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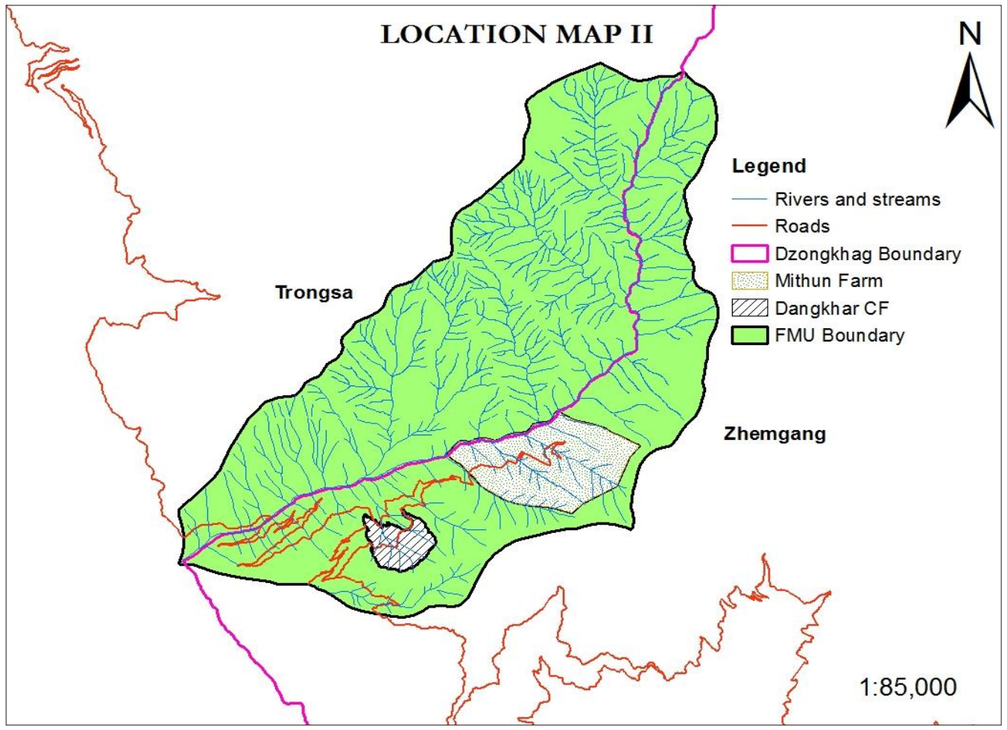
ROYAL GOVERNMENT OF BHUTAN
MINISTRY OF AGRICULTURE AND FORESTS
DEPARTMENT OF FORESTS AND PARK SERVICES
FOREST RESOURCES MANAGEMENT DIVISION
THIMPHU: BHUTAN

"Sustaining Forest Resources for Present and Future Generations"



FOREST MANAGEMENT PLAN
FOR
WANGDIGANG FOREST MANAGEMENT UNIT

PERIOD OF THE PLAN: 1ST JANUARY, 2017 TO 31ST DECEMBER, 2026

Plan prepared by:
Damber Mani Rai, Forestry Officer
Tshering , Sr. Forestry Officer
Ms. Dimple Thapa, Dy, Chief Forestry Officer
Tashi Norbu Waiba, Sr. Forestry Officer

AUTHORITY FOR PREPARATION, REVISION AND APPROVAL OF PLAN

PERIOD OF THE PLAN:

This Plan is valid for the period of 10 years from 2017 to 2026.

AUTHORITY FOR PREPARATION, REVIEW AND APPROVAL:

The authority for preparation of this Plan was given to the Forest Resources Management Division (FRMD), Department of Forests and Park Services (DoFPS), Ministry of Agriculture and Forests (MoAF), Royal Government of Bhutan (RGoB).

PROVISION FOR REVISIONS AND CHANGES:

This Plan may be revised during the period when it is in effect. 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, the Hon'ble Director, DoFPS can authorize a revision/amendment of any section of this Plan.

APPROVAL:

This Plan was examined by a wide section of user groups, clients and organizations. It has been further reviewed and recommended for implementation by the Hon'ble Director , Department of Forests and Park Services (DoFPS) and approved by His Excellency the Minister, Ministry of Agriculture and Forests (MoAF), Royal Government of Bhutan (RGoB).

Submitted for Approval

Chief Forestry Officer
Forest Resources Management Division
Department of Forests & Park Services
Date:

Recommended for Approval

Director
Department of Forests & Park Services
Date: .....

Recommended for Approval

Secretary
Ministry of Agriculture & Forests
Date: .....

Approved/Not Approved

Minister
Ministry of Agriculture & Forests
Date: .....

