Bark is brown to almost black, rough and deeply furrowed. It is blaze reddish brown with white lines. Leaves 11.5-18 by 9.20 cm, broadly ovate, sharply acuminate and dark glossy green above, silky when young, bases truncate or subtruncate. Inflorescence 2-5 peduncles heads.

Regeneration/silvicultural characteristics: The species is a shade bearer. It is very susceptible to difference in elevation, aspect and rainfall and thrives best between 1200-1850 m elevations. It suffers severely from drought, frost and cold driving winds. Severe fires may damage young crops and it is browsed by cattle and deer. Flowering takes place in the month of November and December and sometimes during the other parts of the year.

» ***Michelia champaca***

Habitat: It is a tall, handsome, evergreen tree with a tapering crown of ascending branches, attaining a height of 35 m or more and with a clean straight cylindrical bole of 18-21 m and under ordinary conditions, a girth of 2.5-3.5 m or more. It has thick bark, ash grey, rough, young shoots silky. Leaves 13-25 cm x 5-9 cm, finely acuminate, glabrous above, lanceolate with slender petiole. It flowers large, axillary, solitary, pale yellow to deep yellow, very fragrant. Fruits consist of long clusters of capsules on a spike about 7.5-15 cm long.

Regeneration/silvicultural characteristics: The tree beyond its seedling stage is a light demander, saplings and poles grown under complete overhead light also develop a strikingly clean bole with a tapering crown. It is susceptible to water logging, can tolerate light ground fires. The damaged young shoots may send up new shoots from the base. The tree is frost hardy. The tree coppices well but doesn't produce root suckers. The tree starts flowering at an early age, sometimes tree becomes so heavily loaded with fruit that from exhaustion, stop flowering for some year. Two common varieties are reported, the yellow flowered variety produces leaves in the month of March, while the white flowered mostly later in the hot season. The flower appear in the hot and rainy season from April onwards at intervals. The fruit ripens during August to November.

4. Regeneration

The success of any system depends entirely on the success of the regeneration of the logged areas. Artificial regeneration is the only option if there is no natural regeneration. The practice of keeping the area barren for a year allowing firewood contractors to collect lop and tops from the cable line could mean extended exposure of the area to soil erosion. But in sub-tropical conditions of Bhutan, grasses and shrubs cover the soil soon after the clear cutting. Thus, even with the canopy gone, the cover provided by grasses and shrubs are enough safeguards against soil erosion or soil deterioration.

However, the invasion by grasses and shrubs can mean danger of fire for other inter-cable line stands. Once the area is about to be planted, the weeds and shrubs should be weeded out.

Weeding should take place thrice a year as per the Norms and Standard of Plantation 2016 issued by SFED.

To ensure the survival of artificial regeneration created by the NRDCL the UIC should carry out plantation survival survey by doing total count in the planted areas annually. If the survival percentage is less than 70% the NRDCL should be apprised to carry out beating up and other necessary maintenance work to improve the status of regeneration.

Group Selection System has been prescribed in the broadleaf forests. The group selection system has been prescribed in preference to Strip Clear Cutting system that was in operation in previous plan basically because the latter is seen as environmentally riskier. The large tracts

of land being clear felled would open the area to hazards of monsoonal rain and soil erosions. Even aesthetically, the large openings would be an eye sore. In group selection system, trees develop in clearly defined even-aged aggregations; this is of substantial advantage in developing good form especially in hardwoods.

Under the group selection system, small openings will be created in the stand allowing light to reach the forest floor and creating microclimatic conditions conducive for seed germination and establishment of seedlings.

There are important unresolved problems with sub-tropical and warm broadleaved silviculture in Bhutan; particularly the poorly understood regeneration dynamics of commercial species. Good regeneration has proved extremely difficult. There are also still considerable doubts regarding the best silvicultural systems for managing broadleaved forest. It is likely to be some time before research results are available and it is quite possible that stand succession towards commercially useful species is naturally a very long process (Whitfield, 2001).

Since one of the main reasons for failing of silvicultural systems is the lack of regeneration, it has been proposed during the Consultative Workshop that the group selection system should be combined with artificial regeneration.

The Group Selection System with artificial regeneration is synonymous to the Patch Cutting

System as recommended by the RNR-RC Yuispang as per the *Forest Research Findings and Recommendations during the 8th FYP, RNR RC Yusipang (2003)*. The "patch" in patch cutting system would mean smaller groups (as compared to Group Selection System in Conifers) in Group Selection System. As per their research findings, the patch cutting system with fencing is proven to be the best option in terms of fostering biodiversity, mitigating grazing impact and safeguarding financial viability for sustainable management of mixed broadleaf forests in Eastern Bhutan.

General guidelines for Patch-cut system (group selection system) in broadleaf forest.
(Vide the *Forest Research Findings and Recommendations during the 8th FYP, RNR RCYusipang, 2003)*

» Patches of mature and over-mature trees under which there is existing regeneration or which are most likely to regenerate successfully should be given first preference. This would include large trees with spreading crowns, which absorb sunlight if permitted to reach the forest floor would enhance seedling development.

» In selecting patches, ridge tops are preferred over depressions, up slope positions over down slope in order to minimize damage to regeneration in subsequent felling operations.

» The size of openings should depend on stand composition and condition. In general, the size of opening should vary from 0.15 to 0.5 ha. It should not be too large, as it will favour the growth of other species, which have less timber value.

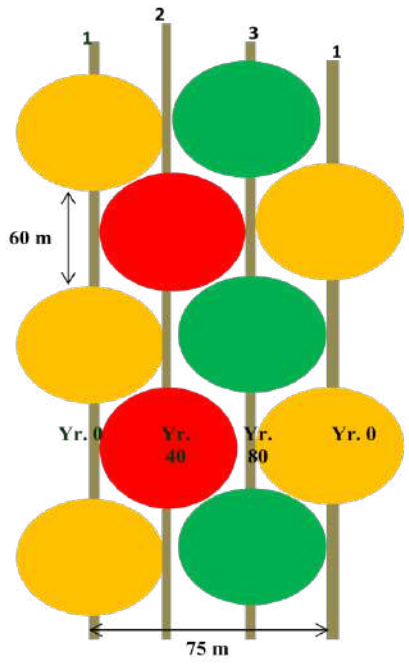
- Distance between the patches retained should be such that patches of trees retained will form a wind firm group of trees and appear as a uniform patch.
- In mature broad-leaved forests with many mature and over-mature trees it is expected that 75% of the standing volume would be harvested by felling 40 to 60 % of the area.
- The direction of the tree lean, and the topography should be taken into account to prevent large trees being felled on nearby advanced growth.
- Dead or dying trees or those showing symptoms of decay or damage (snags, scars conk, mistletoe, etc.) should be retained to safeguard flora and fauna niches or habitats.
- Sufficient seed trees in the interline spaces adjacent to the cable lines opened up should be retained as potential seed sources for seedling regeneration in patch-cuts.

The Patch Cut System has following advantages:

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

In areas where openings 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 distributions of the trees are strictly followed and should match with the openings created under group selection system. Care should also be taken to avoid felling trees on environmentally sensitive areas, buffer areas and corridor protection areas.

The figure in the following page gives the schematic diagram for laying out the groups along the cable lines. This figure is to be used as a guide and reference only and is not to scale with actual dimensions in the field.



Distance between two cable lines = 75 m
Area of the group openings = 0.25 ha
Distance between two group openings along the cable line = 60 m
Cable corridor = 4 m

Figure 26: Cable line layout for sustainable forest management

Only one third of the area of the stand will be subjected to harvesting between intervals of fourty years for mixed broadleaf forests. The groups will be opened up along cable lines. The distance between two cable lines would be 75 meters, and between groups would be 60 meters.

The approach of working to a minimum cable line spacing of 75 m for the group selection system will only work if matched with appropriate felling group sizes. Execution of this plan will keep a minimum of 75 m distance to prevent subsequent cable lines running through old previously cut groups and damaging regeneration. This is owing to the experiences gained from the implementation of the first plan. As have been planned in the paper it does not work in practical ground situation due to terrain, slope, direction of tree leaning, expertise of loggers, etc. Line spacing and group size then need to be carefully considered on a site-by-site basis and provide for a specific number of subsequent passes. One prescription will not be appropriate everywhere.

It is, therefore, very important for cable lines to be recorded properly. Once the cable lines are calibrated for the group openings, it would be important to have the same group opening spacing for the first phase of cable lines since the interlocking openings of second and third passes should not fall on the previously harvested areas. This requirement of the Square Interlocking groups' layout necessitates the excellent record keeping of the worked cable lines and their openings' locations.

The length of the cable lines and number of openings along a cable lines must be determined by the availability of the stocks in a cable line. In the event of good stocks, the AAC or clear cut area equivalent of the FMU (whichever is achieved earlier) could be met even from a single cable line. In such instances, laying of subsequent cable lines must be restricted to next harvesting period only (**NEXT OP**).

15.2. Single Tree Selection System

The Single Tree Selection System will be practiced in Local Use forests areas for rural marking, particularly for firewood and rural house building timber. Selection System follows principles of nature that matured trees are selected and removed to enable regeneration to replace them. The felling should be scattered all over the operational area instead of confining to certain parts of the forest. Felling should involve removing of trees or small groups of trees. This system helps to maintain uneven-aged character of the crop in the forest as in nature. It is observed that in most cases, the trees of best economic interest are selected and felled. Instead of following this, the UIC should judge and familiarize with the forest condition and silviculture of the species and do the selection with the interest of meeting the objectives of the system. As far as possible, selection of trees to be felled should be done for following categories first especially in young and immature stands.

» Dead, dying, diseased, deformed or otherwise defective trees interfering the growth of neighbouring vegetation.

» Trees of undesirable species

» Immature trees which can be removed by judicious thinning

» Mature trees above the exploitable diameter, which will leave gaps for regeneration to come up.

16. FOREST PROTECTION

16.1. Fire

In view of a shortage of access roads and fire fighting equipment, fire protection should primarily address preventative measures. These are awareness education for the local population and contractors, especially during the dry season. This awareness can be initiated through FMU level meetings and informing the Geogs representatives to pass on the information to the people under their jurisdiction. Any possible steps for preventing fire should be taken care by the NRDCL and the unit in-charge.

16.2. Pests and Diseases Management

The forest will be periodically monitored to detect any outbreak of pests or diseases. Regular inspection will be conducted by the FMU staff to detect and report any pest and disease outbreaks to enable earliest possible remedial or preventive measures to be initiated. Reports should be made to the CFO and the relevant research specialist(s) contacted.

Control may include the following:

» Forest sanitation, hygiene measures

» Regular survey of regenerated areas and removal and burning of infected plants and trees and their slash and detached bark,

» Use of insecticides or fungicides in close consultation with the forestry research section of RNRRC.

The planting stock at any nursery which will supply seedlings to the Unit also needs to be monitored for pests and diseases. Affected plants should not be brought into the Unit.

16.3. Grazing

In line with the multiple-use objectives of forest and as provided for in the Forest Policy of Bhutan, grazing will be allowed to continue in the FMU.

More importantly, a participatory approach to secure the cooperation of local villagers in keeping their cattle out of environmentally sensitive areas and away from regenerating coupes will be adopted with high priority. These strategies will be implemented through the combined efforts of Dzongkhag and CFO, Mongar. Fencing (barbed wire) will be adopted to protect regenerating seedlings and saplings in harvested coupes. Barbed wire will be employed to close such areas to grazing for at least 10 years, or sufficient stems are above grazing height, whichever occurs sooner.

It was discussed in the public consultation meeting that people in the Geogs with cattle would be supplied improved breeds of cattle by NRDCL, if they reduced number of unproductive ones. As a remedy for plantation to thrive the following enforcements were discussed to be practised if the cattle were found grazing inside the plantation area:

» The owner of the cattle would be liable for maintenance of fencing damaged

» The owner of the cattle would be liable for replanting equal number of seedlings damaged in addition to seedling cost for replanting

» The owner of the cattle would be imposed fine and penalt y as per FNCR.

The DoFPS in collaboration with Department of Livestock and Research Centres are in the process of conducting studies related to grazing and its impacts.

17. ENVIRONMENTAL STATEMENT FOR ENVIRONMENTAL IMPACT ASSESSMENT, 2002.

The Environmental Assessment Act, 2000 necessitates all developmental proposals in Bhutan to fulfil criteria as per Chapter III, Section 18 for obtaining environmental clearance. The National Environment Commission Secretariat has developed Regulation for the Environmental Clearance of Projects 2002 to be met by any applicant to carry out the forestry activities. 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. Introduction

The goal of the Rongmanchu FMU is to manage the forests on a multiple use, sustained yield basis. This is basically to cater to the needs of the people in the Dzongkhag, support livestock and meet timber and fuelwood demand, watershed and wildlife purposes.

The Environmental Assessment Act 2000 requires environmental clearance for all the development proposals in Bhutan. The National Environment Commission has prepared Forestry Sectoral Guidelines that recommend more specific sets of criteria for the purpose of planning and implementation of forestry projects. These guidelines have been examined to ensure that the practices within Rongmanchu FMU meet these requirements.

The Rongmanchu FMU was brought under management in 2007. The FMU has high way from Lhuentse to Mongar running through it. Since the road length of almost 14.4 km is already constructed by the NRDCL, leading into the FMU. The roads constructed showed little impact on the environment and have been beneficial to the remote villages so as to access necessary facilities.

The RFMU shares boundary with Bomdiling wildlife sanctuary. The main environmental concerns are due to improper land use, heavy grazing pressure from the livestock within as well as from the neighbouring Geogs and Dzongkhags. Skidding or rolling of logs will not be allowed, instead cable crane shall be used and for road construction if possible an Eco-friendly excavator will be used. The cross drains and the side drains will be maintained throughout the season. In the unstable slopes, Bioengineering works needs to be carried out by planting faster and native species. The environmental statement also lists mitigating measures that will be undertaken to lessen any effects on the environment for the future. During planning environmental impacts were carefully taken into account and during the function mapping of the RFMU many areas were delineated for protection and conservation for wildlife, soil and water quality.

Monitoring and evaluation mechanisms are being designed to assist in the future care of the FMU and to aid in the identification of measures to disrupt the environment.

17.2. Method

This environmental statement is based on an EIA conducted in October 2017 as a part of ground truthing and information gathering for the plan. It is based on personal observation, views of the CFO with relevant people and engineering cell NRDCL. The forestry environmental parameter checklist developed by NEC was completed, identifying environmental effects and mitigating measures.

17.3. Environmental Performance of the FMU

The objectives of management are:

» To improve the forest and other vegetative cover of the area.

» To provide the local population, on a priority basis, with a perpetual supply of timber and fuel wood to satisfy their needs.

» To supply timber and fuel wood to the locally based wood-using industries and to various Government organisations, as required.

» To regenerate, either artificially through planting, or through natural regeneration those forest areas currently not satisfactorily regenerated.

» To increase the productivity and stocking of the forest through appropriate logging and silvicultural methods.

» To improve the condition of young stands through thinning.

» To ensure the improvement of the presently degraded forest areas.

» To protect the watershed values of the FMU

» To protect and conserve the environment and ensure the preservation of genetic diversity, wildlife habitat and the aesthetic value of the area.

» To satisfy the needs of the local population for other forest products and grazing through their involvement in all phases of the implementation of this plan.

It will be noted that many of these objectives relate directly to environmental performance of the FMU, and to satisfactorily meet these objectives mitigating measures have been stated. These are discussed below.

17.4. Checklist of Environmental Parameters for Forestry Projects

The initial stage of the EIA involved the completion of the checklist to identify areas where there will be significant environmental effects. The scoring reflects the potential for effect, as the FMU is operated for last ten years.

In general, the operation of Rongmanchu FMU will have no significant adverse effect on the environment. The potentially critical areas of reduction in water quality and, closely linked, erosion control is being taken care. There is no observable evidence that significant erosion or reduction in water quality will occur. Even during the monsoon, the water leaving the

catchment area has a low sediment loading. The environmental functions of the watershed and FMU will remain intact. The critical operations of harvesting/extraction and road construction have been sensitively addressed (Sections 17.5).

17.5. Environmental Statements for the Activities within the FMU.

17.5.1. Setting up of Management Unit.

Rongmanchu FMU is being processed through all the necessary steps required for feasibility study. These steps take care of the Environmental, Social, Economical and Sustainable issues. The process involved the following key stages at its initial stage. The revision has fewer road construction and lesser disturbances to the environment.

» An initial screening process using GIS techniques to locate areas of well stocked forest relatively close to road access. This was followed up by ground reconnaissance of FMU areas, in conjunction with community consultations to ascertain potential conflicts between forestry use and existing uses. These consultations included local communities and staff of CFO and Dzongkhag.

» A forest resource inventory was carried out to provide information about tree stocking, regeneration, timber volumes and site characteristics and understory species. Additionally, this inventory collected information about other flora and fauna (including species sightings, droppings, dung etc. as evidence).

» Zoning within the FMU was then based on the above data, identifying forest types and appropriate management techniques. This management plan incorporates the Forest Function mapping technique prescribed by DoFPS (Schindele, W. and Dhital, D.B. (1997). It should be noted that this mapping directly addresses 8 function mapping requirements listed on page 2 -10 of the forestry sector guidelines (NEC).

» The silvicultural system to be implemented is the Group Selection System/Patch Cut System, in the Broadleaved Forests and Single Tree Selection System in the local use areas. The trees will be harvested by cable craning methods. A buffer of un-harvested patch of at least 60 m will separate each Cable Line from other.

» Best available system: the environmental impact is minimised.

» The rotation age has been selected using age estimates from harvested trees, and ranges from 110–120 years. There will be significant areas of stands reserved from harvesting scattered throughout the FMU so that on a landscape basis, there will continue to be a range of tree ages up to the biological rotation. These stands include those reserved for stream protection (30 m buffers on all streams) and soil protection (all areas steeper than 45 degrees slope) and large areas of forest that because of terrain will not be accessible to cable cranes or suitable for road construction. Annual Allowable Cut (AAC) calculation uses standard, internationally accepted formula for calculating a sustainable yield of timber and are based on the growing stock in the operable area (determined from the inventory data) , using a conservative rotation. The AAC calculated for the area will be economically sustainable. Operational schedules for harvesting are done on a year to

year basis, so that current economic conditions are better known. The inventory data available from the FMU inventory is not sufficiently detailed for operational planning; more detailed inventory data for the potential operational area is collected every two years. Potential Impacts on local communities will be monitored through on-going consultations carried out by Divisional staff as part of their day-to-day work in the FMU and as part of the Operational Planning process. The Ninth Five Year Plan will include provisions for the implementation of Participatory Forest Management, essentially inclusion of community for effective natural forest management.

17.5.2. Implementation of the Management Plan:

Baseline

The area under Management Plan so far has the cattle population that affects the regeneration and added upon it the pressure from the migratory cattle from nearby areas.

Impact

If the Management Plan is not supported financially to regenerate the harvested area, it would diminish project efficiency due to lack of funds.

Mitigating Measures:

» Included detail resources required in the plan

» Raise awareness of the issue through workshops and dialogue.

» Responsible CFO and Unit In-charge

17.5.3. Felling:

Baseline

Felling for rural as well as for commercial from the FMU has been carried out for last decade. Though the felling has been carried out at larger areas, not much of felling damage to the stands was observed.

Impact

With the area opening up for revision, there might occur damages to residual stands.

Mitigating Measures

» Management Plan details requirement for addressing the problem.

» NRDCL and Contractors will be responsible for the details in the Plan to implement.

17.5.4. Uncontrolled allotment to rural use and grazing:

Baseline

Allotments for rural purposes are marked from the FMU, but there does not occur big open areas from such allotments. Grazing pressure is one of the highest in the country. Field visits ascertain us regeneration is a problem at present.

Impact

The lack of regeneration and abuse to forest stand.

Mitigating Measures

» Marking Rules laid tighter in the Plan.

» Dialogue with the local stack holders.

» CFO and Unit In-charge will be responsible for crosschecking.

17.5.5. Road Construction and Maintenance:

Baseline

The Rongmanchu FMU has good road networks at present. The siltation is absent with minimum run off rate during rainy seasons. The pollution of waters down the stream is negligible. Of course, small land slips are common sights in the district but major slides are not common.

Impact

Road construction is the most significant environmental impact in the FMU. Major effects like erosions, compactions, siltation, water pollution, landslides, etc are associated with road construction.

Mitigating Measures

Forest roads are constructed to a good standard. This is demonstrated in the field as well as by the environmental assessment carried out in other FMUs in the country. There is no evidence of any major erosion having been caused by road expansion activities within the FMUs.

» The road network within the Rongmanchu FMU will be kept to a minimum for both environmental and economic reasons.

» The road expansion activities will involve extending existing roads, and will involve about 10 km of new road construction. Should the proposed 10 km road do not suffice the plan period the NRDCL shall not construct additional road under any circumstances.

» The TFDP has prepared a set of Standards for Road Construction and Maintenance in close consultation with the NRDCL. These standards will be adopted in the forest management plan 2018-2028. This will ensure that road construction within the FMU

will meet the recommendations, and ensure that any erosion is minimised or eliminated.

» Roads are regularly maintained to ensure the function for their purpose and do not degrade, causing erosion potential.

17.5.6. Harvesting and Extraction

Baseline

Though harvesting and extraction are carried out on large scale in the FMU, these allotments are not significant in causing environmental concerns at present.

Impact

Harvesting and extraction comprise one of the important forest management activities, with a potential for negative environmental impacts. The harvesting exposes areas thus creating erosion potential and transporting timbers create ground disturbance which leads to soil compaction and damage to regeneration.

Mitigating Measures

The following mitigation measures have been employed to minimize environmental impacts from these activities.

» Harvesting is prohibited on steep slopes to avoid creating erosion potential.

» Harvesting is carried out using Patch Cut System. This minimizes both the potential for negative environmental impact, and reduces the visual impact of harvesting activities with better regeneration method adopted i.e. artificially regenerating the whole operated areas immediately after harvesting with fencing.

» Extraction is by skyline cable cranes. This avoids ground disturbance by physically carrying the logs off the ground to the nearest road. This greatly reduces the erosion potential of harvesting activities on slopes.

» Sanitation felling is practiced to remove dead and diseased trees to improve the environmental condition of the forest. Few deadwood both standing and fallen is retained in the forest to provide habitat and nutrient recycling.

» Inspection of harvesting/extraction sites will be

Figure 27: Skyline cable crane

Figure 28: Monitoring of tree felling

regularly monitored by the Unit In-charge and will carry out as desired.

» The detailed description of harvesting and extraction activities is outlined in the operational plans that are duly approved by the competent authority within the DoFPS, MoAF.