Environment Clearance

དཔལ་ལྡན་འབྲུག་གཞུང་།

National Environment Commission

Royal Government of Bhutan

NECS/ESD/FRMD/3330/2016/166 / **August 3, 2016**

ENVIRONMENTAL CLEARANCE

The National Environment Commission Secretariat (NECS) is pleased to issue environmental clearance in respect of Forest Resources Management Division (FRMD) as approved during the meeting held on August 2, 2016 for the operation of 3rd revised Forest Management Unit (FMU) of Wangdigang measuring an area of 8759 hectares under Trong Gewog, Zhemgang Dzongkhag with following terms and conditions:

1. As per Section 28.3 of the Regulation for the Environmental Clearance of Projects 2002, any modification of proposal/application shall take place only with prior approval from NECS;
2. **The holder shall ensure that this environmental clearance is valid only for operation of 3rd revised Forest Management Unit (FMU) of Wangdigang measuring an area of 8759 hectares under Trong Gewog, Zhemgang Dzongkhag Dzongkhag;**
3. The holder shall ensure that operation of Forest Management Unit is in line with the National Environment Protection Act 2007, Environment assessment Act 2000 and its Regulation 2002, Waste Prevention & Management Act of Bhutan 2009 and its Regulation 2012 and The Water Act of Bhutan 2011 and its Regulations 2014;
4. The holder shall ensure that the activity complies with the Environmental Standards 2010;
5. The holder shall ensure that the activity is carried out as per the management plan submitted for environmental clearance;
6. The holder shall ensure compliance to all the terms and conditions of stakeholder clearances at all times;
7. The holder shall ensure that the activity is within the demarcated lease hold boundary;
8. The holder shall ensure that the annual timber extraction from the FMU does not exceed its Annual Allowable Cut (ACC) as stated in the Management Plan;
9. The holder shall ensure that extraction of timer is done strictly as per the sivicultural system stated in the management plan;
10. The holder shall ensure that prescriptions of the management plan is strictly implemented;
11. The holder shall ensure that local residents, households, communities, public, private parties and any religious, cultural, historic and ecologically important sites are not adversely affected by the activity;
12. The holder shall ensure that NECS and any other relevant authorities are informed of any unanticipated or unforeseen chance-find of any precious metals or minerals or articles, that have economic, cultural, religious or ecological importance;
13. **The holder shall ensure to maintain a buffer of 100feet (30m) between the activity site and the edge of the water bodies;**
14. The holder shall ensure that watershed and catchment areas are protected strictly as proposed in the management plan;
15. The holder shall ensure that protection management circle of the FMU is never encroached;

NATIONAL ENVIRONMENT COMMISSION

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

16. The holder shall ensure adequate regeneration and re-vegetation in the harvested area;
17. The holder shall be solely responsible for any dispute arising due to the activity;
18. The holder shall ensure that reforestation program is implemented as proposed in the management plan;
19. The holder shall ensure that reforested areas are protected from animals;
20. The holder shall ensure that no exotic plant species are introduced during the reforestation;
21. The holder shall ensure that lops and tops are managed properly to ensure maximum survival of regeneration;
22. The holder shall ensure to construct side drains, cross drains, causeways, and other supporting structures (retaining/breast walls) along the approach road to prevent soil erosion, improve its stability and sustainability;
23. The holder shall ensure that adequate safety gadgets and outfits such as safety helmets, eye goggles, breathing masks, ear muffs, safety boots, etc. are provided to all workers and any other person entering the work-site;
24. The holder shall ensure that visual impact on the environment due to the activity is minimized and appropriate measures are put in place to improve the visual impact of the environment;
25. The holder shall ensure that underage workers are not employed;
26. The holder shall ensure that first aid-kit is available at the work-site at all times;
27. The holder shall ensure that proper health check up facilities are provided to all employees and health records are maintained accordingly;
28. The holder shall ensure that the safety signs are posted at strategic locations within the work-site, including signboards indicating the where specific safety gadgets are required to be used;
29. The holder shall ensure that signboard is erected at take-off point of the approach road showing the name of the FMU and contact address of the implementing agency;
30. The holder shall ensure that a copy of this environmental clearance is available at the work-site at all times;
31. The holder shall develop contingency plan to deal with unforeseen environmental risks, hazards & accidents and submit to NECS within three months from the date of renewal of this environmental clearance;
32. **The holder shall ensure that renewal of this environmental clearance is processed at least three months prior to its expiry along with a copy of environmental clearance and a report on the implementation of its terms and conditions;**
33. **The holder shall ensure that monitoring on the implementation of the management plan is conducted at least annually and annual monitoring report is submitted to NECS accordingly;**
34. The holder shall ensure that Detailed Implementation Plan (DIP) is developed focusing on the implementation of the terms and conditions of this environmental clearance and submit to NECS within **3 (three) months** from its date of renewal; and
35. The holder shall ensure strict implementation of the terms and conditions of this environmental clearance at site at all times.