17.5.7. Regeneration and Post Harvesting Treatments

Baseline

Regeneration problem is existed in the field at present. Post harvesting activities are carried out in the harvested areas.

Impact

With revision of the plan, the FMU will be under operation and there might occur regeneration problem alike in the first plan. If regeneration fails the problem couples up with other environmental, social and economical bottlenecks later on.

Mitigating Measures

There are series of operations prescribed for harvesting and Post-harvesting detailed in the Plan.

» The sites are cleared and no residues left to promote regeneration. A regeneration survey is conducted for both artificially and naturally regenerated areas. The stocking density of regeneration is compared to standards prepared by FRMD. If stocking of natural regeneration is inadequate, it is supplemented by enrichment planting of native species until the stocking standard is met. The plan provisions in preferring artificial regeneration in the broad leaved forests and natural regeneration in the conifer areas. Maximum intervention will be employed to ensure continued stocking with the tree species present on the site before harvesting. On sites that are failing to regenerate naturally, or where regeneration may be problematic (such as areas that have logged for sanitation purposes), plantations will be taken up. These are small-scale plantations of local species, and they are monitored for survival rates.

» Regeneration in the Rongmanchu could be a problem with large number of cattle population in the area. For the reason the system adopted will give room to the implementers for safer artificial regeneration with fencing.

» It was discussed in the public consultation meeting that the following enforcement would be practiced if the cattle are found grazing inside the plantation area:

  i. The owner of the cattle would be liable for maintenance of fencing damaged,

  ii. The owner of the cattle would be liable for replanting equal number of seedlings damaged in addition to seedling cost and

  iii. The owner of the cattle would be imposed fine and penalty as per FNCR.

17.5.8. Riparian Zone Protection

Baseline

The streams and rivers are naturally bedded with small bank erosions especially during monsoon seasons. Otherwise, the water quality, quantity, siltation erosion etc problems are negligible.

Impact

If the water bodies within the FMU are not given enough protection or devised proper mechanisms to keep intact the streams and the rivers, there will be problems such as drying up of water bodies, decrease in quantity, erosions, siltation, loses of aquatic life etc.

Mitigating Measures

Stream and river protection are provided in two stages:

» At the FMU planning level, i.e. in this plan, 30 m buffers have been applied to all mapped streams. Further 15 m buffer is provided for the drinking water source for the settlements and urban centres. The importance of buffer zone protection, for both erosion protection and biodiversity reasons, is fully appreciated by operational staff. The main purpose of mapping the buffer zones is to make the best possible estimate of the area reduction necessary for this purpose and thereby to make a conservative estimate of the net area available for harvesting and of AAC. In reality, during forest operations, many more small and perennial streams are identified. Thirty meter buffer zones are applied to these as well.

» During Operational Planning the provisions of the forthcoming Riparian Code of Practice will be applied so that stream protection will be applied on the basis of the stream classification system given in the Code during harvest. This Code will prescribe a range of stream buffer widths for different situations that can be delineated in the field.

» The important consideration is that a conservative area be estimated for the stream buffers that will finally be delineated in the field during operations – and this is done with the provisions in the first bullet point above.

17.5.9. Biodiversity Conservation within the FMU

Baseline

Biodiversity is rich and intact now. The area is rich for both floral and faunal diversity. The species encountered during the forest management inventory are recorded in the Plan document.

Impact

Once the area is brought under management the removal of forest produce in accordance to the Plan will take place. If the implementation is not according to the plan directives, we might lose species from the area.

Mitigating Measures

Objectives of the management plan directly address the conservation of biodiversity. It addresses two key areas of biodiversity:

» Conserving biodiversity and actively promoting it. Biodiversity conservation is addressed by practicing low impact silvicultural systems. Most of the systems followed in FMUs create an uneven-aged forest with a high level of structural diversity. There is minimal disruption to the ground flora or soil structure.

» Deadwood is left to create diverse habitats. Natural regeneration, the preferred method of establishment enhances the stability of the forest by ensuring that species suited to the site re-establish. The list of flora and fauna given in the Forest and Nature Conservation Act 1995, Annexure 6 are also to be totally protected during harvesting operations.

» In addition to practicing minimal impact silvicultural system, there are large areas of the forest that are not commercially operated. These are buffer zones inaccessible and non-operable areas.

» Areas may be non-operable for a number of reasons: they are too steep, they are of special cultural significance, or they are of particularly high biodiversity value.

» Biodiversity is actively promoted by increasing and diversifying the range of habitats that are available. Low impact silvicultural system and harvesting creates a more diverse age structure and ensures that all stages of the stand-cycle are represented.

» Attempts have been made to protect areas from excessive grazing (the major factor affecting biodiversity). These have been successful in some areas but failed in others, with herders breaking down fences. Research is being conducted by RNRRC Yusipang to address this issue, focusing on the social and participatory elements of this problem.

18. CHECKLIST OF ENVIRONMENTAL PARAMETERS FOR FORESTRY PROJECTS

Table 30: Checklist of of environmental parameters

	Adverse Environmental Impacts	Preliminary Evaluation			
		No Significant Effect	Small Effect	Moderate Effect	Major Effect
I. COMMERCIAL LOGGING					
A. Environmental Considerations Regarding Project Operations					
1. Watershed Areas					
a) erosion	*a) downstream economic losses*	9			
b) siltation	*b) downstream economic losses*	9			
c) hydrology	*c) increased peak and flood flows*	9			
d) water quality	*d) loss of downstream beneficial uses*	9			
2. Relation to other dedicated land uses					
a) conservation areas	*a) impaired ecological and recreational opportunities*	9			
b) economic ventures	*b) possible economic loss*	9			
3. Traditional forest uses	3. Impaired beneficial uses	9			
4. Rehabilitation	4. Social problems	9			
5. Relation to regional/ national forestry plans	5. Possible conflicts with established management policies	9			

6. Critical environmental areas	6. Downstream economic losses	9			
a) erosion	*a) downstream economic losses*	9			
b) siltation	*b) downstream economic losses*	9			
c) hydrology	*c) increased peak and flood flows*	9			
d) water quality	*d) loss of downstream beneficial uses*	9			
7. Precious ecology	7. Loss of ecological values	9			
B. Considerations Regarding Planning and Design					
1. Cost/benefit analysis					
2. Operations and maintenance	2. Diminished project efficiency and objectives if lack of funds			9	
3. Data base for decision making		9			
4. Road network design					
a) erosion	*a) downstream economic losses*	9			
b) siltation	*b) downstream economic losses*	9			
c) hydrology	*c) increased peak and flood flows*	9			
d) water quality	*d) loss of downstream beneficial uses*	9			
5. Design of logging activities	5. Unnecessary damage to residual stand			9	
6. Critical environmental areas					
a) erosion	*a) downstream economic losses*	9			
b) siltation	*b) downstream economic losses*	9			
c) hydrology	*c) increased peak and flood flows*	9			

d) water quality	*d) loss of downstream beneficial uses*	9			
7. Precious ecology	7. Loss of ecological values	9			
C. Considerations Regarding Project Operations					
1. Road construction					
a) erosion	*a) downstream economic losses*	9			
b) siltation	*b) downstream economic losses*	9			
c) hydrology	*c) increased peak and flood flows*	9			
d) water quality	*d) loss of downstream beneficial uses*	9			
2. Felling					
a) erosion	*a) downstream economic losses*	9			
b) siltation	*b) downstream economic losses*	9			
c) hydrology	*c) increased peak and flood flows*	9			
d) water quality	*d) loss of downstream beneficial uses*	9			
3. Log conveyance and allocation					
a) erosion	*a) downstream economic losses*	9			
b) soil compaction	*b) increased runoff*	9			
c) log floatation	*c) impede navigation*	N.A.			
d) allocation	*d) less than optimum economic benefits*		9		
4. Logging in riparian zones	4. Degradation of waterways/fisheries	N.A.			
5. Socio-economics					
a) employment opportunities		9			

b) loss of traditional forest use	*b) economic and cultural losses*	9			
D. Considerations Regarding Post-Project Activities					
1. Rehabilitation and conservation		9			
2. Road shutdown		9			
II. REFORESTATION/AFFORESTATION					
AE. **Considerations Regarding Project Operation**					
1. History of forest abuse	1. Negation of project goals if not effectively controlled			9	
2. Relation to other dedicated land uses					
a) conservation areas		9			
b) economic ventures	*b) Interference with more profitable ventures*	9			
c) regional/national forestry plans		9			
3. Rehabilitation	3. Social Problems	9			
4. ilting in degraded forest	4. Possible unnecessary loss of ecological values	9			
AF. **Considerations Regarding Planning and Design**					
1. Cost/benefit analysis		9			
2. Selection of tree species	2. Diminished project objectives	9			
3. Precious ecology		9			

a) wildlife		9			
b) fisheries		9			
c) plants		9			
d) soil and water		9			
4. Allocation of benefits to locals					
a) employment opportunities	*a) social conflict if local people not significantly involved*	9			
b) training		9			
c) non-wood products		9			
5. Operations and maintenance	5. Diminished project efficiency and objectives if lack of funds			9	
6. Data base for decision making		9			
7. Project financing and reservoirs		9			
8. Appropriate technology	8. Diminished project objectives if inappropriate	9			
9. Relation to other dedicated land uses	9. Potential social and economic conflicts	9			
a) extensive land use modification					
10. Road network design	10. Increased erosion	9			
11. Use of grasslands		9			

C. Consideration Regarding Project Operations					
1. Commercial logging	1. Same as in Commercial Logging A and B	9			
2. Reduced water supplies	2. Socioeconomic losses	9			
3. Chemicals and fertilizers	3. Impaired fisheries and aquatic systems	9			
4. First-year operations	4. Increased erosion due to soil disturbance	9			
5. Soil conservation benefits					
a) erosion			9		
b) sedimentation		9			
c) soil capacity		9			
d) soil surface moisture		9			
e) soil nutrients		9			
6. Socioeconomic benefits					
a) employment opportunities			9		
b) fuel-wood			9		
c) enhanced fisheries		9			
d) enhanced recreation/ tourism		9			
7. Water resources benefits		9			
a) minimized overland flows		9			
b) reduced flood peaks		9			
c) water quality		9			

19. FINANCIAL AND ECONOMIC APPRAISAL

19.1. Economic Analysis

Investments in forest management are made with the expectation of high financial as well as economic returns. Economic benefits can be in the form of socio-economic development of the community or the people and at the same time improving the quality of the forests.

Technically, good forest management by using prescribed Silvicultural treatments can improve the existing stands of forests, thereby yielding better growth and also promoting better regeneration of principal species. The forest road is going to act as the lifeline towards developmental projects for accessing communities in future. The objectives of good forest management cannot be derived without a proper and sound financial and economic analysis. And this has been taken into consideration during the management planning.

19.2. Financial Analysis

A ten year financial forecast has been drawn for the Rongmanchu FMU. The financial forecast approximately forecasts the revenue earned, costs incurred and royalties collected and paid. The figures used are based on the information made available by the RM's office Zhonggar Division, taking into account the latest rates. The financial forecast is only for 10 years and does not include the profitability of the FMU in the long run. But all developmental activities within the FMU will be beneficial in the future.

This financial forecast is based on assumptions available and only a projection of a possible cash flow scenario. **This is not a valid/legal statement and therefore should only be used as a guide. The rates are not finalized rates.** They were obtained from average figures available at NRDCL. Therefore the figures are subject to change while calculating with final rates for the Division.

With the road network to the valley, rural allotment is expected to increase and royalty from rural timber and firewood allotment is also going to fetch good revenue to the DFO office. This has not been worked out due to unpredictability of trend in rural demand in coming years.

Table 31: Summary of physical forecast

Assumptions	Figures	
M to cft	35.31	
Volume Recovery NRDCL	40%	
Road construction (Nu/Km)	1,625,000.00	
Length of propose new road construction (km)	10	
Length of existing road (km)	14.4	
New road construction (km/yr)	1	
Road maintenance (Nu/km/yr)	20	
Distance to Depot (km)	24	
Haulage Costs (Nu/cft/km) (Nu/m^3		
Cable Crane (Nu/cft) (Nu/ m^3)	14.9	527
Royalty from rural allotments by DBH, however an average is used for the calculation (Nu/yr), based form the previous plan and adjusted form the current AAC		
Average compensation (penalties and fines) Nu.		
All costs from DFO are taken an average from the last plan period.		
OPE	4.378	
Rural Allotments		
Regeneration maintenance (Nu/ha)	3500	
Area that require planting immediately		
Area that require planting per year		
Coupe regeneration establishment		
Creation of plantation (Nu/ha)	75000	
Plantation maintenance (Nu/ha)	4500	
Existing plantation in the FMU that require maintenance	47.96	

Table 32: Summary of the Financial Forecast

Financial summary for the Plan Period	
Total Revenue for NRDCL	65772530.20
Total Costs for NRDCL	36984797.00
Total Royalty for DoFPS	6737148.00
Total Revenue- Total Royalty- Total Costs NRDCL	**22,050,585.20**

Table 33: 10 year financial forecast for Rongmanchu FMU 2018-2027

	AAC (m^3)	Rec Vol (m3)	Nu/cft	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	10 Years
				Nu	Nu	Nu	Nu	Nu	Nu	Nu	Nu	Nu	Nu	Nu
Revenue: NRDCL														
Commercial Timber	2700	1272	146.44	6577253.02	6577253.02	6577253.02	6577253.02	6577253.02	6577253.02	6577253.02	6577253.02	6577253.02	6577253.02	65772530.20
Rural Timber	500	240												
Total Rev. NRDCL				**6577253.02**	**6577253.02**	**6577253.02**	**6577253.02**	**6577253.02**	**6577253.02**	**6577253.02**	**6577253.02**	**6577253.02**	**6577253.02**	**65772530.20**
Cost NRDCL														
Road Construction				1625000	1625000	1625000	1625000	1625000	1625000	1625000	1625000	1625000	1625000	16250000.00
Road Maintenance				240000	240000	240000	240000	240000	240000	240000	240000	240000	240000	2400000.00
Felling & crosscutting cost			2.5	112285.8	112285.8	112285.8	112285.8	112285.8	112285.8	112285.8	112285.8	112285.8	112285.8	1122858.00
Cable craning			14.93	670570.79	670570.79	670570.79	670570.79	670570.79	670570.79	670570.79	670570.79	670570.79	670570.79	6705707.90
Transportation to depot			6.5	291943.08	291943.08	291943.08	291943.08	291943.08	291943.08	291943.08	291943.08	291943.08	291943.08	2919430.80
Recruits/ Regeneration Maintenance (Nu/Ha)			3500	167860	167860	167860	167860	167860	167860	167860	167860	167860	167860	1678600.00
Artificial Plantation			75000/ ha	375000	375000	375000	375000	375000	375000	375000	375000	375000	375000	3750000.00
Estblished Regeneration/ Plantation maintenance			4500/ ha	215820	215820	215820	215820	215820	215820	215820	215820	215820	215820	2158200.00
Total Cost NRDCL				**2073480**	**2073480**	**2073480**	**2073480**	**2073480**	**2073480**	**2073480**	**2073480**	**2073480**	**2073480**	**36984797.00**
Total Rev. Less Total Cost NRDCL				4503773.02	4503773.02	4503773.02	4503773.02	4503773.02	4503773.02	4503773.02	4503773.02	4503773.02	4503773.02	45037730.20
Royalty Commercial			15	673714.8	673714.8	673714.8	673714.8	673714.8	673714.8	673714.8	673714.8	673714.8	673714.8	6737148.00
Total Rev: Revenue less Cost less Royalty) NRDCL				3830058.22	3830058.22	3830058.22	3830058.22	3830058.22	3830058.22	3830058.22	3830058.22	3830058.22	3830058.22	**38300582.20**

20. RESEARCH

Research programs will be taken care by UWICER and the DFO/FMU staff may collaborate as appropriate. The areas identified for the research activities in the last plan will be taken up on priority bases. The other areas of research are:

» Revive older research site within the FMU

» Utility and treatment packages for the less priority species

» Domestication of Nationally important NWFPs, which are under risk of local extinction

» Study on the Epiphytes, an increase trend within the FMU. It deteriorates the quality of the timbers

» Study on mistletoe attacks on Chir pine trees along Chaskar road.

» Impact of commercial harvesting on wildlife

» Change of forest composition in the operated areas

» Human wildlife conflicts due to harvesting operation

PART 3

IMPLENENTATION OF THE PLAN






PART 3: IMPLEMENTATION OF THE PLAN

21. IMPLEMENTING AGENCY

The Department of Forests is charged with the responsibility of protection and management of the forest resources in Bhutan. It will discharge this responsibility through the Territorial Division. The DFO Mongar as the senior territorial officer will be responsible for the implementation of this Management Plan, assisted by the Unit In-charge and other supporting staff.

21.1. Cutting Cycles

For future return it is felt that proper spacing between cable line layouts must be kept. The improper cable line spacing results in areas being over harvested with no chance for future cutting cycles. The forest will be sustainable if the cable line spacing is properly laid so that subsequent passes can be achieved. To ensure two passes in the future, a minimum of 75 m needs to be kept in between the cable lines. Mixed broad leaf forest has a rotation period of 120 years, this means that two cable lines that will be implemented in the future are occurring at year 40 and year 80. Figure 25 depicts the cable layout. The original line will be revisited in the year 120. This ensures every aspect of sustainability, before the forests are put into management regime. Understandably, terrain in Bhutan possesses a problem for layout. The layout in the field must be tailored to suit the terrain, but to the best possible the guidelines must be followed.

21.2. Annual Coupe

Coupe for harvesting in the operable area must be accessible, minimum environmental problems and they should fulfil following conditions:

» Based on the Silvicultural System the annual coupe will follow required spacing designed.

» The Unit In-charge will determine the extent of cable lines in the compartment to be harvested annually. All prescriptions and restrictions laid down in the plan must be considered and adhered.

» Unit In-charge will arrange to mark the trees as prescribed in Section 20.3.

» Alignment of cable lines in any way for safety, stand composition, environment and cost consideration could be done in consultation with Unit In-charge.

» Cable line may transverse slopes greater than 100% but extraction should not be carried out.

21.3. Tree marking rules

Marking rules for works in the FMU to follow in general to all stands.

» Before starting the work the coupes designated for harvesting will be delineated on the maps and the year of operation indicated. The boundaries will be surveyed in the

forest and demarcated. Species listed for protection if encountered are protected as per FNCRR, 2017.

» No marking will be done 30 meters on each side of the perennial streams.

» In addition to 30 m buffer for perennial streams another 15 m is left along the streams sources where the local water supply protection felt necessary.

» Dead, dying, diseased and malformed trees will be given preference for marking.

» Marking must be done only by trained staff with authorised hammer only.

21.4. Harvesting

To avoid wastage the trees will be cut 10 cm above ground. The hauling method for transporting logs from the coupe to road head will be done by skyline cable system. Contractors must be well informed about the stumps height. Damaged trees left behind through bad felling techniques, even if not marked must be salvaged. Harvesting in the Working Circle is to be carried out in accordance to the following prescriptions.

Figure 29: Logs at road head

» The layout of the cable lines should be planned well in advance of the harvesting operations after the coupe has been demarcated.

» The cable corridors should be as prescribe by the silvicultural system.

» Only chain saws and hand saws will be used for felling, crosscutting, de-limbing purposes, while axe could be used only for fuel wood splitting.

» Species that need debarking should be carried out at the earliest for safety purposes for any reasons.

» Measurements are to be recorded in the Log Register. The Register should be up to date and ready to produce for any Government related purposes and the same to be submitted to the CFO.

» Records of all the trees marked and issued for rural and commercial use or for conversion within the forest, will be maintained and furnished monthly to the CFO through compartment record forms.

» Fuel wood will be collected from the harvested residues. It is important to collect from the entire cable line rather than allotting green trees, once the accessible area is finished collecting. To avoid excessive environmental damage the practice of manual rolling of logs will be discouraged, and may only be used on sites where the slope is gentle (<25%).

21.5. Reforestation of Harvested Sites

The harvested coupe or site must be cleaned to enable easy planting or natural regeneration

to take place. One of the main reasons for wasteful and inefficient utilisation of forest resource and equipment is the lack of supervision of the harvesting operation. The CFO and his staff will ensure that all phases of harvesting by the NRDCL and other users are properly supervised.

Figure 30: Reforested harvested area

It is crucially important that harvested areas are effectively regenerated as soon as possible after harvesting. Artificial regeneration in the broad leaved forest and Natural regeneration is given priority in the Conifer forest in the FMU. But if natural regeneration fails either enrichment or complete stocking by planting must be carried out in the Conifer forests. Monitoring of regeneration stocking is part of this process. If the monitoring of regeneration indicates poor stocking, remedial action must be taken in the planting season following harvesting.

The FMU, UIC will ensure that stocking of natural regeneration is monitored following completion of the harvesting operation. The enrichment planting and fencing to protect regeneration will be carried out by NRDCL in consultation with the FMU, UIC.

The harvested area must be reforested immediately after the harvesting operations. Prior to plantation, nurseries for local viable species should be raised in advance. The area shall be planted with commercially viable local species. There is a need for heavy maintenance of plantation. Number of wage personnel (caretaker) to look after plantation and nurseries should be increased. Number of weeding should also be increased as per field experiences rather than working as per literature and plan prescriptions. Regular maintenance of plantation shall be done to ensure successful survival percentage of the plants. The CFO shall evaluate the plantation at the end of three years and if the survival percentage is lower than 70%, immediate beating up should 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 the regeneration has reached a height that will ensure its survival. If the second survey (6^{th} year) indicates poor stocking, remedial action must be taken in the planting season following. The FMU, UIC will ensure that stocking of natural regeneration is first monitored within three years following completion of the harvesting operation. The factors that limit the success of regeneration include; grazing pressure, protracted harvesting periods and weeds and brush growth. These problems must be addressed if regeneration is to have a fighting chance. It is recommended in this plan period to adopt more tending activities, 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.

21.6. Road Construction

Roads need to be constructed to allow harvesting of the production Compartments. For this plan period, the proposed road construction will join the existing farm road at Umling and then join with Lagay equivalent to 10 km as depicted in the map. Road extension will give full access to Forest areas of various stockings. During the preliminary field visits, the continuation of forest road to harvest the production areas are Khepachu II and Khepachu III found feasible (Annexure 13). However, feasibility and potential studies was to be conducted during the planning process of the road construction in order to harvest the production area.

Road construction in the FMU requires extra precautions to achieve environmental best practice. See Annexure 1 for more details. The basic necessity in forest road construction is to avoid steep and fragile areas. This is 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 efficiently draining compacted road surface.

Figure 31: Forest road construction

Road survey design and construction will be carried out by NRDCL. The road is to be located by marking a gridline on the ground. This gridline is then used as a basis for the road design, which will vary the location of the road as necessary to meet the standards mentioned below in terms of bend radius, proportion of cut/fill for various slopes, etc. NRDCL will mark the design centreline in the field so that contractor compliance to it can be monitored effectively. The road design should be part of the contract document. A set of road standards have been developed by the Forest Engineers of TFDP, incorporating experience and observations over the eight years of the project. These are available from TFDP or FRMD.

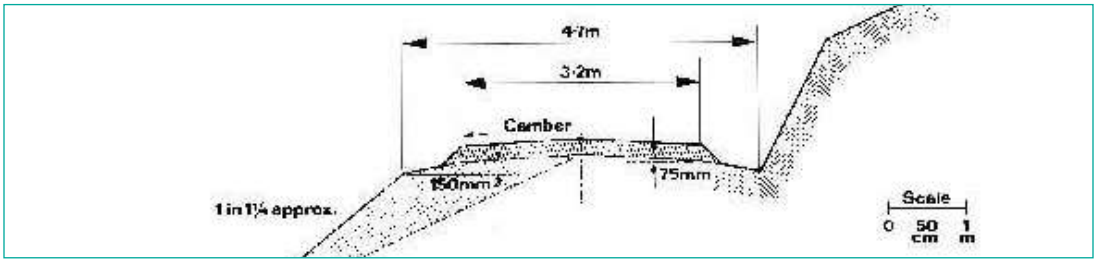


Figure 32: Road construction design

22. PLANNING

22.1. Operational Plan and implementation

A Biannual Operational Plan will be prepared by the CFO Mongar to facilitate the timely implementation of this Management Plan. Guidelines for the preparation of such Operational Plans have been prepared by FRMD (2002) and are available in all territorial Divisions.

The Operational Plan will spell out in detail the sequence of operations for each of the activities envisaged in the overall Management Plan, including the start and end dates for accomplishing them. The Operational Plan is also 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 fires, etc. If and when these occur, the current Operational Plan should be immediately reviewed and areas of operation modified to deal most efficiently with possible changes in the sustainable level of harvest.

The Operational Plan will be prepared in consultation with all of the agencies and parties who will be using the forest. 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 Rolling Operational Plan will include detail of activities for the coming year (year 1) and an outline of activities for the following year (year 2). The guideline for Operational Planning prepared by FRMD is issued to UIC offices also. It is user friendly and contains detailed process for preparing and implementing the Operational Plan. FRMD will continue to update the changes.

The operational planning 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 OP is to determine and to co-ordinate the timely input of resources.

Table 34: Concept of rolling plan

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	...
Detailed Outline		Detailed Outline		Detailed Outline		
	Detailed Outline		Detailed Outline		Detailed Outline	

Concept of Rolling Plan

Operational Plans will be prepared before NRDCL financial year begins so that the budget for OP can be presented before the management committee. It is therefore, recommended that the OP be prepared as recommended by the Forest Management Code of Bhutan. The timing and the schedule of steps for Management Planning and Op writing is given below: The OP 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 OP is shown in the **Table 35**.

Table 35: 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 plans for fire management; grazing control and rural timber To involve relevant stakeholders in planning for activities which have a direct impact in their "interest"	Participatory plan for grazing management; fire management or rural timber harvesting (to be incorporated within the OP	DoFPS, FMU, UIC, DzFO	First step is to enter into discussions with stakeholders and their representatives Use PRA techniques to prepare a plan Plan costs are included in the OP
3. Operational inventory	To assess the resource availability for the planned harvesting area Calculation of the harvestable volume	a. Site-level inventory data for operational area to be harvested b. Precise estimate of volume to be removed during the coming year.	FMU, UIC NRDCL	For the areas proposed for harvesting during the next 2 years May be combined with Harvesting plan and cable line survey
4. Harvesting plan and cable line survey	To plan for harvesting and extraction Activities	a. Agreed extraction and road construction plan	NRDCL	Within the selected identified harvestable area for the year May be combined with Operational inventory

5. Preparation of Operational Plan	To prepare a cost plan for implementation during the next 2 years (involving stakeholder participation for some activities) To formalise local institutional responsibility for planned activities (e.g. grazing, fire management, rural timber distribution)	Approved operational plan with budget Identified responsibilities for each planned activity Calculated costs for each planned activities	FMU, UIC with local stakeholders as required	Activities linked with objectives identified in the FMP and following options and guidelines in the FMP Each activity with identified responsibility for implementation, estimated cost, and site-specific location OP prepared according to standard formats
6. FMU annual report presented to the Forest 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 Forest Management committee	FMU, UIC presents to the Forest Management committee	During Forest Management committee annual meeting Implementation problems need to be addressed before endorsing the new OP
7. OP reviewed by FMU committee and endorsed	For the Forest Management committee to endorse the OP (prior to approval by DoFPS) To endorse expenditure estimates for the coming financial year	OP endorsed by Forest Management committee	FMU, UIC presents to the Forest Management committee	During Forest Management committee annual meeting

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 Forest Management committee	Forest Management committee	Meeting needs to take place 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 the OP for Implementation	Approved plan and budget	Approval by FRMD and Director DoFPS	OP approval linked with sanctioned budget for all planned activities
10. OP implementation by NRDCL	To carry out planned activities	Harvested timber; protected area; roads; fuel wood etc	According to responsibilities identified in the operational plan e.g. FMU, UIC, NRDCL, DzFO etc.	Each activity with a specific responsibility and budget
11. Monitoring of activities	To assess the level of achievement of planned activities	Information for FMU annual report	FMU, UIC	DoFPS responsibility is to monitor the implementation of activities carried out by NRDCL Monitoring also has a cost which needs to appear in the OP
12. DoFPS, UIC prepares FMU annual report	To report progress against planned activities To highlight any problems being encountered in implementation	FMU Annual report	FMU, UIC	Prepared annually Progress is reported against each FMP objective and the associated activities

13. Prepare the next year's operational plan (steps 2-5)	To prepare the next operational plan taking into account progress over the past year	Operational plan	FMU, UIC	Operational plans may alter in response to Forest Management committee suggestions and recommendations

22.2. Mid -Term and Final Review

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. The evaluation should be based on a review of the objectives and options to see how well the management plan is being implemented. If objectives are not being achieved this should be examined, reasons determined and activities redefined if appropriate.

Figure 33: Evaluation of FMU by evaluation team

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

The results of Mid-term Review should be discussed with the FMU Level Management Committee.

The Evaluation Team must conduct the midterm evaluation in October to December 2022 and the final evaluation in October to December 2026.

22.3. FMU Level Management Committee

The FMU level Management Committee Meeting should be chaired by the CFO Mongar to ensure the smooth implementation of the Management Plan.

Therefore, the Committee consists of:

» CFO, Mongar Territorial Division, Chairperson
» FRMD Representative
» RM, Zhonggar Division, NRDCL
» FMU, UIC, Rongmanchu FMU
» Unit Manager, Rongmanchu FMU, NRDCL
» Gups and Mangmis of Menji and Tshenkhar Geogs
» 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 (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 General, 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 OPs. To review achievements during the past year (based on annual report submitted by the UIC) and advice and act on any issue identified.

» To make recommendation for changes in the proposed OP 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 OP before submission to the Director General, 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 OP.

22.4. Staff

The CFO, Mongar Division is the overall controlling Officer of the area. The UIC of the FMU will have direct responsibility in control and management of FMU. They will be under the administrative control of the CFO, Mongar Division. The Divisional Forest 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 in his jurisdiction.

22.4.1. Responsibility

For the smooth implementation of the plan in the FMU, following staff is the minimum required;
Unit In-charge = 1
Forest Ranger II = 1
Asst. Forester = 4

The UIC will be responsible for the day to day implementation of the plan under the overall guidance of the Divisional Forest Officer. The UIC will keep records of all the works, supervise and initiate other silvicultural activities as envisaged in this plan. The UIC will be responsible to CFO, Mongar.

Forest Ranger II will be responsible for carrying out operational inventory, help to prepare the OP, supervise road construction and maintenance and keep the track of regeneration of the harvested areas. Forest Ranger II 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 Forest Ranger II.

22.5. Buildings

The office building was constructed in 2014 attached with the UIC quarter.

The two unit staff quarters are in dilapidated condition and at present it demands major renovation owing to foundation sinking which led to major cracks on the wall.

22.6. Vehicles and Equipment

Lack of mobility is the main cause of inadequate implementation and supervision pertinent to field activities by the Departmental staff. This is hindering smooth implementation of management plan. With assistance from the FRMD the FMU was supplied one number bike to ease implementation of field activities.

The office is supplied with computer from FRMD and now it has two computers.

23. 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 (such as commercial timber production) from the forest.

To ensure that this policy is being carried out in the management of FMU, 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 and the second stage checks that the objectives of the plan are being achieved over the longer term. Monitoring (checking on inputs on a year to year basis) is the term used for the 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 FMCB, 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. The TFDP working closely with the FRMD developed a new monitoring and evaluation process in 1999 for use on FMUs in Bhutan. Different forms were developed on different time scales; **Monitoring Form A** for the annual monitoring process, **Evaluation Form A** for the five year evaluation, **and Evaluation Form B** for the once only Evaluation. The field data collection forms used, consists of **Physical and Financial Forms 1-3, Environmental Forms 4-11** and the **Physical, Financial and Environmental Summary Form.**

The necessary Monitoring and Evaluation Forms is available with DFO office or at FRMD.

23.1. Record Keeping

The records should be kept by blocks and compartments. This would ensure that each activity that occurs is recorded in the format and easy to find format. Totals of the AAC allotment would then be submitted monthly to the DFO as is already required. It is essential that all records of activities and operations within the FMU be maintained so that analysis and investigation of past management can be carried out and AAC allotments can be followed. Although record keeping may not seem as important as some management activities, it is the backbone of future management decisions and the importance must be stressed.

The guidelines to complete and fill the forms; one for Rural Allotment, one for Commercial Allotment and one for Stand Tending and Regeneration activities are available in all territorial Divisions and UIC offices.

It is also important to record ***all activities*** for future management and monitoring and evaluation

23.2. Mid-term Review of the FMU Plan

The Head of FRMD will ensure that the Plan is reviewed five years after implementation. The review should be preceded by an Evaluation.

The Mid-term review will be discussed with the FMU Level Management Committee.

23.3. 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, TD will ensure that monitoring is carried out on an annual basis according to the guidelines issued by FRMD. In the context of FMU implementation, *inputs* includes machinery availability and staff skills and availability, while *outputs* include operational plan completion, road construction, production of forest produce, and the like.

It is essential that monitoring forms are recorded regularly and are handed over for review. The plan must be monitored to obtain the best practice of forest management.

23.4. Evaluation

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

The Chief Forestry Officer, 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 obtained from DFO/FRMD.

Corrective action, if it is necessary, may require changes to a range of inputs or to implementation methodology. Staffs that are independent of field activities will carry out the evaluation.

The Director, DoFPS will appoint the Evaluation Team.

The Evaluation Team must conduct the midterm evaluation in October to December 2022 and the final evaluation in October to December 2026.

24. CONSTRAINTS AND RISKS

Constraints to forest conservation and management planning are:

» Lack of mobility leading to an inability of the staff to supervise any management activities in the FMU.

» Lack of skilled and trained forest workers.

» Uncertainty of recruit establishment due to grazing pressure and undergrowth competition.

» Potential negative effects of cattle grazing on regeneration success.

» Lack of internet connectivity facility in the FMU office.

» Lack of research information.

25. DEVIATIONS FROM PLAN PRESCRIPTIONS

The annual harvested area should be managed to allow for unforeseen situations. For these and any other *bona fide* reasons, the annual coupe may vary ±10%. However, the total volume harvested over successive five years period must be no more than five times the AAC volume.

Unforeseen other circumstances may warrant deviation from the Plan prescriptions. In such an event, the CFO Mongar must obtain prior written approval from the Director, DoFPS. Any such request for Plan deviation(s) must be fully justified and such approved deviation(s) entered into the Management Plan during its next scheduled revision. The National Environment Commission Secretariat (NECS) or the Competent Authority established by the Ministry must be informed of the plan deviations approved by the Head of Department if any.

REFERENCES

ASTE, C. (1994). Forestry Integrated Wildlife Management. Integrated Forestry Management Project, Wangtangla – Thrumsingla.

Davidson, J. (2000). Ecology and Management of the Broadleaved forest in Eastern Bhutan; Final Technical report Field Doc. FD00:7. Khangma : TFDP.

Dick, J. H. & Yonten, D. P. (1996). A Preliminary Sectoral Environmental Assessment and a Framework for Environmental Monitoring. Third Forestry Development Project, Field Document No. 13 (UFT/BHU/008/BHU), Food and Agriculture Organisation of the United Nations and Forestry Services Division, Ministry of Agriculture, Royal Government of Bhutan.

DoF. (2000). Department of Forest, Policies, Strategies and Programs for the 9th Five Year Plan. departmental Report.

Dorji, D & Chong, P. W. (1998). Management Plan for Lingmethang Forest Management Unit. Royal Government of Bhutan, Ministry of Agriculture, Forestry Services Division. 82 pp+ 12 Annexure.

Grierson, A. J. C. & Long, D. G. (1983). Flora of Bhutan. Volume 1, Part 1. Royal Botanic Garden, Edenburg. Pp 186.

Grierson, A. J. C. & Long, D. G. (1983). Flora of Bhutan. Volume 1, Part 2. Royal Botanic Garden, Edenburg. Pp 187-462.

Grierson, A. J. C. & Long, D. G. (1983). Flora of Bhutan. Volume 1, Part 3. Royal Botanic Garden, Edenburg. Pp 463-834.

Grierson, A. J. C. & Long, D. G. (1983). Flora of Bhutan. Volume 2, Part 1. Royal Botanic Garden, Edenburg. Pp 426

Incoll, W. (1999). An Environment Monitoring and Evaluation System for Use in FMUs in Eastern Bhutan. Field Document No.99:10, Third Forestry Development Project, Khangma, Bhutan.

LUPP. (1995). Sustainable Land Use. Guidelines for Bhutan Volume VII.8. guidelines on land Capability Classification and Management Recommendations, Thimphu, Bhutan-DANIDA Land Use Planning Project, Ministry of Agriculture, Royal Government of Bhutan.

Maier, E. J. (1995). Assessment of the Holistic Approach of Management Plan for FMU Nahi. BG-IFMP Working Paper No.1.

McDougal, C. & Tshering, K. (1998). The Tiger Conservation Strategy. Nature Conservation Section, Forest Services Division, Ministry of Agriculture, Royal Government of Bhutan.

Annexure 1: Road Standards

As stated above the road standards developed in the east by TFDP will be implemented for design, drainage and construction of all forest roads in the FMU. Following are the standards:

Road Design

1. Road lengths and density should be minimised, consistent with access requirements to reduce environmental impacts and enhance access economics.
2. Where possible locate roads in areas with low side slopes, the maximum side slopes allowed in all areas except rock is 100%.
3. 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.
4. Roads should be planned in such a way as to balance cut and fill to minimise transport of construction materials.
5. 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 work commencing.
6. Roads should be kept as narrow as possible to reduce damage to the environment and to reduce costs.
7. 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.
8. Minimum radius formed by curves or corners should be 15 ms and should where possible fit the topography of the land.
9. Roads should be located on elevated areas where possible to minimise side cutting, width of clearing and drainage problems.
10. Side cutting should be carried out leaving a stepped batter, each step no more than 3 m in vertical height and no more than 100% gradient with a 1.5 m horizontal step.
11. Convex road surface should be maintained at all times with the centre line 30cm higher than the edges.
12. Stabilise and re-vegetate cut and fill slopes with shrubs, grasses and legumes as soon as possible after construction.
13. Ensure proper maintenance of roads and enforce road use restrictions during critical weather conditions such as monsoon seasons.

Drainage

1. Road planning should ensure that roads are located in such a way as to minimise stream river crossings.
2. Roads should not be constructed in areas, which are prone to flooding in the monsoon seasons.
3. In areas where side slopes of 70% or greater extend for a distance of 100 m 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.
4. 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.
5. 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%.

Table 36: Road gradient and in relation to distance between culverts

Road gradient %	Distance between culverts (ms)
4	110
5-8	90
9-10	80
11-15	60

1. 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.
2. Culverts pipes (Hume pipe) should be buried a minimum of 700mm below the surface of the road.
3. In areas of high seasonal rainfall, catch drains should be constructed above the road to collect surface runoff and prevent it reaching the road.
4. Drains should not be allowed to directly enter a watercourse but should be diverted into surrounding vegetation at least 50 m before a watercourse.
5. Sumps or silt traps should be places in drains every 50 m in erodable soils and must be cleaned regularly.

Road Construction

Figure 34: Road construction

1. All timbers above 30 cm 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).
2. 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.
3. Where side slopes of 70% or more extend more than 100 m downhill no side casting of spoil should be allowed. In this situation end haul methods must be used.
4. Forest roads should only be constructed on stable soil types where there is no possibility of slippage.
5. All road construction on side slopes of over 50% or difficult terrain, such as boulder fields, must be carried out using excavators.
6. Batter and fill slopes should not exceed 100%
7. 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).
8. 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.
9. The adverse gradient should not exceed 10%. However, grades of up to 12% will be allowed for distances of up to 300 m if this substantially reduces road length. Following this incline a minimum distance of 100 m of grades of 10% or less must be maintained.
10. The favourable gradient should not exceed 12%. However, grades of up to 15% for distances of up to 300 m will be allowed if this substantially reduces road length. These grades should be followed by grades of less than 10% for distances of 100 m or more.

Annexure 2: FMU Level Management Committee

Rongmanchu FMU Level Management Committee

As stated in the Forest and Nature Conservation Rule the FMU Level Management Committee has been established in order to have wider view in the management planning process. The Committee consists of:

1. CFO, Mongar
2. RM, Zhonggar
3. UIC, Rongmanchu
4. UM, Rongmanchu
5. Gups and Mangmi of Menji and Tshenkhar Geog.
6. Tsogpas of the Villages
7. The management Planner

The Committee can co-opt any members they feel important for the management planning.

Term of References for the FMU Level Management Committee

A. During Forest Management Plan Preparation

- To represent the interest of identified stakeholder groups during the planning process for FMP preparation.
- To discuss and agree on FMU, Forest management objectives for different parts of the forest (management circles and zonations), based on national priorities and combined with specific local conditions and local needs.
- To consult (along with FRMD), with specific groups of stakeholders likely to be significantly affected by the proposed activities such as road construction and harvesting and ensure that their interests are effectively accommodated in the final version of the management plan.
- To review and endorse the draft forest management plan before it is presented to Director, DoFPS, and Minister of Agriculture for final approval.

This will require four FMU, Level Management Committee meetings during the year, when the MP is being prepared.

B. During Operational Planning, Implementation and Monitoring

- To represent the interest of identified stakeholder groups during annual planning and review of activities under Ops.
- To review achievements during the previous year (based on the FMU annual report submitted by the FMU, UIC) and advice and act on any issues identified in the report.

- » To make recommendations for change to the proposed OP for the coming year based on the previous year's experience and on the need to achieve the agreed objectives in the FMP.
- » To endorse activities, priorities and funding arrangements within the draft OP before submission to Director General, DOFPS.
- » To participate in the mid-term evaluation of the FMP.
- » To hold any additional meetings as required in response to specific issues arising from FMP and OP implementation.
- » To participate in the final (10 year), Evaluation of the FMP.

This will require at least one annual meeting of the FMU Level Management Committee during each year of FMP implementation. Meetings need to be timed to ensure consistency with the annual planning cycle and financial year.

Stakeholder Analysis for Rongmanchu Forest Management Unit

Stakeholder	Interest	Impact of FMU management	Importance rank (1-5)	Representation on FMU management committee
Local herders	Grazing	-ve initially then +ve	2	Through Gup and Dzongkhag extension agent
Local residents	Rural timber, firewood, flag posts, leaf litter, NWFPs, medicinal plants, mushrooms, water, sang (incense), fodder, stones, sand, rock	all = except rural timber, firewood & flag posts (+ve)	1	Through Gup
Migratory herders	Grazing, firewood	=	2	Through Dzongkhag extension agents
Community	Sokshing rights	=	2	Through Gup
Religious community (local)	Firewood, incense, flag posts	Firewood & flag posts +ve; incense =	3	Through Gup
Religious community (non- local)	Timber (large dimensions)	+ve	5	Not now required
NRDCL	Timber, jobs, forest development (e.g. roading, plantation, protection), profits, meet state timber needs	+ve	1	NRDCL representatives
Wood using industry	Wood chips, Firewood, Timber, Residues, Profits	+ve	1	Through NRDCL representatives and a representative nominated by wood users association

Contractors	Profits	+ve	3	Through NRDCL
Labour	Employment (jobs)	+ve	1	Through Gup and NRDCL
DOFPS Territorial Division FRMD	Protection of the environment and biodiversity Ensure timber supplies to rural people and govt. departments sustainably Control over activities	Environment and biodiversity = Otherwise +ve	1	Through DOFPS and FRMD Representatives
Tourists (local) Tourists (non- local) Tour operators	Scenery, nature, profits	Profits +ve Others =	4	Through Dzongkhag
Researchers	Protected area, Production area, Information	all +ve	2.5	Through DOFPS

+ve denotes a positive impact on the "stake" of the forest management operations
-ve denotes a negative impact on the stake of the forest management operations
= denotes that the stake is unaffected by the forest management operations
1 = most important stakeholder
5 = least important stakeholder

Agreed composition of the Forest Management Committee Members

Organisations	Description
NRDCL	RM & UM
FRMD	Nominated by head FRMD
DoFPS	CFO (chair) & UIC
Gups	Covering the majority of the forest adjacent population
Wood industry	Representative to be nominated by the wood users association
Dzongkhag	GFEO

Annexure 3: Record Keeping Forms for the FMUs

Record keeping within the FMUs has been identified as a critical area that needs evaluation and constant monitoring to ensure that proper records of all activities are maintained. To date records have been kept in ledgers in the territorial offices, these records although thought to be comprehensive appear to be lacking some vital information. Furthermore, the information from the same areas seems mismatching and incomplete.

This annexure intends to direct the way in which records will be maintained from now on. Records from the check post will be maintained as usual but records for the activities within the FMU will now be maintained on a **Sub-compartment basis** as recommended and endorsed in the **Second national Level Management Committee Meeting.** Thus, the forms are available for easy references any time.