Failure to comply with any of the above terms and conditions shall constitute an offence under the Environmental Assessment Act 2000, its Regulations 2002, the National Environment Protection Act 2007 and any other relevant laws. Penalties for such offences shall include but not limited to suspension and/or revocation of environmental clearance in part or whole without any liability on the part of the Royal Government.

This environmental clearance is valid till **August 2, 2021** and is subject to periodic review.

Secretary

To,

The Chief Forestry Officer,
Forest Resources Management Division,
Department of Forest and Park Services,
Thimphu

Copy to:

1. The Dasho Dzongdag, Dzongkhag Environment Committee, Zhemgang for kind information.
2. The Director, Department of Forests and Park Services, Thimphu for kind information.
3. The Offtg. Dzongkhag Environment Officer, Dzongkhag Administration, Zhemgang for necessary action.
4. Guard file (FRMD), ESD, NECS for record.

Letter No. 49
Received on 3/8/16
File No. .....

LIST OF ABBREVIATIONS

AAC	: Annual Allowable Cut
cm	: Centimeter
DBH	: Diameter at Breast Height
DBHOB	: Diameter at Breast Height over Bark
DzFO	: Dzongkhag Forestry Officer
GFEO	: Geog Forest Extension Officer
CFO	: Chief Forestry Officer
EA	: Environmental Assessment
NRDCL	: Natural Resources Development Corporation Limited
FRMD	: Forest Resources Management Division
FMP	: Forest Management Plan
FMU	: Forest Management Unit
DoFPS	: Department of Forests & Park Services
GIS	: Geographic Information System
Hac.	: Hectare
Km	: Kilometre
m	: Metre
masl	: Metre Above Sea Level
mm	: Milimetre
MoAF	: Ministry of Agriculture & Forests
m^3	: Cubic Metre
NWFP	: Non-Wood Forest Products/Produces
Nu.	: Ngultrum
OP	: Operational Plan
PRA	: Participatory Rural Appraisal
RGoB	: Royal Government of Bhutan
UM	: Unit Manager
RM	: Regional Manager
RNR	: Renewable Natural Resources
RNR-RC	: Renewable Natural Resources Research Centre
RO	: Range Officer
RRA	: Rapid Rural Appraisal
SFED	: Social Forestry & Extension Division
UIC	: Unit Incharge
WC	: Working Circle
%	: Percent

EXECUTIVE SUMMARY

The Forest Management Plan for Wangdigang Forest Management Unit has been prepared according to the standards and best forest management practices laid out in Forest Management Code of Bhutan for sustainable forest management in Bhutan. The Forest management Plan consists of three parts as follows:

PART 1: GENERAL DESCRIPTION and PAST MANAGEMENT

PART 2: THE FUTURE MANAGEMENT

PART 3: IMPLEMENTATION OF THE PLAN

PART 1: GENERAL DESCRIPTION and PAST MANAGEMENT

1. Wangdigang Forest Management Unit with an area of 8759hectares is located in Trong Geog under Zhemgang Dzongkhag while part of it falls under Baling Geog under Trongsa Dzongkhag. The entire forest is government owned falling under the jurisdiction of Chief Forest Officer of Zhemgang Divisional Forest Office. However, there are some private lands within the FMU and also Zhemgang town falls within the FMU. Dangkhar Community Forest lies within the FMU and some private forests are also coming inside the FMU.
2. This Management Plan from the year 2017 – 2026 is the third plan for Wangdigang FMU. The first plan covered the period from 1992 to 2002 and the second plan covered the period from March, 2005 to February, 2015. The first Management Plan was officially extended till 2004, since the plan implementation was delayed for three years due to forest road construction in the FMU.
3. The FMU rises from less than 796 masl at confluence of the Wangdichu and Mangdechu rivers in the south to 4143 masl below snowline on its northern border.