Required Backup Information

It is recommended that all the records within the FMU be transferred to these formats so that all the operations that have taken place in the Rongmanchu FMU are concise and contained within a consistent format. Some vague information from the past are suggested updating and recording the necessary information. Although record keeping may not seem as important as some of the management activities, it is the backbone of future management decisions and the importance must be stressed.

Updating and Safekeeping Maps.

Along with the new formats, it is important that proper maps and all field notes of the area are maintained. Maps of the FMU can be obtained from FRMD or enlarged topographic map sheets can be acquired from the Survey Department. New activities within the FMU should be recorded and information submitted to FRMD for map updating.

How to Complete and Maintain the Forms.

Three separate formats have been endorsed: **for Rural Allotment, for Commercial Allotment and For Stand and Regeneration activities.** These are meant to maintain important information in a summarised way. They do not have to be only records maintained; other records are important and must maintain them.

There is not a section within these forms for totaling activities. The monthly and yearly totals should be compiled in the regular reports to the CFO. Copies of these reports should be maintained in a folder in the Divisional Office.

There will be three forms for each sub-compartment. These forms should be photocopied (three for each compartment or sub-compartment) and stored in a ring binder so that extra sheet can be inserted where and when needed. The Unit Office must maintain records in the soft copies in computer.

Filling up the Forms:

Recording of information should be done after each activity. The Block, Compartment and Sub-Compartment can be listed, and the forms will then be active for that sub-compartment until the sheet is full. This may mean for the entire ten year period or longer, will be on the same sheet. All forms require that the Management Circle (MC) and Working Circle (WC) be recorded.

Management Circle (MC) - Production (P), Protection (Pt) or Non Production (NP) state the acronym of the management circle in which the activity is taking place.

Working Circle (WC) - Blue Pine (BP), Hardwood (H), Mixed Conifer (MC), Fir (F), state the acronym of the working circle in which the activity is taking place. More than one WC can be recorded.

Further information required on the **Rural Allotment** form is mainly the name and address of the permit holder along with the permit number, tree marking book number, species, product type provided and quantity. In the Comment column record any relevant information, this should include permit holder's name and may also include area description or stem per hectare remaining etc.

Information required on the **Commercial Allotment** form is the designated cable line number (year and number, i.e. 2018-01), the length of the cable line and the azimuth of the line. The number of groups per line must be recorded along with the area of the cable line. The number of tree marked in the cable line and group must be recorded with the total standing volume, NRDCL's recovery volume is recorded in the next column. The other activities column is for any activity that does not fit anywhere else. The marking book number is recorded next to this column. The Comment column must include a description of the cable line location as indicated by the traverse notes, including the tie point, for example: 283 m WNW (Tenzin Wangpo) from the junction of Rongmanchu top.

Further information required on the **Stand Tending and Regeneration form** if the cable line number, the activity completed (Eg: thinning), including the year and area, for regeneration, natural should be indicated for future regeneration survey results (this will be recorded on the same line in the future). If beating up of the artificial regeneration is required the species must be noted. When surveying, the result must record along with whether a resurvey must be done, the year for the next survey can be noted under the Comment column. This column should also contain details of the plantation or thinning locations.

Annexure 4: Tree marking Rules

Marking Rules for Single Tree Selection System

» Selection System will be used on sensitive and exposed sites where other Silvicultural system cannot be applied.

» Trees marked for harvesting will be evenly distributed throughout the stands.

» Mature and over mature trees should be given preference for removal.

» Dead, dying, diseased and malformed trees will be marked on a priority basis. However, care should be taken so that no large openings are created in the stands by marking these trees.

» In a mixed stand, even distribution of species should be left standing as future crop.

» Where cable cranes are to be used, the extraction line will be as narrow as possible not wider than four meters.

» Trees damaged during harvesting will be marked and removed during the subsequent coup cleaning operation.

Marking guidelines for Chir pine under the seed tree system

The following guidelines in carrying out seeding (or first) felling are not intended to be applied rigidly, but may be taken as a basis for the framing of site specific prescriptions.

» Seed tree system will be applied to Chir pine stands or mixed stands in which conifer is the predominant species both in numbers and special distribution.

» The larger trees (DBH OB >30cm), with sound, well-developed crowns, should be selected as seed-bearers (seed trees) and should be spaced at about 15-20 trees per hectare (i.e. approx. 22 to 26 m apart). If no such trees are available smaller trees (more trees per hectare) should be retained.

» Smaller trees and poles, if thinly scattered, should be felled to create blanks for regeneration. But well-stocked groups of promising stands should be left to form part of the future crop.

» Well-established advanced growth of both saplings and poles should be completely freed from overhead cover.

» This system will not be applied to areas with heavy undergrowth of competing shrubs or herbaceous layer unless ground seedbed preparation is undertaken, prior to or soon after the felling operation.

» This system should not be applied to stands on steep and over-exposed slopes or on south facing slopes. In the case of gentle south facing slopes, the cable lines may be oriented southwest with corresponding reduction in corridor width to reduce over-exposure to sunlight. On hot aspects it may be advisable to leave considerably more trees per hectare or the felling may be made in patch or in comparatively small groups.

- In mixed stands with a predominance of Chir pine, silvicultural treatment will favour the regeneration of pines.
- Slope condition, wind firmness of surrounding and retained seed-bearers as well as the visual stand value will be considered whilst using the system.
- Diseased, malformed, dying, non-wind firm and fire/resin-tap damage stems will be cut on a priority basis.
- Retained seed bearers should have a complete canopy, capable of bearing viable cones, disease-free, wind firm and reasonable form.
- Retained stems should not be the oldest or tallest in the stand. Over-mature trees should be felled on a priority basis.
- The configuration of the area selected for felling under this system may be irregular in shape.
- Maximum size of a contiguous area harvested should not exceed one hectare in extent.
- Advanced growth should be retained and protected where possible during felling.
- No logs that have not been debarked and lops and tops should be retained; to avoid bark beetle infestation or build-up of fungal infection.
- No resin tapping will be permitted on retained seed bearers, which will be marked prior to felling.

Marking guidelines for blue pine under the seed tree system

- The seed tree system is used in pure pine stands or mixed 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 values will be considered.
- About 20 to 25 trees per hectare (i.e. approx. 22 to 26 m apart) will be left standing.
- Diseased, malformed and dying trees will be cut on priority basis.
- Trees left standing will be of good health and form to ensure good seed source.
- Trees left standing will not be the oldest or tallest in the stand. Over mature trees will be cut on priority basis.
- The shape of the area chosen for the seed tree system can be irregular.
- Maximum size of a contiguous area harvested using this system should not exceed one hectare.

Marking guidelines for patch clear-felling (Group Selection System for Broadleaf forests)

In general, the following factors are to be considered when determining the spatial framework and sequential order of the patches selected for harvest:

» Create several patch or group openings along a line totalling 2-3 Ha per sub-coupe (including sky-line corridor), and with each opening separated by patch of intact forest (of at least 50-60 m)

» The direction of the tree lean, and topography has to be taken into account to prevent large trees being felled on nearby advanced growth,

» Dead or dying trees or those showing symptoms of decay or damage (snags, scars, conk, etc.) will be retained between patches and in the interline spaces to safeguard flora and fauna niches or habitats, but not in the harvested patches themselves, where there is the risk of wind throw and danger to personnel working underneath and where their value as refuges in such open spaces is questionable (Note; guidelines such as this one should be based on specific management objectives and current understanding of practical measures of biodiversity conservation).

» The totally protected *Taxus baccata* (Yew) shall not be marked for felling under any circumstance and all species listed for protection under the Forest and Nature Conservation Act 1995 must also be protected if encountered.

Marking Rules for Thinning in Young Blue Pine Stands.

» Thinning will be carried out in immature stands. The objective of the thinning is to increase growth and quality of the stands and at the same time provides small dimension timber to the local people. Healthy, vigorous trees will be released by cutting suppressed, diseased and malformed trees. Considering the fact that there is great variation in the age, density condition of the immature stands.

» The stands for thinning will be identified from the forest type map and verified in the field.

» The stands identified for thinning, if falls within the harvestable limit of the cable cranes, will be subjected to thinning.

» Marking of trees for thinning will depend on the number of stems per hectare, age or size classes and the spatial distribution.

» In stands less than 10 m in average height the target spacing should be approximately 4.5 m x 4.5 m or about 500 trees per hectare.

» In stands with pole crop (average height 10-20 m) the spacing of the trees after the thinning should be more than 5-6 m or approximately 300 to 400 trees per hectare.

» In stands which, at present have less than desired trees density and spacing, only trees, which grow in cluster very close together and therefore, compete for light and nutrients can be removed. Diseased trees, especially those infected with mistletoe should be

removed.

» Care must be taken not to create large openings in the thinned stands.

» Diseased, malformed and suppressed trees will be thinned on a priority basis.

» Under no circumstances the marking officer should give in to pressure from potential local users to mark good quality, healthy and best trees in the stands.

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 5: Forest Management Inventory Results

Result type	Mean	Total	Relative error (RE)	Total RE	Absolute Error
Tree count	143.89	921,388.72	3.71	3.71	
Tree volume	195.89	1,254,322.09	265.03	320.59	55.58
Tree basal area	19.33	123,771.99	243.27	303.48	
Tree biomass	92,693.23	593,515,449.68	305.91		27,567.22

Annexure 6: Number of tree count

FMU	Tree Dbh Class	Trees	Total tree count
Rongmanchu	10 - 20	Brassaiopsis sp.	1208.12
Rongmanchu	10 - 20	Magnolia champaca	402.70
Rongmanchu	10 - 20	Albizia sp.	805.41
Rongmanchu	10 - 20	Albizia procera	402.70
Rongmanchu	10 - 20	Acer sp.	2416.23
Rongmanchu	10 - 20	Acer campbellii	2416.23
Rongmanchu	10 - 20	Persea sp.	5235.16
Rongmanchu	10 - 20	Robinia pseudoacacia	402.70
Rongmanchu	10 - 20	Alnus nepalensis	402.70
Rongmanchu	10 - 20	Cornus capitata	1610.82
Rongmanchu	10 - 20	Phoebe sp.	7248.69
Rongmanchu	10 - 20	Phoebe attenuata	2818.93
Rongmanchu	10 - 20	Neocinnamomum caudatum	1610.82
Rongmanchu	10 - 20	Quercus sp.	8859.51
Rongmanchu	10 - 20	Quercus semecarpifolia	3624.34
Rongmanchu	10 - 20	Quercus oblongata	805.41
Rongmanchu	10 - 20	Quercus lanata	1208.12
Rongmanchu	10 - 20	Quercus lamellosa	805.41
Rongmanchu	10 - 20	Quercus griffithii	18524.42
Rongmanchu	10 - 20	Quercus glauca	5235.16
Rongmanchu	10 - 20	Quercus semicarpifolia	6443.28
Rongmanchu	10 - 20	Betula utilis	805.41
Rongmanchu	10 - 20	Betula alnoides	2818.93
Rongmanchu	10 - 20	Artocarpus hirsutus	3624.34
Rongmanchu	10 - 20	Abies densa	402.70
Rongmanchu	10 - 20	Ulmus lanceifolia	402.70
Rongmanchu	10 - 20	Rhododendron sp.	15302.78
Rongmanchu	10 - 20	Rhododendron anthopogon	805.41
Rongmanchu	10 - 20	Rhododendron arboreum	28189.34
Rongmanchu	10 - 20	Rhododendron ciliatum	402.70
Rongmanchu	10 - 20	Rhododendron falconeri	16510.90
Rongmanchu	10 - 20	Rhododendron kesangiae	1208.12
Rongmanchu	10 - 20	Rhododendron hodgsonii	805.41
Rongmanchu	10 - 20	Stereospermum sp.	402.70

Rongmanchu	10 - 20	Rhaphidophora sp.	805.41
Rongmanchu	10 - 20	Cupressus sp.	402.70
Rongmanchu	10 - 20	Melia azedarach	1208.12
Rongmanchu	10 - 20	UNKNOWN	15705.49
Rongmanchu	10 - 20	Morus sp.	805.41
Rongmanchu	10 - 20	Phyllanthus emblica	402.70
Rongmanchu	10 - 20	Ailanthus grandis	402.70
Rongmanchu	10 - 20	Ailanthus integrifolia	805.41
Rongmanchu	10 - 20	Pinus roxburghii	32216.39
Rongmanchu	10 - 20	Pinus wallichiana	12886.56
Rongmanchu	10 - 20	Daphne sp.	4832.46
Rongmanchu	10 - 20	Beilschmiedia sp.	3624.34
Rongmanchu	10 - 20	Beilschmiedia dalzellii	402.70
Rongmanchu	10 - 20	Ficus sp.	2013.52
Rongmanchu	10 - 20	Macaranga sp.	4429.75
Rongmanchu	10 - 20	Macaranga denticulata	4027.05
Rongmanchu	10 - 20	Exbucklandia populnea	402.70
Rongmanchu	10 - 20	Michelia champaca	402.70
Rongmanchu	10 - 20	Castanopsis sp.	3221.64
Rongmanchu	10 - 20	Castanopsis indica	1610.82
Rongmanchu	10 - 20	Lyonia sp.	402.70
Rongmanchu	10 - 20	Lyonia ovalifolia	5235.16
Rongmanchu	10 - 20	Symplocos sp.	8859.51
Rongmanchu	10 - 20	Symplocos lucida	51143.52
Rongmanchu	10 - 20	Symplocos glomerata	4832.46
Rongmanchu	10 - 20	Gmelina arborea	402.70
Rongmanchu	10 - 20	Prunus sp.	402.70
Rongmanchu	10 - 20	Mallotus philippensis	402.70
Rongmanchu	10 - 20	Lithocarpus glutinosus	402.70
Rongmanchu	10 - 20	Rhus sp.	2013.52
Rongmanchu	10 - 20	Rhus paniculata	805.41
Rongmanchu	10 - 20	Rhus chinensis	5235.16
Rongmanchu	10 - 20	Acacia lenticularis	1208.12
Rongmanchu	10 - 20	Acacia catechu	1208.12
Rongmanchu	10 - 20	Erythrina arborescens	402.70
Rongmanchu	10 - 20	Schima wallichii	1610.82

Rongmanchu	10 - 20	Daphniphyllum himalayense	3624.34
Rongmanchu	10 - 20	Cinnamomum sp.	7248.69
Rongmanchu	10 - 20	Cinnamomum bejolghota	402.70
Rongmanchu	10 - 20	Cinnamomum tamala	402.70
Rongmanchu	10 - 20	Bauhinia sp.	2013.52
Rongmanchu	20 - 30	Brassaiopsis sp.	1208.12
Rongmanchu	20 - 30	Magnolia champaca	402.70
Rongmanchu	20 - 30	Juglans regia	1208.12
Rongmanchu	20 - 30	Acer sp.	805.41
Rongmanchu	20 - 30	Acer campbellii	2416.23
Rongmanchu	20 - 30	Persea sp.	1208.12
Rongmanchu	20 - 30	Alnus nepalensis	805.41
Rongmanchu	20 - 30	Phoebe sp.	7651.39
Rongmanchu	20 - 30	Phoebe attenuata	1208.12
Rongmanchu	20 - 30	Quercus sp.	7651.39
Rongmanchu	20 - 30	Quercus semecarpifolia	2818.93
Rongmanchu	20 - 30	Quercus oblongata	402.70
Rongmanchu	20 - 30	Quercus lamellosa	4429.75
Rongmanchu	20 - 30	Quercus griffithii	12886.56
Rongmanchu	20 - 30	Quercus glauca	2013.52
Rongmanchu	20 - 30	Quercus semicarpifolia	1610.82
Rongmanchu	20 - 30	Betula utilis	805.41
Rongmanchu	20 - 30	Betula alnoides	2013.52
Rongmanchu	20 - 30	Alstonia scholaris	402.70
Rongmanchu	20 - 30	Abies densa	2416.23
Rongmanchu	20 - 30	Aquilaria malaccensis	402.70
Rongmanchu	20 - 30	Rhododendron sp.	15705.49
Rongmanchu	20 - 30	Rhododendron anthopogon	4429.75
Rongmanchu	20 - 30	Rhododendron arboreum	18121.72
Rongmanchu	20 - 30	Rhododendron ciliatum	1208.12
Rongmanchu	20 - 30	Rhododendron falconeri	7248.69
Rongmanchu	20 - 30	Rhododendron kesangiae	1208.12
Rongmanchu	20 - 30	Rhododendron hodgsonii	805.41
Rongmanchu	20 - 30	Syzygium cumini	1208.12
Rongmanchu	20 - 30	Tsuga dumosa	1208.12
Rongmanchu	20 - 30	UNKNOWN	6443.28

Rongmanchu	20 - 30	Ailanthus grandis	805.41
Rongmanchu	20 - 30	Pinus roxburghii	15705.49
Rongmanchu	20 - 30	Pinus wallichiana	10873.03
Rongmanchu	20 - 30	Daphne sp.	7248.69
Rongmanchu	20 - 30	Beilschmiedia sp.	4027.05
Rongmanchu	20 - 30	Ficus sp.	1208.12
Rongmanchu	20 - 30	Macaranga sp.	1208.12
Rongmanchu	20 - 30	Macaranga denticulata	2818.93
Rongmanchu	20 - 30	Michelia champaca	402.70
Rongmanchu	20 - 30	Lyonia sp.	2416.23
Rongmanchu	20 - 30	Lyonia ovalifolia	2818.93
Rongmanchu	20 - 30	Symplocos sp.	4429.75
Rongmanchu	20 - 30	Symplocos paniculata	1610.82
Rongmanchu	20 - 30	Symplocos lucida	8456.80
Rongmanchu	20 - 30	Symplocos glomerata	2416.23
Rongmanchu	20 - 30	Gmelina arborea	805.41
Rongmanchu	20 - 30	Lithocarpus glutinosus	402.70
Rongmanchu	20 - 30	Rhus sp.	402.70
Rongmanchu	20 - 30	Rhus paniculata	805.41
Rongmanchu	20 - 30	Rhus chinensis	402.70
Rongmanchu	20 - 30	Acacia lenticularis	402.70
Rongmanchu	20 - 30	Acacia mearnsii	402.70
Rongmanchu	20 - 30	Erythrina arborescens	805.41
Rongmanchu	20 - 30	Schima wallichii	1208.12
Rongmanchu	20 - 30	Ziziphus sp.	402.70
Rongmanchu	20 - 30	Daphniphyllum himalayense	2013.52
Rongmanchu	20 - 30	Cinnamomum sp.	3221.64
Rongmanchu	20 - 30	Cinnamomum bejolghota	1610.82
Rongmanchu	30 - 40	Brassaiopsis sp.	402.70
Rongmanchu	30 - 40	Albizia lebbeck	805.41
Rongmanchu	30 - 40	Acer sp.	805.41
Rongmanchu	30 - 40	Acer oblongum	402.70
Rongmanchu	30 - 40	Acer campbellii	2818.93
Rongmanchu	30 - 40	Persea sp.	4027.05
Rongmanchu	30 - 40	Alnus sp.	402.70
Rongmanchu	30 - 40	Alnus nepalensis	1208.12

Rongmanchu	30 - 40	Nyssa javanica	402.70
Rongmanchu	30 - 40	Phoebe sp.	7651.39
Rongmanchu	30 - 40	Phoebe attenuata	805.41
Rongmanchu	30 - 40	Neocinnamomum caudatum	805.41
Rongmanchu	30 - 40	Phlomoides rotata	805.41
Rongmanchu	30 - 40	Quercus sp.	8859.51
Rongmanchu	30 - 40	Quercus semecarpifolia	805.41
Rongmanchu	30 - 40	Quercus oblongata	805.41
Rongmanchu	30 - 40	Quercus lanata	1610.82
Rongmanchu	30 - 40	Quercus lamellosa	4832.46
Rongmanchu	30 - 40	Quercus griffithii	9664.92
Rongmanchu	30 - 40	Quercus glauca	805.41
Rongmanchu	30 - 40	Quercus semicarpifolia	805.41
Rongmanchu	30 - 40	Betula sp.	402.70
Rongmanchu	30 - 40	Betula utilis	402.70
Rongmanchu	30 - 40	Betula alnoides	2013.52
Rongmanchu	30 - 40	Toona ciliata	805.41
Rongmanchu	30 - 40	Abies densa	402.70
Rongmanchu	30 - 40	Rhododendron sp.	17719.01
Rongmanchu	30 - 40	Rhododendron anthopogon	1208.12
Rongmanchu	30 - 40	Rhododendron arboreum	3624.34
Rongmanchu	30 - 40	Rhododendron ciliatum	402.70
Rongmanchu	30 - 40	Rhododendron falconeri	5235.16
Rongmanchu	30 - 40	Rhododendron kesangiae	805.41
Rongmanchu	30 - 40	Stereospermum chelonoides	805.41
Rongmanchu	30 - 40	Alangium alpinum	402.70
Rongmanchu	30 - 40	NA	402.70
Rongmanchu	30 - 40	Tsuga dumosa	805.41
Rongmanchu	30 - 40	UNKNOWN	7248.69
Rongmanchu	30 - 40	Ailanthus grandis	402.70
Rongmanchu	30 - 40	Pinus roxburghii	6443.28
Rongmanchu	30 - 40	Pinus wallichiana	5637.87
Rongmanchu	30 - 40	Daphne sp.	2818.93
Rongmanchu	30 - 40	Beilschmiedia sp.	3221.64
Rongmanchu	30 - 40	Beilschmiedia bhutanica	805.41
Rongmanchu	30 - 40	Ficus sp.	805.41

Rongmanchu	30 - 40	Macaranga sp.	1208.12
Rongmanchu	30 - 40	Macaranga denticulata	1610.82
Rongmanchu	30 - 40	Michelia sp.	402.70
Rongmanchu	30 - 40	Castanopsis sp.	805.41
Rongmanchu	30 - 40	Castanopsis tribuloides	402.70
Rongmanchu	30 - 40	Lyonia sp.	1208.12
Rongmanchu	30 - 40	Lyonia ovalifolia	402.70
Rongmanchu	30 - 40	Symplocos sp.	5235.16
Rongmanchu	30 - 40	Symplocos lucida	5235.16
Rongmanchu	30 - 40	Symplocos glomerata	2416.23
Rongmanchu	30 - 40	Gmelina arborea	402.70
Rongmanchu	30 - 40	Rhus chinensis	1208.12
Rongmanchu	30 - 40	Schima wallichii	2013.52
Rongmanchu	30 - 40	Daphniphyllum himalayense	805.41
Rongmanchu	30 - 40	Cinnamomum sp.	2818.93
Rongmanchu	30 - 40	Cinnamomum bejolghota	402.70
Rongmanchu	30 - 40	Bauhinia sp.	402.70
Rongmanchu	40 - 50	Brassaiopsis sp.	402.70
Rongmanchu	40 - 50	Magnolia sp.	402.70
Rongmanchu	40 - 50	Juglans regia	805.41
Rongmanchu	40 - 50	Acer sp.	402.70
Rongmanchu	40 - 50	Acer campbellii	1610.82
Rongmanchu	40 - 50	Persea sp.	3624.34
Rongmanchu	40 - 50	Persea fructifera	402.70
Rongmanchu	40 - 50	Alnus sp.	805.41
Rongmanchu	40 - 50	Alnus nepalensis	402.70
Rongmanchu	40 - 50	Nyssa javanica	402.70
Rongmanchu	40 - 50	Phoebe sp.	8054.10
Rongmanchu	40 - 50	Phoebe attenuata	402.70
Rongmanchu	40 - 50	Quercus sp.	10067.62
Rongmanchu	40 - 50	Quercus oblongata	402.70
Rongmanchu	40 - 50	Quercus lanata	1208.12
Rongmanchu	40 - 50	Quercus lamellosa	2416.23
Rongmanchu	40 - 50	Quercus griffithii	4429.75
Rongmanchu	40 - 50	Quercus glauca	805.41
Rongmanchu	40 - 50	Quercus semicarpifolia	402.70

Rongmanchu	40 - 50	Betula utilis	402.70
Rongmanchu	40 - 50	Betula alnoides	2818.93
Rongmanchu	40 - 50	Artocarpus hirsutus	402.70
Rongmanchu	40 - 50	Abies densa	805.41
Rongmanchu	40 - 50	Rhododendron sp.	4832.46
Rongmanchu	40 - 50	Rhododendron anthopogon	402.70
Rongmanchu	40 - 50	Rhododendron arboreum	2013.52
Rongmanchu	40 - 50	Rhododendron falconeri	2416.23
Rongmanchu	40 - 50	Rhododendron kesangiae	402.70
Rongmanchu	40 - 50	Rhododendron hodgsonii	402.70
Rongmanchu	40 - 50	Tsuga dumosa	3624.34
Rongmanchu	40 - 50	UNKNOWN	1208.12
Rongmanchu	40 - 50	Ailanthus grandis	805.41
Rongmanchu	40 - 50	Pinus roxburghii	2416.23
Rongmanchu	40 - 50	Pinus wallichiana	2416.23
Rongmanchu	40 - 50	Daphne sp.	805.41
Rongmanchu	40 - 50	Beilschmiedia sp.	4027.05
Rongmanchu	40 - 50	Beilschmiedia bhutanica	805.41
Rongmanchu	40 - 50	Ficus sp.	805.41
Rongmanchu	40 - 50	Michelia champaca	805.41
Rongmanchu	40 - 50	Castanopsis hystrix	402.70
Rongmanchu	40 - 50	Myrica sp.	402.70
Rongmanchu	40 - 50	Symplocos sp.	2013.52
Rongmanchu	40 - 50	Symplocos lucida	2416.23
Rongmanchu	40 - 50	Symplocos glauca	402.70
Rongmanchu	40 - 50	Symplocos glomerata	805.41
Rongmanchu	40 - 50	Lagenaria siceraria	402.70
Rongmanchu	40 - 50	Rhus sp.	402.70
Rongmanchu	40 - 50	Schima wallichii	2013.52
Rongmanchu	40 - 50	Daphniphyllum himalayense	402.70
Rongmanchu	40 - 50	Cinnamomum sp.	3624.34
Rongmanchu	50 - 60	Engelhardtia sp.	402.70
Rongmanchu	50 - 60	Brassaiopsis sp.	402.70
Rongmanchu	50 - 60	Magnolia sp.	402.70
Rongmanchu	50 - 60	Magnolia doltsopa	402.70
Rongmanchu	50 - 60	Juglans regia	402.70

Rongmanchu	50 - 60	Albizia lebbeck	402.70
Rongmanchu	50 - 60	Acer sp.	1610.82
Rongmanchu	50 - 60	Acer campbellii	1208.12
Rongmanchu	50 - 60	Persea sp.	1610.82
Rongmanchu	50 - 60	Persea bootanica	402.70
Rongmanchu	50 - 60	Cornus capitata	402.70
Rongmanchu	50 - 60	Phoebe sp.	4832.46
Rongmanchu	50 - 60	Phoebe attenuata	805.41
Rongmanchu	50 - 60	Camellia sinensis	402.70
Rongmanchu	50 - 60	Quercus sp.	4832.46
Rongmanchu	50 - 60	Quercus semiserrata	402.70
Rongmanchu	50 - 60	Quercus semecarpifolia	805.41
Rongmanchu	50 - 60	Quercus oblongata	402.70
Rongmanchu	50 - 60	Quercus lamellosa	4429.75
Rongmanchu	50 - 60	Quercus griffithii	1208.12
Rongmanchu	50 - 60	Quercus glauca	1208.12
Rongmanchu	50 - 60	Quercus semicarpifolia	805.41
Rongmanchu	50 - 60	Betula utilis	402.70
Rongmanchu	50 - 60	Betula alnoides	1610.82
Rongmanchu	50 - 60	Toona ciliata	402.70
Rongmanchu	50 - 60	Abies densa	2416.23
Rongmanchu	50 - 60	Ocotea lancifolia	402.70
Rongmanchu	50 - 60	Rhododendron sp.	2818.93
Rongmanchu	50 - 60	Rhododendron arboreum	402.70
Rongmanchu	50 - 60	Rhododendron falconeri	1610.82
Rongmanchu	50 - 60	Duabanga sp.	402.70
Rongmanchu	50 - 60	Tsuga dumosa	2013.52
Rongmanchu	50 - 60	UNKNOWN	402.70
Rongmanchu	50 - 60	Pinus roxburghii	2013.52
Rongmanchu	50 - 60	Pinus wallichiana	402.70
Rongmanchu	50 - 60	Daphne sp.	402.70
Rongmanchu	50 - 60	Beilschmiedia sp.	2818.93
Rongmanchu	50 - 60	Michelia sp.	402.70
Rongmanchu	50 - 60	Michelia champaca	1208.12
Rongmanchu	50 - 60	Castanopsis hystrix	402.70
Rongmanchu	50 - 60	Symplocos sp.	805.41

Rongmanchu	50 - 60	Symplocos lucida	805.41
Rongmanchu	50 - 60	Lagenaria siceraria	402.70
Rongmanchu	50 - 60	Rhus sp.	402.70
Rongmanchu	50 - 60	Acacia sp.	402.70
Rongmanchu	50 - 60	Schima wallichii	402.70
Rongmanchu	50 - 60	Cinnamomum sp.	1208.12
Rongmanchu	60 - 70	Magnolia sp.	402.70
Rongmanchu	60 - 70	Juglans regia	402.70
Rongmanchu	60 - 70	Albizia lebbeck	402.70
Rongmanchu	60 - 70	Acer sp.	402.70
Rongmanchu	60 - 70	Acer campbellii	2818.93
Rongmanchu	60 - 70	Persea sp.	1610.82
Rongmanchu	60 - 70	Persea bootanica	402.70
Rongmanchu	60 - 70	Phoebe sp.	2416.23
Rongmanchu	60 - 70	Phoebe attenuata	402.70
Rongmanchu	60 - 70	Neocinnamomum caudatum	402.70
Rongmanchu	60 - 70	Quercus sp.	4429.75
Rongmanchu	60 - 70	Quercus oblongata	402.70
Rongmanchu	60 - 70	Quercus lanata	1208.12
Rongmanchu	60 - 70	Quercus lamellosa	2818.93
Rongmanchu	60 - 70	Quercus griffithii	1208.12
Rongmanchu	60 - 70	Quercus glauca	805.41
Rongmanchu	60 - 70	Betula sp.	402.70
Rongmanchu	60 - 70	Betula alnoides	805.41
Rongmanchu	60 - 70	Rhododendron sp.	1208.12
Rongmanchu	60 - 70	Rhododendron arboreum	805.41
Rongmanchu	60 - 70	Rhododendron falconeri	1208.12
Rongmanchu	60 - 70	Rhododendron griffithianum	402.70
Rongmanchu	60 - 70	Tsuga dumosa	5637.87
Rongmanchu	60 - 70	UNKNOWN	2818.93
Rongmanchu	60 - 70	Ailanthus grandis	402.70
Rongmanchu	60 - 70	Ailanthus integrifolia	402.70
Rongmanchu	60 - 70	Pinus roxburghii	3221.64
Rongmanchu	60 - 70	Daphne sp.	402.70
Rongmanchu	60 - 70	Beilschmiedia sp.	402.70
Rongmanchu	60 - 70	Michelia sp.	402.70

Rongmanchu	60 - 70	Michelia champaca	805.41
Rongmanchu	60 - 70	Symplocos sp.	805.41
Rongmanchu	60 - 70	Symplocos glomerata	402.70
Rongmanchu	60 - 70	Lithocarpus glutinosus	402.70
Rongmanchu	60 - 70	Schima wallichii	805.41
Rongmanchu	60 - 70	Daphniphyllum himalayense	402.70
Rongmanchu	60 - 70	Cinnamomum sp.	805.41
Rongmanchu	70 - 80	Magnolia sp.	805.41
Rongmanchu	70 - 80	Acer campbellii	1610.82
Rongmanchu	70 - 80	Persea sp.	402.70
Rongmanchu	70 - 80	Phoebe sp.	402.70
Rongmanchu	70 - 80	Quercus sp.	1610.82
Rongmanchu	70 - 80	Quercus semiserrata	402.70
Rongmanchu	70 - 80	Quercus oblongata	805.41
Rongmanchu	70 - 80	Quercus lanata	1208.12
Rongmanchu	70 - 80	Quercus lamellosa	1208.12
Rongmanchu	70 - 80	Quercus glauca	805.41
Rongmanchu	70 - 80	Abies densa	1208.12
Rongmanchu	70 - 80	Cupressus sp.	402.70
Rongmanchu	70 - 80	Tsuga dumosa	1610.82
Rongmanchu	70 - 80	UNKNOWN	2013.52
Rongmanchu	70 - 80	Pinus roxburghii	2416.23
Rongmanchu	70 - 80	Beilschmiedia sp.	402.70
Rongmanchu	70 - 80	Symplocos sp.	402.70
Rongmanchu	70 - 80	Symplocos glomerata	402.70
Rongmanchu	70 - 80	Cassia sp.	805.41
Rongmanchu	70 - 80	Cinnamomum sp.	805.41
Rongmanchu	80 - 90	Albizia lebbeck	402.70
Rongmanchu	80 - 90	Acer campbellii	805.41
Rongmanchu	80 - 90	Echinocarpus dasycarpus	402.70
Rongmanchu	80 - 90	Phoebe sp.	402.70
Rongmanchu	80 - 90	Quercus sp.	805.41
Rongmanchu	80 - 90	Quercus semiserrata	402.70
Rongmanchu	80 - 90	Quercus semecarpifolia	402.70
Rongmanchu	80 - 90	Quercus oblongata	402.70
Rongmanchu	80 - 90	Quercus lamellosa	1610.82

Rongmanchu	80 - 90	Quercus semicarpifolia	402.70
Rongmanchu	80 - 90	Betula sp.	402.70
Rongmanchu	80 - 90	Abies densa	402.70
Rongmanchu	80 - 90	Rhododendron hodgsonii	402.70
Rongmanchu	80 - 90	Cupressus sp.	805.41
Rongmanchu	80 - 90	Tsuga dumosa	3221.64
Rongmanchu	80 - 90	UNKNOWN	402.70
Rongmanchu	80 - 90	Ailanthus integrifolia	402.70
Rongmanchu	80 - 90	Pinus roxburghii	805.41
Rongmanchu	80 - 90	Beilschmiedia sp.	402.70
Rongmanchu	80 - 90	Ficus sp.	402.70
Rongmanchu	80 - 90	Castanopsis sp.	402.70
Rongmanchu	80 - 90	Symplocos sp.	402.70
Rongmanchu	80 - 90	Acacia sp.	402.70
Rongmanchu	80 - 90	Schima wallichii	402.70
Rongmanchu	90 - 100	Engelhardtia sp.	402.70
Rongmanchu	90 - 100	Magnolia champaca	402.70
Rongmanchu	90 - 100	Albizia lebbeck	805.41
Rongmanchu	90 - 100	Acer campbellii	402.70
Rongmanchu	90 - 100	Alnus nepalensis	402.70
Rongmanchu	90 - 100	Phoebe sp.	402.70
Rongmanchu	90 - 100	Quercus sp.	1208.12
Rongmanchu	90 - 100	Quercus semiserrata	402.70
Rongmanchu	90 - 100	Quercus semecarpifolia	402.70
Rongmanchu	90 - 100	Quercus oblongata	402.70
Rongmanchu	90 - 100	Quercus lamellosa	805.41
Rongmanchu	90 - 100	Betula utilis	402.70
Rongmanchu	90 - 100	Tsuga dumosa	4429.75
Rongmanchu	90 - 100	Pinus roxburghii	402.70
Rongmanchu	90 - 100	Beilschmiedia sp.	402.70
Rongmanchu	90 - 100	Beilschmiedia sikkimensis	402.70
Rongmanchu	90 - 100	Beilschmiedia bhutanica	402.70
Rongmanchu	100 +	Engelhardtia sp.	402.70
Rongmanchu	100 +	Quercus sp.	2013.52
Rongmanchu	100 +	Quercus lamellosa	4027.05
Rongmanchu	100 +	Abies densa	402.70

Rongmanchu	100 +	Rhododendron kesangiae	402.70
Rongmanchu	100 +	Tsuga dumosa	12886.56
Rongmanchu	100 +	Pinus roxburghii	402.70
Rongmanchu	100 +	Beilschmiedia sp.	805.41
Rongmanchu	100 +	Symplocos sp.	1208.12
Rongmanchu	100 +	Cinnamomum sp.	402.70

Annexure 7: Tree Volume

FMU Region	Trees	Total tree volume	Mean tree volume
Rongmanchu	Tsuga dumosa	356712.92	55.71
Rongmanchu	Quercus lamellosa	102296.62	15.98
Rongmanchu	Quercus sp.	89293.40	13.95
Rongmanchu	Pinus roxburghii	54256.11	8.47
Rongmanchu	Symplocos sp.	50218.02	7.84
Rongmanchu	Beilschmiedia sp.	45909.60	7.17
Rongmanchu	Phoebe sp.	41309.57	6.45
Rongmanchu	Acer campbellii	31548.25	4.93
Rongmanchu	Abies densa	31311.99	4.89
Rongmanchu	UNKNOWN	28472.28	4.45
Rongmanchu	Rhododendron sp.	26488.29	4.14
Rongmanchu	Cinnamomum sp.	23083.67	3.61
Rongmanchu	Quercus griffithii	20207.41	3.16
Rongmanchu	Pinus wallichiana	18196.00	2.84
Rongmanchu	Persea sp.	17173.58	2.68
Rongmanchu	Rhododendron falconeri	15036.12	2.35
Rongmanchu	Symplocos lucida	14475.78	2.26
Rongmanchu	Rhododendron kesangiae	14171.18	2.21
Rongmanchu	Betula alnoides	13248.45	2.07
Rongmanchu	Schima wallichii	12156.82	1.90
Rongmanchu	Quercus glauca	10338.96	1.61
Rongmanchu	Engelhardtia sp.	10140.53	1.58
Rongmanchu	Rhododendron arboreum	9905.53	1.55
Rongmanchu	Albizia lebbeck	9788.03	1.53
Rongmanchu	Quercus semiserrata	9547.43	1.49
Rongmanchu	Quercus oblongata	8830.16	1.38
Rongmanchu	Quercus lanata	7837.24	1.22
Rongmanchu	Cupressus sp.	7567.20	1.18
Rongmanchu	Daphne sp.	6748.53	1.05
Rongmanchu	Symplocos glomerata	6679.33	1.04
Rongmanchu	Michelia champaca	5593.96	0.87
Rongmanchu	Quercus semicarpifolia	5515.33	0.86
Rongmanchu	Acer sp.	5501.07	0.86
Rongmanchu	Quercus semecarpifolia	5486.55	0.86

Rongmanchu	Magnolia sp.	5003.61	0.78
Rongmanchu	Beilschmiedia bhutanica	4777.27	0.75
Rongmanchu	Alnus nepalensis	4729.14	0.74
Rongmanchu	Beilschmiedia sikkimensis	4080.19	0.64
Rongmanchu	Phoebe attenuata	3855.47	0.60
Rongmanchu	Betula utilis	3741.21	0.58
Rongmanchu	Castanopsis sp.	3652.33	0.57
Rongmanchu	Betula sp.	3606.97	0.56
Rongmanchu	Cassia sp.	3538.17	0.55
Rongmanchu	Juglans regia	3279.55	0.51
Rongmanchu	Ficus sp.	3222.65	0.50
Rongmanchu	Acacia sp.	3014.22	0.47
Rongmanchu	Daphniphyllum himalayense	3001.45	0.47
Rongmanchu	Macaranga denticulata	2609.55	0.41
Rongmanchu	Ailanthus integrifolia	2496.01	0.39
Rongmanchu	Magnolia champaca	2350.18	0.37
Rongmanchu	Rhododendron hodgsonii	2299.24	0.36
Rongmanchu	Michelia sp.	2212.02	0.35
Rongmanchu	Rhododendron anthopogon	2139.26	0.33
Rongmanchu	Ailanthus grandis	1843.15	0.29
Rongmanchu	Persea bootanica	1798.42	0.28
Rongmanchu	Neocinnamomum caudatum	1735.70	0.27
Rongmanchu	Castanopsis hystrix	1624.25	0.25
Rongmanchu	Toona ciliata	1517.49	0.24
Rongmanchu	Macaranga sp.	1452.55	0.23
Rongmanchu	Brassaiopsis sp.	1444.02	0.23
Rongmanchu	Rhus chinensis	1442.05	0.23
Rongmanchu	Echinocarpus dasycarpus	1280.83	0.20
Rongmanchu	Nyssa javanica	1244.69	0.19
Rongmanchu	Lagenaria siceraria	1234.06	0.19
Rongmanchu	Lyonia sp.	1209.43	0.19
Rongmanchu	Alnus sp.	1192.13	0.19
Rongmanchu	Lyonia ovalifolia	1121.31	0.18
Rongmanchu	Cornus capitata	1047.53	0.16
Rongmanchu	Rhus sp.	887.18	0.14
Rongmanchu	Magnolia doltsopa	826.96	0.13

Rongmanchu	Lithocarpus glutinosus	817.38	0.13
Rongmanchu	Persea fructifera	678.56	0.11
Rongmanchu	Phlomoides rotata	636.22	0.10
Rongmanchu	Rhododendron griffithianum	628.40	0.10
Rongmanchu	Artocarpus hirsutus	602.76	0.09
Rongmanchu	Myrica sp.	575.00	0.09
Rongmanchu	Camellia sinensis	528.50	0.08
Rongmanchu	Rhododendron ciliatum	524.39	0.08
Rongmanchu	Ocotea lancifolia	493.34	0.08
Rongmanchu	Duabanga sp.	473.30	0.07
Rongmanchu	Cinnamomum bejolghota	468.38	0.07
Rongmanchu	Gmelina arborea	448.07	0.07
Rongmanchu	Symplocos glauca	442.28	0.07
Rongmanchu	Bauhinia sp.	366.72	0.06
Rongmanchu	Symplocos paniculata	352.61	0.06
Rongmanchu	Acer oblongum	335.19	0.05
Rongmanchu	Stereospermum chelonoides	301.73	0.05
Rongmanchu	NA	285.82	0.04
Rongmanchu	Syzygium cumini	279.76	0.04
Rongmanchu	Castanopsis tribuloides	242.35	0.04
Rongmanchu	Erythrina arborescens	211.55	0.03
Rongmanchu	Acacia lenticularis	189.16	0.03
Rongmanchu	Alangium alpinum	187.06	0.03
Rongmanchu	Rhus paniculata	180.61	0.03
Rongmanchu	Morus sp.	140.95	0.02
Rongmanchu	Acacia catechu	137.02	0.02
Rongmanchu	Acacia mearnsii	131.54	0.02
Rongmanchu	Castanopsis indica	111.26	0.02
Rongmanchu	Aquilaria malaccensis	95.47	0.01
Rongmanchu	Melia azedarach	87.01	0.01
Rongmanchu	Ziziphus sp.	86.27	0.01
Rongmanchu	Alstonia scholaris	79.88	0.01
Rongmanchu	Albizia sp.	73.39	0.01
Rongmanchu	Exbucklandia populnea	46.85	0.01
Rongmanchu	Cinnamomum tamala	42.14	0.01
Rongmanchu	Rhaphidophora sp.	41.10	0.01

Rongmanchu	Beilschmiedia dalzellii	35.40	0.01
Rongmanchu	Ulmus lanceifolia	29.20	0.00
Rongmanchu	Prunus sp.	28.07	0.00
Rongmanchu	Albizia procera	25.13	0.00
Rongmanchu	Mallotus philippensis	23.48	0.00
Rongmanchu	Phyllanthus emblica	20.54	0.00
Rongmanchu	Robinia pseudoacacia	14.97	0.00
Rongmanchu	Stereospermum sp.	10.77	0.00

Annexure 8: Tree basal area (Mean)

FMU	Tree species	Tree Dbh Class	Tree basal area
Rongmanchu	Engelhardtia sp.	50 - 60	110.10
Rongmanchu	Engelhardtia sp.	90 - 100	261.91
Rongmanchu	Engelhardtia sp.	100 +	329.06
Rongmanchu	Brassaiopsis sp.	10 - 20	23.29
Rongmanchu	Brassaiopsis sp.	20 - 30	72.06
Rongmanchu	Brassaiopsis sp.	30 - 40	45.67
Rongmanchu	Brassaiopsis sp.	40 - 50	50.61
Rongmanchu	Brassaiopsis sp.	50 - 60	88.84
Rongmanchu	Magnolia sp.	40 - 50	67.51
Rongmanchu	Magnolia sp.	50 - 60	89.85
Rongmanchu	Magnolia sp.	60 - 70	116.92
Rongmanchu	Magnolia sp.	70 - 80	350.88
Rongmanchu	Magnolia doltsopa	50 - 60	88.84
Rongmanchu	Magnolia champaca	10 - 20	8.10
Rongmanchu	Magnolia champaca	20 - 30	21.38
Rongmanchu	Magnolia champaca	90 - 100	267.70
Rongmanchu	Juglans regia	20 - 30	45.99
Rongmanchu	Juglans regia	40 - 50	131.73
Rongmanchu	Juglans regia	50 - 60	106.40
Rongmanchu	Juglans regia	60 - 70	113.86
Rongmanchu	Albizia sp.	10 - 20	12.46
Rongmanchu	Albizia procera	10 - 20	3.83
Rongmanchu	Albizia lebbeck	30 - 40	96.49
Rongmanchu	Albizia lebbeck	50 - 60	91.89
Rongmanchu	Albizia lebbeck	60 - 70	137.77
Rongmanchu	Albizia lebbeck	80 - 90	223.17
Rongmanchu	Albizia lebbeck	90 - 100	528.47
Rongmanchu	Acer sp.	10 - 20	29.92
Rongmanchu	Acer sp.	20 - 30	35.33
Rongmanchu	Acer sp.	30 - 40	69.14
Rongmanchu	Acer sp.	40 - 50	50.61
Rongmanchu	Acer sp.	50 - 60	369.48
Rongmanchu	Acer sp.	60 - 70	146.25
Rongmanchu	Acer oblongum	30 - 40	38.74

Rongmanchu	Acer campbellii	10 - 20	52.13
Rongmanchu	Acer campbellii	20 - 30	146.72
Rongmanchu	Acer campbellii	30 - 40	297.40
Rongmanchu	Acer campbellii	40 - 50	249.11
Rongmanchu	Acer campbellii	50 - 60	273.68
Rongmanchu	Acer campbellii	60 - 70	929.07
Rongmanchu	Acer campbellii	70 - 80	738.71
Rongmanchu	Acer campbellii	80 - 90	451.14
Rongmanchu	Acer campbellii	90 - 100	291.49
Rongmanchu	Persea sp.	10 - 20	68.54
Rongmanchu	Persea sp.	20 - 30	64.05
Rongmanchu	Persea sp.	30 - 40	386.88
Rongmanchu	Persea sp.	40 - 50	575.38
Rongmanchu	Persea sp.	50 - 60	345.54
Rongmanchu	Persea sp.	60 - 70	514.75
Rongmanchu	Persea sp.	70 - 80	192.43
Rongmanchu	Persea bootanica	50 - 60	106.40
Rongmanchu	Persea bootanica	60 - 70	131.58
Rongmanchu	Persea fructifera	40 - 50	72.87
Rongmanchu	Robinia pseudoacacia	10 - 20	3.83
Rongmanchu	Alnus sp.	30 - 40	40.99
Rongmanchu	Alnus sp.	40 - 50	106.40
Rongmanchu	Alnus nepalensis	10 - 20	10.25
Rongmanchu	Alnus nepalensis	20 - 30	36.69
Rongmanchu	Alnus nepalensis	30 - 40	112.63
Rongmanchu	Alnus nepalensis	40 - 50	50.61
Rongmanchu	Alnus nepalensis	90 - 100	308.11
Rongmanchu	Echinocarpus dasycarpus	80 - 90	228.51
Rongmanchu	Nyssa javanica	30 - 40	43.30
Rongmanchu	Nyssa javanica	40 - 50	69.87
Rongmanchu	Cornus capitata	10 - 20	16.84
Rongmanchu	Cornus capitata	50 - 60	99.19
Rongmanchu	Phoebe sp.	10 - 20	147.97
Rongmanchu	Phoebe sp.	20 - 30	339.40
Rongmanchu	Phoebe sp.	30 - 40	722.77
Rongmanchu	Phoebe sp.	40 - 50	1222.89

Rongmanchu	Phoebe sp.	50 - 60	1138.33
Rongmanchu	Phoebe sp.	60 - 70	806.08
Rongmanchu	Phoebe sp.	70 - 80	159.44
Rongmanchu	Phoebe sp.	80 - 90	239.40
Rongmanchu	Phoebe sp.	90 - 100	285.45
Rongmanchu	Phoebe attenuata	10 - 20	40.93
Rongmanchu	Phoebe attenuata	20 - 30	46.11
Rongmanchu	Phoebe attenuata	30 - 40	65.03
Rongmanchu	Phoebe attenuata	40 - 50	58.48
Rongmanchu	Phoebe attenuata	50 - 60	188.28
Rongmanchu	Phoebe attenuata	60 - 70	113.86
Rongmanchu	Camellia sinensis	50 - 60	90.53
Rongmanchu	Neocinnamomum caudatum	10 - 20	33.17
Rongmanchu	Neocinnamomum caudatum	30 - 40	80.48
Rongmanchu	Neocinnamomum caudatum	60 - 70	113.86
Rongmanchu	Phlomoides rotata	30 - 40	68.89
Rongmanchu	Quercus sp.	10 - 20	141.25
Rongmanchu	Quercus sp.	20 - 30	340.81
Rongmanchu	Quercus sp.	30 - 40	842.41
Rongmanchu	Quercus sp.	40 - 50	1543.31
Rongmanchu	Quercus sp.	50 - 60	1138.60
Rongmanchu	Quercus sp.	60 - 70	1383.14
Rongmanchu	Quercus sp.	70 - 80	678.97
Rongmanchu	Quercus sp.	80 - 90	430.56
Rongmanchu	Quercus sp.	90 - 100	853.15
Rongmanchu	Quercus sp.	100 +	2220.21
Rongmanchu	Quercus semiserrata	50 - 60	99.19
Rongmanchu	Quercus semiserrata	70 - 80	173.20
Rongmanchu	Quercus semiserrata	80 - 90	223.17
Rongmanchu	Quercus semiserrata	90 - 100	297.59
Rongmanchu	Quercus semecarpifolia	10 - 20	61.01
Rongmanchu	Quercus semecarpifolia	20 - 30	122.73
Rongmanchu	Quercus semecarpifolia	30 - 40	68.89
Rongmanchu	Quercus semecarpifolia	50 - 60	167.91
Rongmanchu	Quercus semecarpifolia	80 - 90	223.17
Rongmanchu	Quercus semecarpifolia	90 - 100	279.47

Rongmanchu	Quercus oblongata	10 - 20	12.65
Rongmanchu	Quercus oblongata	20 - 30	18.22
Rongmanchu	Quercus oblongata	30 - 40	77.74
Rongmanchu	Quercus oblongata	40 - 50	55.79
Rongmanchu	Quercus oblongata	50 - 60	79.07
Rongmanchu	Quercus oblongata	60 - 70	113.86
Rongmanchu	Quercus oblongata	70 - 80	365.37
Rongmanchu	Quercus oblongata	80 - 90	202.42
Rongmanchu	Quercus oblongata	90 - 100	285.45
Rongmanchu	Quercus lanata	10 - 20	15.37
Rongmanchu	Quercus lanata	30 - 40	150.51
Rongmanchu	Quercus lanata	40 - 50	168.32
Rongmanchu	Quercus lanata	60 - 70	383.66
Rongmanchu	Quercus lanata	70 - 80	530.72
Rongmanchu	Quercus lamellosa	10 - 20	15.59
Rongmanchu	Quercus lamellosa	20 - 30	196.14
Rongmanchu	Quercus lamellosa	30 - 40	483.20
Rongmanchu	Quercus lamellosa	40 - 50	356.64
Rongmanchu	Quercus lamellosa	50 - 60	983.64
Rongmanchu	Quercus lamellosa	60 - 70	890.25
Rongmanchu	Quercus lamellosa	70 - 80	520.60
Rongmanchu	Quercus lamellosa	80 - 90	867.41
Rongmanchu	Quercus lamellosa	90 - 100	564.91
Rongmanchu	Quercus lamellosa	100 +	5086.32
Rongmanchu	Quercus griffithii	10 - 20	307.90
Rongmanchu	Quercus griffithii	20 - 30	588.51
Rongmanchu	Quercus griffithii	30 - 40	854.40
Rongmanchu	Quercus griffithii	40 - 50	663.22
Rongmanchu	Quercus griffithii	50 - 60	277.25
Rongmanchu	Quercus griffithii	60 - 70	373.53
Rongmanchu	Quercus glauca	10 - 20	86.73
Rongmanchu	Quercus glauca	20 - 30	80.26
Rongmanchu	Quercus glauca	30 - 40	91.58
Rongmanchu	Quercus glauca	40 - 50	143.40
Rongmanchu	Quercus glauca	50 - 60	283.75
Rongmanchu	Quercus glauca	60 - 70	269.99

Rongmanchu	Quercus glauca	70 - 80	358.37
Rongmanchu	Quercus semicarpifolia	10 - 20	131.50
Rongmanchu	Quercus semicarpifolia	20 - 30	82.80
Rongmanchu	Quercus semicarpifolia	30 - 40	77.55
Rongmanchu	Quercus semicarpifolia	40 - 50	53.17
Rongmanchu	Quercus semicarpifolia	50 - 60	195.24
Rongmanchu	Quercus semicarpifolia	80 - 90	239.40
Rongmanchu	Betula sp.	30 - 40	30.00
Rongmanchu	Betula sp.	60 - 70	113.86
Rongmanchu	Betula sp.	80 - 90	202.42
Rongmanchu	Betula utilis	10 - 20	8.38
Rongmanchu	Betula utilis	20 - 30	36.60
Rongmanchu	Betula utilis	30 - 40	28.66
Rongmanchu	Betula utilis	40 - 50	50.61
Rongmanchu	Betula utilis	50 - 60	92.23
Rongmanchu	Betula utilis	90 - 100	261.91
Rongmanchu	Betula alnoides	10 - 20	52.41
Rongmanchu	Betula alnoides	20 - 30	101.65
Rongmanchu	Betula alnoides	30 - 40	202.23
Rongmanchu	Betula alnoides	40 - 50	455.47
Rongmanchu	Betula alnoides	50 - 60	363.03
Rongmanchu	Betula alnoides	60 - 70	255.08
Rongmanchu	Alstonia scholaris	20 - 30	13.95
Rongmanchu	Artocarpus hirsutus	10 - 20	47.32
Rongmanchu	Artocarpus hirsutus	40 - 50	75.94
Rongmanchu	Toona ciliata	30 - 40	91.41
Rongmanchu	Toona ciliata	50 - 60	92.23
Rongmanchu	Abies densa	10 - 20	8.10
Rongmanchu	Abies densa	20 - 30	111.93
Rongmanchu	Abies densa	30 - 40	38.74
Rongmanchu	Abies densa	40 - 50	119.84
Rongmanchu	Abies densa	50 - 60	597.65
Rongmanchu	Abies densa	70 - 80	525.32
Rongmanchu	Abies densa	80 - 90	217.89
Rongmanchu	Abies densa	100 +	674.19
Rongmanchu	Ocotea lancifolia	50 - 60	88.84

Rongmanchu	Ulmus lanceifolia	10 - 20	5.35
Rongmanchu	Aquilaria malaccensis	20 - 30	18.22
Rongmanchu	Rhododendron sp.	10 - 20	266.77
Rongmanchu	Rhododendron sp.	20 - 30	753.67
Rongmanchu	Rhododendron sp.	30 - 40	1582.29
Rongmanchu	Rhododendron sp.	40 - 50	736.79
Rongmanchu	Rhododendron sp.	50 - 60	662.66
Rongmanchu	Rhododendron sp.	60 - 70	349.68
Rongmanchu	Rhododendron anthopogon	10 - 20	15.38
Rongmanchu	Rhododendron anthopogon	20 - 30	218.13
Rongmanchu	Rhododendron anthopogon	30 - 40	106.49
Rongmanchu	Rhododendron anthopogon	40 - 50	51.37
Rongmanchu	Rhododendron arboreum	10 - 20	478.88
Rongmanchu	Rhododendron arboreum	20 - 30	791.55
Rongmanchu	Rhododendron arboreum	30 - 40	339.82
Rongmanchu	Rhododendron arboreum	40 - 50	318.50
Rongmanchu	Rhododendron arboreum	50 - 60	97.42
Rongmanchu	Rhododendron arboreum	60 - 70	227.72
Rongmanchu	Rhododendron ciliatum	10 - 20	4.55
Rongmanchu	Rhododendron ciliatum	20 - 30	62.78
Rongmanchu	Rhododendron ciliatum	30 - 40	28.47
Rongmanchu	Rhododendron falconeri	10 - 20	264.28
Rongmanchu	Rhododendron falconeri	20 - 30	351.56
Rongmanchu	Rhododendron falconeri	30 - 40	492.99
Rongmanchu	Rhododendron falconeri	40 - 50	370.89
Rongmanchu	Rhododendron falconeri	50 - 60	386.32
Rongmanchu	Rhododendron falconeri	60 - 70	383.09
Rongmanchu	Rhododendron griffithianum	60 - 70	113.86
Rongmanchu	Rhododendron kesangiae	10 - 20	24.48
Rongmanchu	Rhododendron kesangiae	20 - 30	45.07
Rongmanchu	Rhododendron kesangiae	30 - 40	67.21
Rongmanchu	Rhododendron kesangiae	40 - 50	50.61
Rongmanchu	Rhododendron kesangiae	100 +	861.08
Rongmanchu	Rhododendron hodgsonii	10 - 20	14.30
Rongmanchu	Rhododendron hodgsonii	20 - 30	29.38
Rongmanchu	Rhododendron hodgsonii	40 - 50	58.75

Rongmanchu	Rhododendron hodgsonii	80 - 90	239.40
Rongmanchu	Syzygium cumini	20 - 30	56.46
Rongmanchu	Duabanga sp.	50 - 60	86.18
Rongmanchu	Stereospermum sp.	10 - 20	3.83
Rongmanchu	Stereospermum chelonoides	30 - 40	63.96
Rongmanchu	Rhaphidophora sp.	10 - 20	9.36
Rongmanchu	Cupressus sp.	10 - 20	11.42
Rongmanchu	Cupressus sp.	70 - 80	192.43
Rongmanchu	Cupressus sp.	80 - 90	457.60
Rongmanchu	Melia azedarach	10 - 20	21.82
Rongmanchu	Alangium alpinum	30 - 40	43.30
Rongmanchu	NA	30 - 40	28.47
Rongmanchu	Tsuga dumosa	20 - 30	44.52
Rongmanchu	Tsuga dumosa	30 - 40	76.77
Rongmanchu	Tsuga dumosa	40 - 50	552.52
Rongmanchu	Tsuga dumosa	50 - 60	465.73
Rongmanchu	Tsuga dumosa	60 - 70	1797.26
Rongmanchu	Tsuga dumosa	70 - 80	682.89
Rongmanchu	Tsuga dumosa	80 - 90	1760.17
Rongmanchu	Tsuga dumosa	90 - 100	3126.18
Rongmanchu	Tsuga dumosa	100 +	17917.72
Rongmanchu	UNKNOWN	10 - 20	266.75
Rongmanchu	UNKNOWN	20 - 30	300.53
Rongmanchu	UNKNOWN	30 - 40	674.25
Rongmanchu	UNKNOWN	40 - 50	186.10
Rongmanchu	UNKNOWN	50 - 60	88.84
Rongmanchu	UNKNOWN	60 - 70	925.97
Rongmanchu	UNKNOWN	70 - 80	885.85
Rongmanchu	UNKNOWN	80 - 90	233.92
Rongmanchu	Morus sp.	10 - 20	19.93
Rongmanchu	Phyllanthus emblica	10 - 20	5.35
Rongmanchu	Ailanthus grandis	10 - 20	9.14
Rongmanchu	Ailanthus grandis	20 - 30	27.90
Rongmanchu	Ailanthus grandis	30 - 40	45.67
Rongmanchu	Ailanthus grandis	40 - 50	120.47
Rongmanchu	Ailanthus grandis	60 - 70	125.53

Rongmanchu	Ailanthus integrifolia	10 - 20	11.54
Rongmanchu	Ailanthus integrifolia	60 - 70	141.98
Rongmanchu	Ailanthus integrifolia	80 - 90	207.51
Rongmanchu	Pinus roxburghii	10 - 20	502.46
Rongmanchu	Pinus roxburghii	20 - 30	770.93
Rongmanchu	Pinus roxburghii	30 - 40	581.52
Rongmanchu	Pinus roxburghii	40 - 50	381.04
Rongmanchu	Pinus roxburghii	50 - 60	438.78
Rongmanchu	Pinus roxburghii	60 - 70	1030.89
Rongmanchu	Pinus roxburghii	70 - 80	1062.06
Rongmanchu	Pinus roxburghii	80 - 90	404.84
Rongmanchu	Pinus roxburghii	90 - 100	309.99
Rongmanchu	Pinus roxburghii	100 +	432.96
Rongmanchu	Pinus wallichiana	10 - 20	240.23
Rongmanchu	Pinus wallichiana	20 - 30	515.99
Rongmanchu	Pinus wallichiana	30 - 40	499.19
Rongmanchu	Pinus wallichiana	40 - 50	376.09
Rongmanchu	Pinus wallichiana	50 - 60	85.52
Rongmanchu	Daphne sp.	10 - 20	93.72
Rongmanchu	Daphne sp.	20 - 30	333.31
Rongmanchu	Daphne sp.	30 - 40	270.97
Rongmanchu	Daphne sp.	40 - 50	114.65
Rongmanchu	Daphne sp.	50 - 60	95.68
Rongmanchu	Daphne sp.	60 - 70	113.86
Rongmanchu	Beilschmiedia sp.	10 - 20	63.36
Rongmanchu	Beilschmiedia sp.	20 - 30	172.38
Rongmanchu	Beilschmiedia sp.	30 - 40	326.78
Rongmanchu	Beilschmiedia sp.	40 - 50	654.75
Rongmanchu	Beilschmiedia sp.	50 - 60	677.95
Rongmanchu	Beilschmiedia sp.	60 - 70	141.98
Rongmanchu	Beilschmiedia sp.	70 - 80	182.69
Rongmanchu	Beilschmiedia sp.	80 - 90	247.72
Rongmanchu	Beilschmiedia sp.	90 - 100	291.49
Rongmanchu	Beilschmiedia sp.	100 +	1644.68
Rongmanchu	Beilschmiedia sikkimensis	90 - 100	303.76
Rongmanchu	Beilschmiedia dalzellii	10 - 20	5.35

Rongmanchu	Beilschmiedia bhutanica	30 - 40	75.31
Rongmanchu	Beilschmiedia bhutanica	40 - 50	128.66
Rongmanchu	Beilschmiedia bhutanica	90 - 100	303.76
Rongmanchu	Ficus sp.	10 - 20	35.36
Rongmanchu	Ficus sp.	20 - 30	53.74
Rongmanchu	Ficus sp.	30 - 40	71.39
Rongmanchu	Ficus sp.	40 - 50	142.87
Rongmanchu	Ficus sp.	80 - 90	202.42
Rongmanchu	Macaranga sp.	10 - 20	65.06
Rongmanchu	Macaranga sp.	20 - 30	72.78
Rongmanchu	Macaranga sp.	30 - 40	96.81
Rongmanchu	Macaranga denticulata	10 - 20	69.29
Rongmanchu	Macaranga denticulata	20 - 30	138.20
Rongmanchu	Macaranga denticulata	30 - 40	154.98
Rongmanchu	Exbucklandia populnea	10 - 20	10.25
Rongmanchu	Michelia sp.	30 - 40	45.67
Rongmanchu	Michelia sp.	50 - 60	92.23
Rongmanchu	Michelia sp.	60 - 70	133.63
Rongmanchu	Michelia champaca	10 - 20	8.61
Rongmanchu	Michelia champaca	20 - 30	16.73
Rongmanchu	Michelia champaca	40 - 50	117.02
Rongmanchu	Michelia champaca	50 - 60	269.98
Rongmanchu	Michelia champaca	60 - 70	239.40
Rongmanchu	Castanopsis sp.	10 - 20	54.80
Rongmanchu	Castanopsis sp.	30 - 40	58.86
Rongmanchu	Castanopsis sp.	80 - 90	228.51
Rongmanchu	Castanopsis indica	10 - 20	18.86
Rongmanchu	Castanopsis hystrix	40 - 50	50.61
Rongmanchu	Castanopsis hystrix	50 - 60	79.07
Rongmanchu	Castanopsis tribuloides	30 - 40	40.99
Rongmanchu	Myrica sp.	40 - 50	53.17
Rongmanchu	Lyonia sp.	10 - 20	7.12
Rongmanchu	Lyonia sp.	20 - 30	114.37
Rongmanchu	Lyonia sp.	30 - 40	97.92
Rongmanchu	Lyonia ovalifolia	10 - 20	109.81
Rongmanchu	Lyonia ovalifolia	20 - 30	139.26

Rongmanchu	Lyonia ovalifolia	30 - 40	28.47
Rongmanchu	Symplocos sp.	10 - 20	151.00
Rongmanchu	Symplocos sp.	20 - 30	204.19
Rongmanchu	Symplocos sp.	30 - 40	445.69
Rongmanchu	Symplocos sp.	40 - 50	256.89
Rongmanchu	Symplocos sp.	50 - 60	191.92
Rongmanchu	Symplocos sp.	60 - 70	235.44
Rongmanchu	Symplocos sp.	70 - 80	197.39
Rongmanchu	Symplocos sp.	80 - 90	212.67
Rongmanchu	Symplocos sp.	100 +	2290.78
Rongmanchu	Symplocos paniculata	20 - 30	79.58
Rongmanchu	Symplocos lucida	10 - 20	825.31
Rongmanchu	Symplocos lucida	20 - 30	373.78
Rongmanchu	Symplocos lucida	30 - 40	481.88
Rongmanchu	Symplocos lucida	40 - 50	367.47
Rongmanchu	Symplocos lucida	50 - 60	178.44
Rongmanchu	Symplocos glauca	40 - 50	64.05
Rongmanchu	Symplocos glomerata	10 - 20	72.43
Rongmanchu	Symplocos glomerata	20 - 30	127.58
Rongmanchu	Symplocos glomerata	30 - 40	243.57
Rongmanchu	Symplocos glomerata	40 - 50	122.90
Rongmanchu	Symplocos glomerata	60 - 70	133.63
Rongmanchu	Symplocos glomerata	70 - 80	192.43
Rongmanchu	Lagenaria siceraria	40 - 50	61.23
Rongmanchu	Lagenaria siceraria	50 - 60	88.84
Rongmanchu	Gmelina arborea	10 - 20	8.10
Rongmanchu	Gmelina arborea	20 - 30	41.15
Rongmanchu	Gmelina arborea	30 - 40	31.38
Rongmanchu	Cassia sp.	70 - 80	346.96
Rongmanchu	Prunus sp.	10 - 20	5.85
Rongmanchu	Mallotus philippensis	10 - 20	7.12
Rongmanchu	Lithocarpus glutinosus	10 - 20	8.10
Rongmanchu	Lithocarpus glutinosus	20 - 30	13.95
Rongmanchu	Lithocarpus glutinosus	60 - 70	125.53
Rongmanchu	Rhus sp.	10 - 20	33.43
Rongmanchu	Rhus sp.	20 - 30	12.65

Rongmanchu	Rhus sp.	40 - 50	55.79
Rongmanchu	Rhus sp.	50 - 60	88.84
Rongmanchu	Rhus paniculata	10 - 20	9.36
Rongmanchu	Rhus paniculata	20 - 30	30.87
Rongmanchu	Rhus chinensis	10 - 20	80.94
Rongmanchu	Rhus chinensis	20 - 30	16.73
Rongmanchu	Rhus chinensis	30 - 40	93.24
Rongmanchu	Acacia sp.	50 - 60	82.27
Rongmanchu	Acacia sp.	80 - 90	212.67
Rongmanchu	Acacia lenticularis	10 - 20	13.06
Rongmanchu	Acacia lenticularis	20 - 30	24.80
Rongmanchu	Acacia mearnsii	20 - 30	23.06
Rongmanchu	Acacia catechu	10 - 20	19.84
Rongmanchu	Erythrina arborescens	10 - 20	7.12
Rongmanchu	Erythrina arborescens	20 - 30	27.90
Rongmanchu	Schima wallichii	10 - 20	19.24
Rongmanchu	Schima wallichii	20 - 30	62.89
Rongmanchu	Schima wallichii	30 - 40	190.61
Rongmanchu	Schima wallichii	40 - 50	325.74
Rongmanchu	Schima wallichii	50 - 60	99.19
Rongmanchu	Schima wallichii	60 - 70	237.41
Rongmanchu	Schima wallichii	80 - 90	250.53
Rongmanchu	Ziziphus sp.	20 - 30	21.55
Rongmanchu	Daphniphyllum himalayense	10 - 20	69.54
Rongmanchu	Daphniphyllum himalayense	20 - 30	101.57
Rongmanchu	Daphniphyllum himalayense	30 - 40	86.90
Rongmanchu	Daphniphyllum himalayense	40 - 50	57.13
Rongmanchu	Daphniphyllum himalayense	60 - 70	125.53
Rongmanchu	Cinnamomum sp.	10 - 20	129.81
Rongmanchu	Cinnamomum sp.	20 - 30	151.66
Rongmanchu	Cinnamomum sp.	30 - 40	252.77
Rongmanchu	Cinnamomum sp.	40 - 50	561.69
Rongmanchu	Cinnamomum sp.	50 - 60	294.43
Rongmanchu	Cinnamomum sp.	60 - 70	267.83
Rongmanchu	Cinnamomum sp.	70 - 80	346.39
Rongmanchu	Cinnamomum sp.	100 +	335.55

Rongmanchu	Cinnamomum bejolghota	10 - 20	4.79
Rongmanchu	Cinnamomum bejolghota	20 - 30	82.55
Rongmanchu	Cinnamomum bejolghota	30 - 40	33.82
Rongmanchu	Cinnamomum tamala	10 - 20	5.59
Rongmanchu	Bauhinia sp.	10 - 20	21.86
Rongmanchu	Bauhinia sp.	30 - 40	28.47

Annexure 9: Tree biomass abg (Mean)

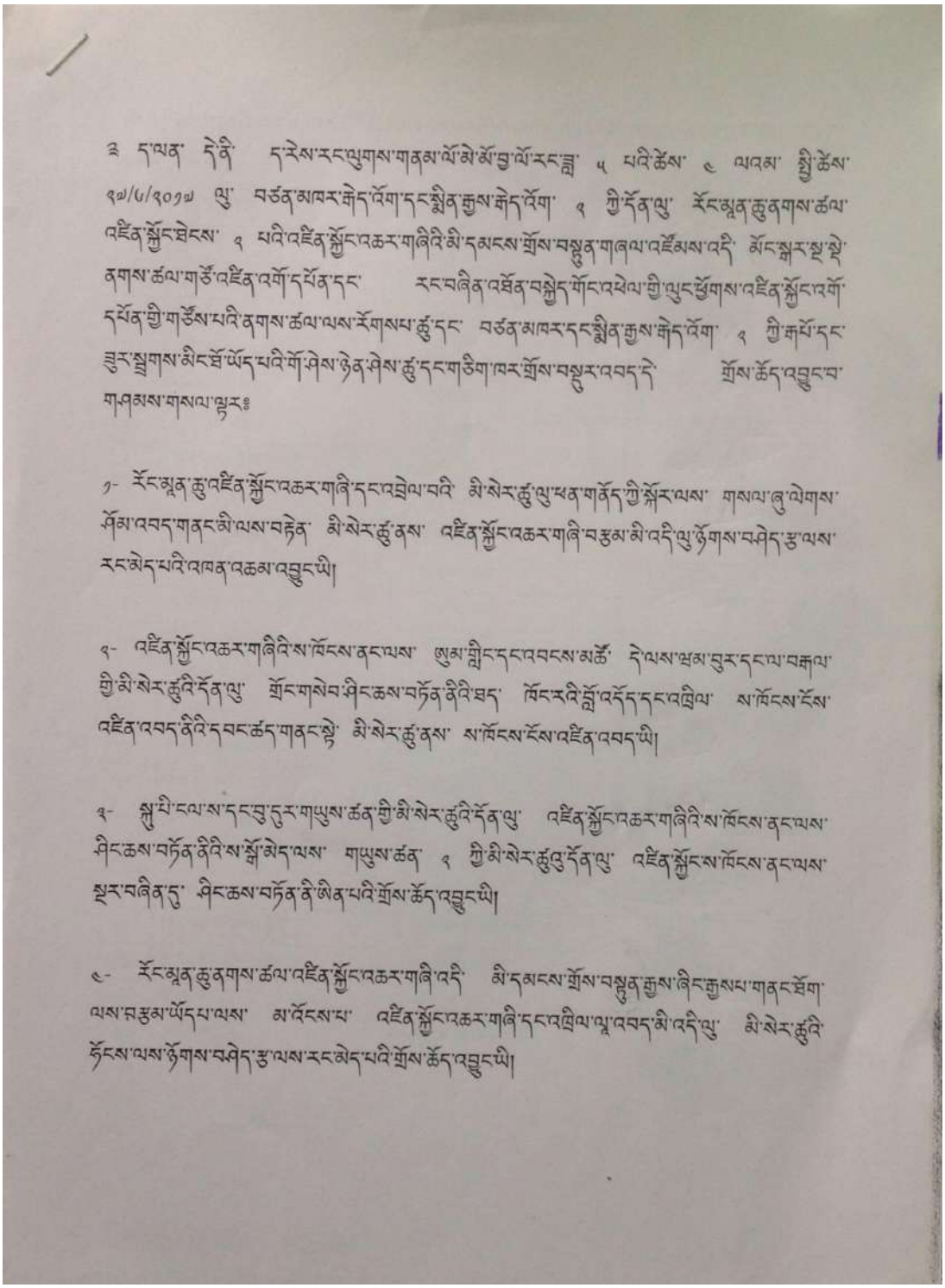
FMU Name	Tree species	Tree biomass abg (Mean)
Rongmanchu	Tsuga dumosa	17,602.480
Rongmanchu	Quercus lamellosa	7,851.637
Rongmanchu	Quercus sp.	7,632.096
Rongmanchu	Pinus roxburghii	4,988.389
Rongmanchu	Symplocos sp.	3,901.876
Rongmanchu	Phoebe sp.	3,840.169
Rongmanchu	Beilschmiedia sp.	3,744.793
Rongmanchu	Acer campbellii	2,695.928
Rongmanchu	Quercus griffithii	2,668.893
Rongmanchu	Rhododendron sp.	2,624.045
Rongmanchu	Cinnamomum sp.	2,047.675
Rongmanchu	Abies densa	1,796.822
Rongmanchu	Quercus glauca	1,619.139
Rongmanchu	Persea sp.	1,617.540
Rongmanchu	Abelia triflora	1,550.830
Rongmanchu	Symplocos lucida	1,490.715
Rongmanchu	Rhododendron falconeri	1,471.706
Rongmanchu	Betula alnoides	1,278.042
Rongmanchu	Quercus lanata	1,165.916
Rongmanchu	Schima wallichii	1,135.050
Rongmanchu	Pinus wallichiana	1,052.757
Rongmanchu	Rhododendron kesangiae	1,023.692
Rongmanchu	Cupressus sp.	826.183
Rongmanchu	Albizia lebbeck	788.401
Rongmanchu	Quercus oblongata	753.416
Rongmanchu	Quercus semiserrata	738.114
Rongmanchu	Rhododendron arboreum	710.039
Rongmanchu	Daphne sp.	676.720
Rongmanchu	Engelhardtia sp.	668.346
Rongmanchu	Symplocos glomerata	633.099
Rongmanchu	Michelia champaca	525.939
Rongmanchu	Quercus semicarpifolia	512.778
Rongmanchu	Acer sp.	512.185
Rongmanchu	Quercus semecarpifolia	453.021

Rongmanchu	Alnus nepalensis	445.870
Rongmanchu	Magnolia sp.	442.539
Rongmanchu	Beilschmiedia bhutanica	397.088
Rongmanchu	Phoebe attenuata	379.578
Rongmanchu	Betula utilis	328.868
Rongmanchu	Juglans regia	319.430
Rongmanchu	Castanopsis sp.	307.792
Rongmanchu	Daphniphyllum himalayense	302.604
Rongmanchu	Betula sp.	301.047
Rongmanchu	Beilschmiedia sikkimensis	297.645
Rongmanchu	Ficus sp.	293.087
Rongmanchu	Cassiope sp.	284.945
Rongmanchu	Cassia sp.	284.945
Rongmanchu	NA	277.625
Rongmanchu	Macaranga denticulata	274.870
Rongmanchu	Rhodiola sp.	252.381
Rongmanchu	Acacia sp.	243.749
Rongmanchu	Galinsoga quadriradiata	234.014
Rongmanchu	Rhododendron anthopogon	214.170
Rongmanchu	Ailanthus integrifolia	198.772
Rongmanchu	Rhododendron hodgsonii	185.998
Rongmanchu	Magnolia champaca	181.666
Rongmanchu	Ailanthus grandis	180.290
Rongmanchu	Castanopsis hystrix	165.017
Rongmanchu	Persea bootanica	164.296
Rongmanchu	Neocinnamomum caudatum	163.305
Rongmanchu	Rhus chinensis	155.741
Rongmanchu	Macaranga sp.	151.689
Rongmanchu	Toona ciliata	149.263
Rongmanchu	Brassaiopsis sp.	142.635
Rongmanchu	Nyssa javanica	128.307
Rongmanchu	Rhaphidophora glauca	123.973
Rongmanchu	Alnus sp.	123.683
Rongmanchu	Lyonia sp.	121.793
Rongmanchu	Lagenaria siceraria	118.866
Rongmanchu	Lyonia ovalifolia	108.682

Rongmanchu	Michelia sp.	103.556
Rongmanchu	Echinocarpus dasycarpus	102.716
Rongmanchu	Cornus capitata	99.379
Rongmanchu	Rhus sp.	86.505
Rongmanchu	Magnolia doltsopa	79.404
Rongmanchu	Lithocarpus glutinosus	74.900
Rongmanchu	Phlomoides rotata	68.775
Rongmanchu	Persea fructifera	67.578
Rongmanchu	Myrica sp.	60.297
Rongmanchu	Artocarpus hirsutus	59.936
Rongmanchu	Rhododendron griffithianum	57.844
Rongmanchu	Rhododendron ciliatum	52.687
Rongmanchu	Camellia sinensis	50.216
Rongmanchu	Ocotea lancifolia	46.795
Rongmanchu	Gmelina arborea	45.310
Rongmanchu	Cinnamomum bejolghota	44.443
Rongmanchu	Symplocos glauca	44.137
Rongmanchu	Bauhinia sp.	39.461
Rongmanchu	Acer oblongum	35.667
Rongmanchu	Symplocos paniculata	34.334
Rongmanchu	Castanopsis tribuloides	34.180
Rongmanchu	Stereospermum chelonoides	29.221
Rongmanchu	Syzygium cumini	29.197
Rongmanchu	Calamus erectus	25.856
Rongmanchu	Aster sp.	22.436
Rongmanchu	Erythrina arborescens	21.900
Rongmanchu	Acacia lenticularis	19.197
Rongmanchu	Rhus paniculata	18.235
Rongmanchu	Alangium alpinum	17.727
Rongmanchu	Acacia catechu	15.152
Rongmanchu	Morus sp.	15.035
Rongmanchu	Acacia mearnsii	13.264
Rongmanchu	Castanopsis indica	12.022
Rongmanchu	Aquilaria malaccensis	9.524
Rongmanchu	Geum sp.	8.937
Rongmanchu	Melia azedarach	8.685

Rongmanchu	Ziziphus sp.	8.177
Rongmanchu	Alstonia scholaris	8.145
Rongmanchu	Albizia sp.	8.007
Rongmanchu	Begonia sp.	7.581
Rongmanchu	Phlogacanthus thyrsiformis	6.833
Rongmanchu	Debregeasia longifolia	5.169
Rongmanchu	Exbucklandia populnea	4.656
Rongmanchu	Brassaiopsis mitis	4.655
Rongmanchu	Cinnamomum tamala	4.638
Rongmanchu	Rhaphidophora sp.	4.336
Rongmanchu	Galium sp.	4.313
Rongmanchu	Beilschmiedia dalzellii	3.835
Rongmanchu	Ulmus lanceifolia	3.090
Rongmanchu	Gentiana sp.	2.980
Rongmanchu	Prunus sp.	2.907
Rongmanchu	Albizia procera	2.785
Rongmanchu	Mallotus philippensis	2.306
Rongmanchu	Phyllanthus emblica	2.199
Rongmanchu	Buddleja sp.	1.922
Rongmanchu	Randia sp.	1.769
Rongmanchu	Robinia pseudoacacia	1.605
Rongmanchu	Stereospermum sp.	1.161
Rongmanchu	Drosera peltata	1.002

Annexure 10: Public Consultation Meeting



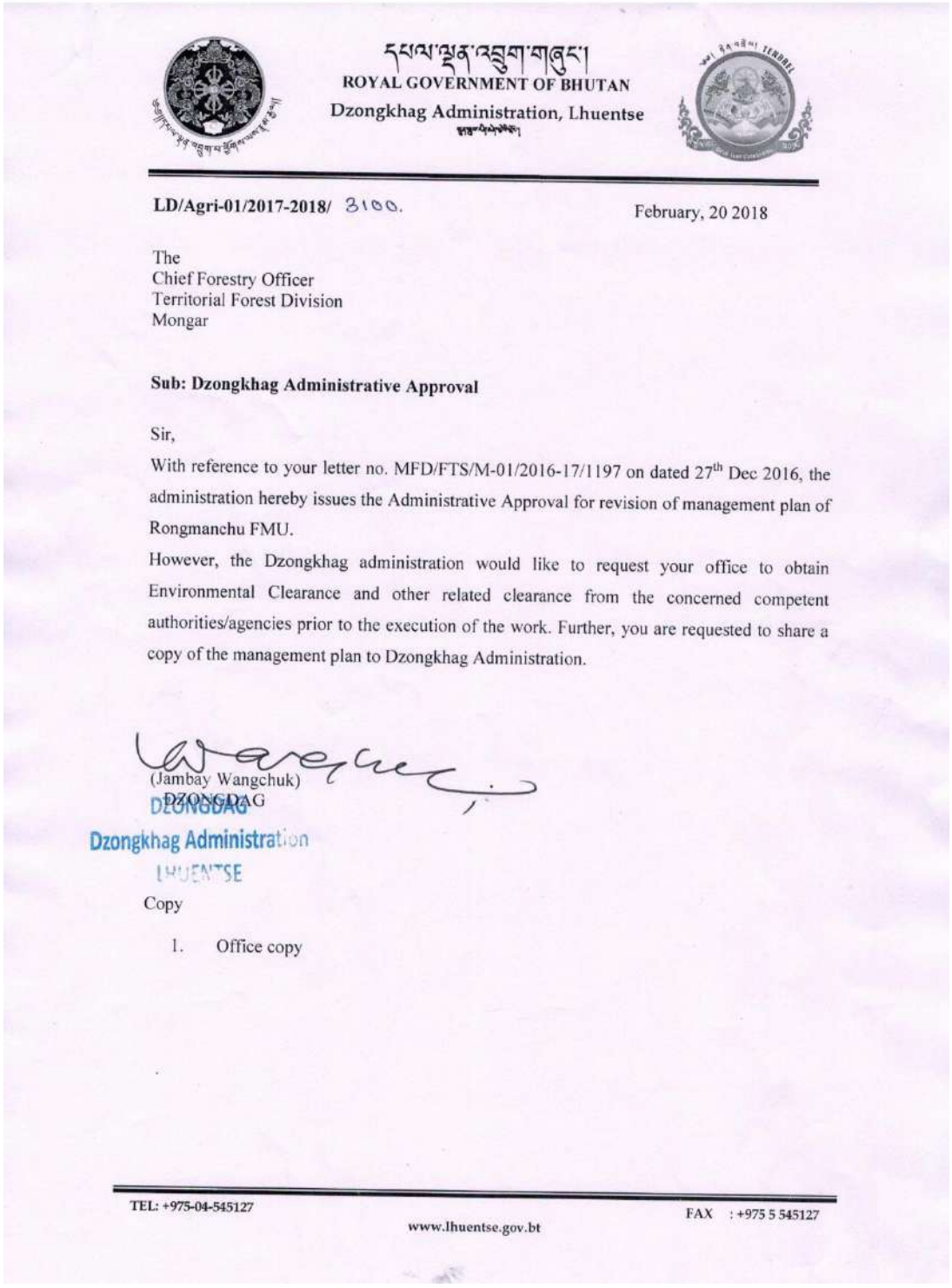
Public consultation for 2nd forest management plan of rongmanchu FMU 2017

ཚད་	མིང་གསལ།	སྡོད་གནས་ཁ་གྲང་	ལག་རྟིས
༡	འཕྲིས་ཐུ་མཆོ་	སྨིན་སྒྲིད།	
༢	ཀུ་བ་ལ།	བྱ་དུར།	
༣	དཔལ་ལྡན།	ཕམ་བུར།	
༤	ཚེ་ཐོ་རྡོ།	བྱ་དུར།	
༥	འཇིགས་མེད་བསྟན་འཛིན།	སྨིན་སྒྲིད་ཞེད་འོག	
༦	པད་མ་འོད་ཟེར	ཤུམ་གྲིང་	
༧	ཚེ་ཆོས་འཕེལ།	ཤུམ་གྲིང་	
༨	ཀུན་བཟང་ཆོས་འཕེལ།	ཤུམ་གྲིང་	
༩	དབང་འདུས།	དོན་མཁར།	
༡༠	རྣམ་རྒྱལ་བསྟན་འཛིན།	ཞེན་གྲིང་	
༡༡	འཇིགས་མེད།	འབངས་མཆོ།	
༡༢	བསོད་ནམས་ཆོས་སྐྱིད།	འབངས་མཆོ།	
༡༣	འཆི་མེད་དཔལ་སྒྲོན།	འབངས་མཆོ།	
༡༤	འཇིགས་མེད་ཚེ་དབང་	ཕམ་བུར།	
༡༥	ཚེ་དབང་རྡོ།	ཀུ་ཀི་ངལ་ས་	
༡༦	སངས་བསྟན་འཛིན།	བྱ་དུར།	
༡༧	ཆོས་སྐྱིད་ལ།	ཕམ་བུར།	
༡༨	ཆོས་ཀྱིད་ནོར་བུ།	ཕམ་བུར་ཆོགས་པ་	
༡༩	བསྟན་འཛིན་ཆོས་འཕེལ།	ཀུ་སྦུ་ངལ་ས་	
༢༠	སངས་ལ།	བྱ་དུར།	
༢༡	ཀུན་བཟང་གསལ་སྒྲོན།	དམངས་མི་བཙན་མཁར།	
༢༢	ཚེ་བརྟེན་དབང་འདུས།	ཁྲི་བཙན་མཁར།	
༢༣	བཀྲིས་ནོར་བུ།	ཁྲི་སྨིན་སྒྲིད།	

20/ ཨཱཀཱཤ། ཚེམིཏཡཱཀ

Figure 35: Public consultation meeting at Fawan, Tshenkhar Geog

Annexure 11: Dzongkhag Administrative approval for plan revision



ROYAL GOVERNMENT OF BHUTAN
Dzongkhag Administration, Lhuentse

LD/Agri-01/2017-2018/ 3100.

February, 20 2018

The
Chief Forestry Officer
Territorial Forest Division
Mongar

Sub: Dzongkhag Administrative Approval

Sir,

With reference to your letter no. MFD/FTS/M-01/2016-17/1197 on dated 27th Dec 2016, the administration hereby issues the Administrative Approval for revision of management plan of Rongmanchu FMU.

However, the Dzongkhag administration would like to request your office to obtain Environmental Clearance and other related clearance from the concerned competent authorities/agencies prior to the execution of the work. Further, you are requested to share a copy of the management plan to Dzongkhag Administration.

(Jambay Wangchuk)
DZONGDAG

DZONGDAG
Dzongkhag Administration
LHUENTSE

Copy

1. Office copy

TEL: +975-04-545127
FAX : +975 5 545127
www.lhuentse.gov.bt

རང་བཞིན་འཐོན་བསྐྱེད་ཀོང་འཕེལ་ལས་འཛིན་ཚད།

Natural Resources Development Corporation Limited
ROYAL GOVERNMENT OF BHUTAN
THIMPHU, BHUTAN

NRDCL

NRDCL/HQ/Engg-Sec/08/2017/498 February 20, 2018

The Chief Forestry Officer
Mongar Forest Division
Mongar

Sub: **Environment Impact Assessment Report of Rongmanchu FMU**

Ref: **MFD/FTS/M-01/2017-2018/333, 26th December**

Sir,

With reference to above cited letter, please kindly find herewith the enclosed Environmental Impact Assessment Report of Rongmanchu FMU of forest road for revision of FMU plan along with the Environmental Management Plan, Google earth images showing the tentative alignment of road, dump site & Labour camp locations.

For any queries please contact Mr. Nidup Dorji Jr. Engineer, Forest Resource Division at 02-323868/323834 or email: nidupdorji@nrdcl.bt.

This is submitted for your kind information and further necessary action please.

Yours sincerely,

(Sonam Wangchuk)
Chief Executive Officer

Copy to:
1. Chief Forestry Officer, FRMD, DoFPS, for kind information.
2. Dy. General Manager, Forest Resource Division, NRDCL HO for necessary action.
3. Regional Manager, Zhonggar Regional Office, Mongar, for necessary actions.

The nation's premier supplier of natural resources as construction materials at the most affordable rates and in sustainable manner

Post Box No. 192. Telephone - CEO: 00-975-2-322615, EPABX: 00-975-2-323834/323868/ 328959, Fax No.: 00975-2-325585, E-mail: info@nrdcl.bt website: www.nrdcl.bt

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR CONSTRUCTION OF FOREST ROAD AT RONGMANCHU FMU, KHEPACHU BLOCK, LHUENTSE DZONGKHAG

1 Name of the applicant : Natural Resources Development Corporation Ltd.

2 Name of project : Construction of forest road

3 Present mailing address : Chief Executive Officer, NRDCL Thimphu, P.O. Box no. 192, Tel. no. 326749, EPABX no. 00975-02-323834/323868. Fax no. 00975-02-325585. Email: info@nrdcl.bt

4 Name of environmental focal person : Mr. Nidup Dorji, Junior Engineer, Forest Resources Division, NRDCL HQ, Thimphu. Tel. no. 02-323834/323868. Email: nidupdorji@nrdcl.bt

5 Project objectives : Timber harvesting & afforestation of harvested areas

6 Relevence to overall planning : Revision of Forest Management Plan

7 Funding and costs : Funded by NRDCL, Thimphu 16,250,000.00

8 Project description

8.1 Project location :18km along Fawan - Bangtsho farm road.

Table 1: Road location details by Dzongkhag and Geog

Road chainage		Dzongkhag	Gewog	Town	Village
From	To				
0 + 000	0 + 10000	Lhuentse	Tsenkhar		Wambur

8.2 Category of road : New Road

8.3 Road specification Forest Road

Table 2. Road Specification/Quantities

Item	Unit	Specification/Quantities
Right of way clearing	m	10.00
Formation Width	m	5.00
Pavement Width including edging	m	3.50
Pavement material (Edging, soling & agttes)	cum	10,050.00
Volume of excavated material		
a) Excavation in soil all type	cum	50,670.20
b) Excavation in rock all type	cum	32,530.00
Average road gradient	%	±7
Maximum road gradient	%	±12
Cross drain	no	NIL
Box/Hume pipe culvert	no	13
V-shaped side drain diamensions		
In soil (horizontal x vertical)	cm	40CM X 30 Cm
In rock (horizontal x vertical)	cm	30 CM X 20 CM
Total length of v-shaped drain	m	9,980.50
Box shaped side drain diamensions (lengthxbreadthxheight)	cm	NIL
Total length of box drain	m	NIL

8.4 Excavated Materials : The excavated material will be managed and disposed off safely at designated locations through the use of excavator and tipper trucks or hydraulic tractors.

8.5 Explosives : Approximate quantity of explosive to be used is as under:

Sl. No	Particulars	Quantity	
1	Safety fuse	1205 coils	(Approx)
2	detonator	2105Nos.	(Approx)
3	D-chord	1701 m	(Approx)
4	Jelatine	2701 kgs	(Approx)

Control single shot blasting technique will be adopted with the engagement of a trained & certified blaster.

9 Alternatives : NIL

10 Public Consultation : Public consultation meeting conducted

11 Project site Physical Environmental details

11.1 Topography and Geology

Table 3: Topography and observations along the road

Chainage(Km 0+000)		distance (m)	Side slope %	Observation on geology & possible problem	Method of slope & terrain stabilization Above & Below road
From	To				
0 + 000	0 + 10000	10000 (Khepachu block)	10 -120	Pre-cambrian and no problem foreseen	Normal Bio-engineering + Retaining & Breast wall structure works wherever required.
Total		10,000.00			

11.2 Water Course Crossings

Table 4: Details of water courses that will require crossing along the proposed road

Chainage at which road crosses water course	Name of water course	Type of crossing	If bridge, Length of bridge (m)	Down stream water users- details		
				Name of community or individual	House hold (no)	Type of use
0000 + 0187	N A	Hume pipe culvert	NIL	Lhagay	86	Drinking & irrigation
0187+ 0381	N A	Hume pipe culvert	NIL	Lhagay		
0381 + 1359	NA	Hume pipe culvert	NIL	Lhagay		
1359 + 1584	NA	Hume pipe culvert	NIL	Lhagay		
1584 + 1953	NA	Hume pipe culvert	NIL	Lhagay		
1953 + 2193	NA	Hume pipe culvert	NIL	Lhagay		

2193 + 2733	NA	Hume pipe culvert	NIL	Lhagay		
2733 + 2874	NA	Hume pipe culvert	NIL	Lhagay		
2874 + 3187	NA	Hume pipe culvert	NIL	Lhagay		
3187 + 4317	NA	Hume pipe culvert	NIL	Lhagay		
4317 + 5117	NA	Hume pipe culvert	NIL	Lhagay		
5117 + 5437	NA	Hume pipe culvert	NIL	Lhagay		
5437 + 6000	NA	Hume pipe culvert	NIL	Lhagay		

12 Project Site Ecological Description

12.1 Land Use/Vegetation

Table 5: Land use and forest clearance required for road construction

Chainage from take off		Land use	Area (M^2)	Tenure	Affected House hold no
From	To				
0 + 000	10000 + 000	Mixed Hard Wood	100,000.00	10 years	NIL

Table 6: Areas Required for Project Facilities

Facility	Land use	Area (m^2)	Tenure/ownership	Remarks
Labour camp	Mixed Hard Wood	2000 per annum	Govt. reserve forest	Till project completes
Others				

12.2. Protected area : The protected areas such as Soil protection, local water supply protection, Reparian protection, Wild life protection etc. shall be indentified where no commercial activities shall be allowed.

13 Project social environment

13.1. Population

Table 7: Project Beneficiaries. Households with possible access <2km either side of the road

Dzongkhag	Gewog	Households (No)
Lhuentse	Tshengkhar	86

Source of information: as per attached No Objection letter of the Gup, Tshenkhar Geog

Loss of Houses, Services, Infrastructure and Cultural Heritage Sites

Type of loss	NOS	Description of disturbance
Service	NIL	NIL
House	NIL	NIL
Infrastructure	NIL	NIL
Cultural sites	NIL	NIL
Heritage	NIL	NIL

13.3 Aesthetics

No aesthetic distrubance is foreseen however, grass seeding & other bio-engineering technique measures shall be applied on the slopes for reclaiming immediately after road construction.

14 Project Impacts and Mitigation Measures

Type of negative impact	Mitigation measures	Estimated metigation costs
Blockage of water canal	Cleaning & maintenance	Nu. 10,000.00 (Lumpsum)
House	NIL	NIL
Infrastructure	NIL	NIL

14.1. Monitoring Program

Monitoring of the construction works will be done by Site supervisor, Rongmanchu Unit, NRDCL, including time to time monitoring by the Unit Manager, Rongmanchu Unit under Zhonggar Regional Office, Mongar. The Regional Manager, Mongar Regional Office, NRDCL Mongar, shall also carry out the frequent monitoring. Also the Engineer from Forest Resource Division, NRDCL HO, shall carry out the monitoring of the construction works as & when required.

Nidup Dorji
Jr. Engineer
Forest Resouce Division,HO,NRDCL

Annexure 13: Environmental management plan for forest road construction

ENVIRONMENTAL MANAGEMENT PLAN FOR CONSTRUCTION OF 10.00KMsFOREST ROAD AT RONGMANCHU FMU UNDER ZHONGGAR REGIONAL OFFICE, NRDCL, IN LHUNTSE DZONGKHAG.

Sl. No.	Activity	Potential Negative Environment Impact	Mitigation Measures	Public Participation and Coordination	Socio-Economic and cultural considerations	Budgeting	Supervision	Monitoring
1	Work camp location, operation & closure, restriction on workers (sanitation, fuel wood collection, poaching etc.)	• Garbage, oil & grease pollution Damage to vegetation & wildlife	• Provide sanitary facilities and restore • Provide fuel to workers	• DoF&PS • Awareness of labours	• Consider local culture and compensate, if required	• Incorporated	• Unit Manager • Site supervisor	• Regional Manager • Engineer, NRDCL HQ • External team
2	Explosive & toxic waste management	• Fire & explosion hazard • Ground & surface water pollution	• Do not store near surface water • Use plastic sheeting under hazardous material • Collect waste properly & dispose off safely	• Contact Ministry of Home & Cultural Affairs in case of hazard or needing material innihilation	• Consider local drinking water sources	• Incorporated	• Unit Manager • Site supervisor	• Regional Manager • Engineer NRDCL HQ • External team
3	Water Management	• Sedimentation of surface water • Slope failure • Creation of new gullies • Water seepage	• Build check dams • Tap excess water by catch drains and dispose off to natural gullies	• Involve locals when deciding about discharge location • Dzongkhag administration	• Irrigation channel and drinking water supplies need consideration	• Will be incorporated if required.	• Unit Manager • Site supervisor	• Regional Manager • Engineer NRDCL HQ • External team

(Nidup Dorji)
Jr. Engineer
Forest Resourse Division, NRDCL HQ

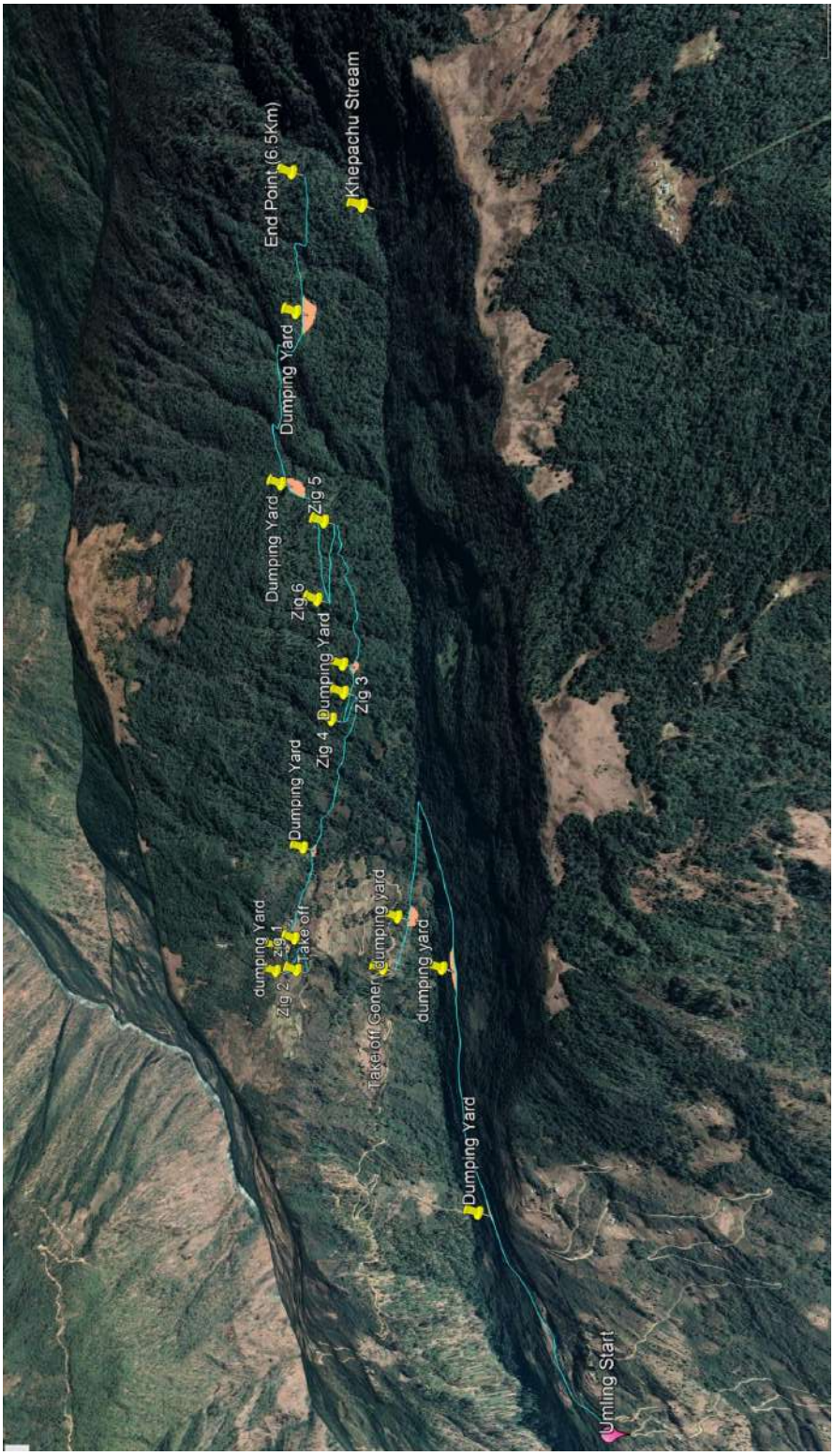


Figure 36: Overview of proposed forest road-A

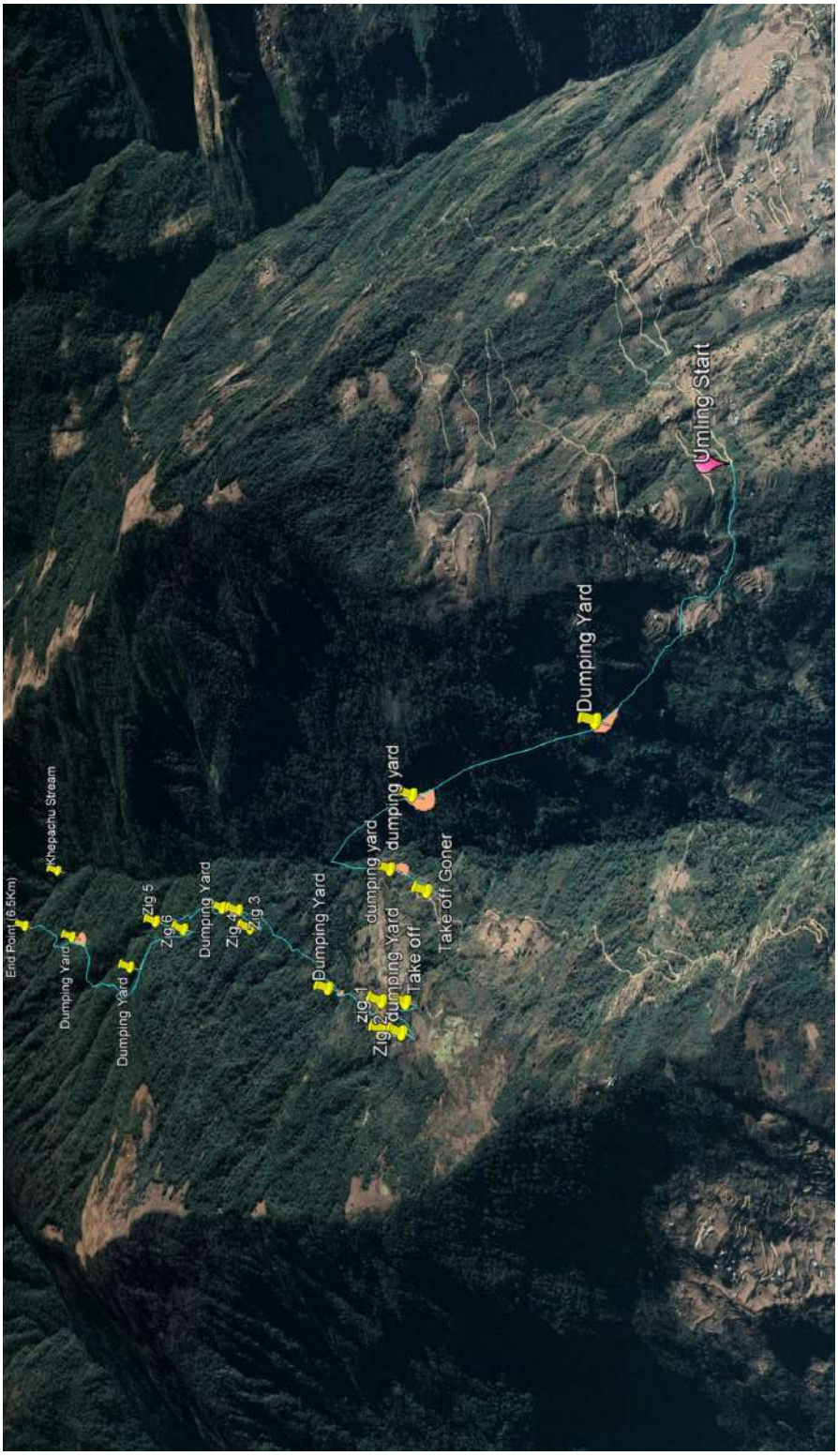


Figure 37: Overview of proposed forest road -B

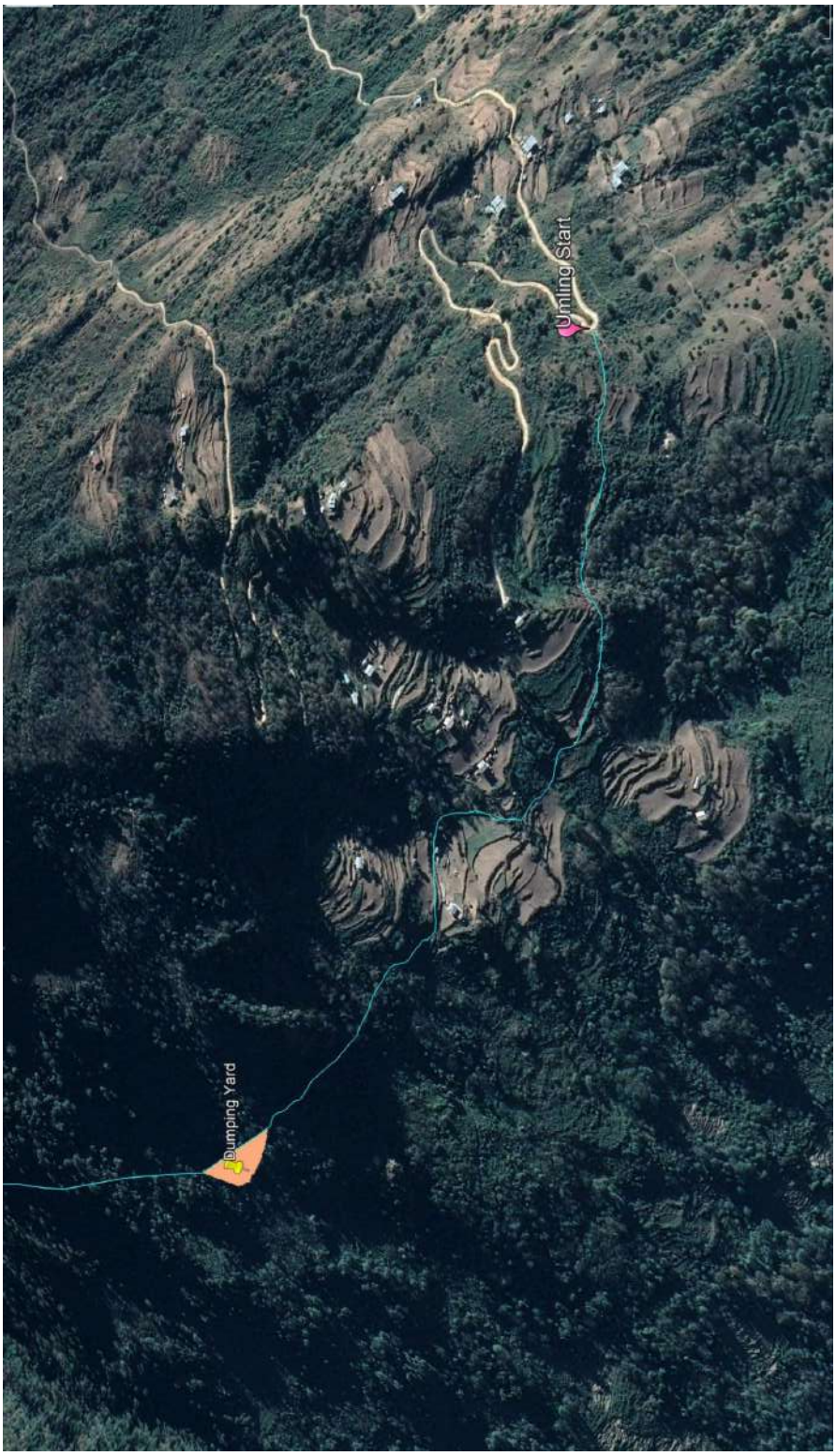


Figure 38: Road starts from Umling village

Annexure 14: Compartment Record Sheet

Block: ..... Compartment: .....

Sub-Compartment: .....

Year	Harvesting		Tending		Planting		Other	Remarks
	Area (ha)	Vol. (m3)	Area (ha)	Vol. (m3)	Area (ha)	Species		
2018								
2019								
2020								
2021								
2022								
2023								
2024								
2025								
2026								
2027								

Annexure 15: Rural Allotment

Block: ..... Compartment: .....

Sub-Compartment: .....

MC	WC	Date	Name and Address	Permit #	TMB #	Particulars			Volume (m^3)			Comments
						Species	Product Type	Amount	Marked	Recovered	Firewood	

Annexure 16: Commercial Allotment

Block: ..... Compartment: .....

Sub-Compartment: .....

MC	WC	Year of Activity	Commercial Activities					Volume (m^3)				Other Activities	TMB No.	Comments
			Cable Lines			Groups/ Patches/ Other		Marked		Extracted (NRDCL)	Firewood (lops/tops)			
			Line No.	Length (m)	Azimuth	Total No.	Total Area (ha)	No. of trees	Vol. (m^3)					

Annexure 17: Stand Tending and Regeneration

Block: ..... Compartment: .....

Sub-Compartment: .....

MC	WC	Cable line No.	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?	

THANK YOU to Forest Management Inventory crews of Rongamnchu FMU.

Sanjip Rai, FR I
EID No. 201007359

Tshewang Tenzin, FR II
EID No. 20130803110

Dina Nath Mishra, Asst. Fr
EID No. 200708002

Dawa Tenzin, Field Asst.
RFMU, NRDCL

Tenzin Wangpo, FR II
EID No. 20150905861

Sonam Loday, Forester
EID No. 200304038

Sonam Choizang, Forester
EID No. 200204061

Ngawang Dorji, Forester
EID No. 20130803139

Dorji Wangdi, FR II
EID No. 20150905860

Purna Bahadur Rai, Sr. Forester
EID No. 201107176

Tashi Wangdi, Sr. FR II
EID No. 2108033

Forest management inventory crews were trained by Ms. Kezang Yangdon, Dy. Chief and Mr. Ugyen Penjor, Sr. FO from FRMD, Thimphu. These pictures were taken at Umlingbadep depot during practical data collection session.