4. The monsoon brings heavy rain during the months of June, July and August. There is snowfall in the upper reaches of the FMU in winter.
5. The major forest types that comprises in the FMU are Broadleaved (81%), Fir (3%) and Chir Pine (1%). Other includes Agriculture (9%), Shrubs (3%), Meadows (1%), Rocky (1%) and Zhemgang Town Area (1%). However, most forest types are inaccessible and present management activities are confined in the broadleaf zone.
6. About 27 km of Trongsa – Gelephu National Highway passes through the FMU. Specifically for the Management Plan implementation, 14.787Km forest road connecting to the highway has been constructed into the inner forests of the FMU.
7. With an area of 358 Sqkm, Trong Geog has 392 households with male population of 3815 and female population of 3382 (Gewog at a Glance, 2014, Zhemgang Dzongkhag).
8. The people of Trong Geog are dependent on the forests of Wangdigang for construction timber, fencing posts, prayer flags and non-wood forest products like mushroom, bamboo, *patsha* (cane shoot), *paani* (betel leaf), *Guli* (wild avocado), etc. Beside, drinking water source for Zhemgang town and water for irrigating the fields are sourced from the FMU.
9. Wangdigang FMU plays a vital role for livestock from within and outside providing grazing ground even for migratory cattle.
10. Some commercially important tree species found in the FMU are *Micheliachampaca, Perseafructifera, Alnus sp., Toona ciliate, Juglans regia, Pinus roxburghii, Ficus sp., Castonopsis indica, Schima wallichii, Macaranga sp., Acer sp. and Betula sp.*
11. The wildlife seen or recorded in the FMU are **Kasha**/Barking Deer (*Muntiacus muntjak*), **Shoow**/Sambar Deer (*Cervus unicolor*), **Ri-Phag**/Wild Boar (*Sus scrofa*), **Chaa-seer**/Common Languor (*Presbytis entellus*) and **Domm**/Himalayan Black Bear (*Selenarctos thibetanus*).

12. A forest management inventory was carried out in the FMU by the FRMD Forest Inventory crew during early 2015. The field work involved the recording of 244 systematic sample plots of 0.05hac each in a grid of 250m x 200m.
1. 13.The analysis of Forest Inventory Data using R-statistics shows that the total volume of growing stock over 10cm DBH trees is 296649.47m3 for the whole FMU, 237.70 m3/ha at per hectare level and 11.88m3/plot at per plot level.
13. Environmental Impact Assessment was carried out in the FMU in March, 2015 using the recommendations given in the Forestry Sector Guidelines prepared by National Environment Commission and the Forest Management Code of Bhutan.
14. Wangdigang FMU has been classified into accessible and inaccessible areas, protection and production forests and organized into Blocks, Compartments and Sub-Compartments based on the topographic features.
15. The forest protection totaling 6639hectares (75.80%) of the FMU are permanently dedicated for total protection of watershed, flora and fauna and soil stability. Except for controlled grazing and collection of NWFPs, no other form of intervention will be permitted in the protection forests.
16. In the past, commercial scale silvicultural treatments in the FMU started with coupes allocated to Gedu Wood Manufacturing Corporation in 1984. In 1987–88, a coupe of 30 hac. was opened for supplying Champ (*Michelia sp.*) timber for National Assembly Hall construction in Thimphu.
17. In the past management plan, strip clear fellings were applied as silvicultural system for harvesting of commercial timbers from the annual cable line coupes.

PART 2: FUTURE MANAGEMENT

1. The goal of the Wangdigang FMU is to manage on a multiple use, sustainable basis for production of timber, fuel wood and other forest products and for conservation of watershed, wildlife and environment.

2. To co-ordinate and balance the various economic, ecological and social aspects, various forest functions were identified based on pre-determined criteria. A forest function map was prepared in consultation with stakeholders.
3. Based on the different forest functions, three different functions were identified namely;
    a. Production function where harvesting would be carried out,
    b. Protection function for protection of flora and fauna, soil protection, riparian reserve, religious and historical sites and drinking water source protection.
    c. Non-production area which are inaccessible.
4. Total Production Forest in the FMU which are managed for sustainable supply of fuel wood and timber is only 1163hac which is about 13.28% of the total FMU area of 8759 hectares.
5. Land Registration Division under the Department of Survey and Land Records have registered1650 acres equivalent to 664.42 hectares of land within the FMU for establishment of Mithun Breeding Farm.
6. Single Tree Selection System has been prescribed as the appropriate silviculture system for extraction of timbers from the Production area of the FMU.
7. The current plan have no AAC prescribed for commercial use. However, sanitation logging shall be carried on priority basis with due approval from DoFPS,MoAF. The AAC for the FMU in this plan period is **2100 m^3**(standing volume) for Rural use only.
8. The commercial harvesting should not take place in the FMU since the production area had been exhausted. Harvesting in interlines cannot be prescribed since the natural regeneration and plantations along the old cable lines have not established. The 14.787 km forest road should be properly maintained so that the water siltation is minimized and road remains pliable all-round the year.

PART 3: IMPLEMENTATION OF THE PLAN

1. The Chief Forestry Officer (CFO), Zhemgang Forest Division is responsible for the implementation of the management plan. Annual Operational Plan of the FMU should be prepared by CFO, Zhemgang Forest Division well in advance of the operating year to facilitate implementation of the management plan.
2. A rolling biennial Operation Plan will be prepared by CFO, and Unit In-charge to facilitate the timely implementation of this management plan. Guidelines for the preparation of the Operational Plan have been prepared and are available at FRMD.
3. Monitoring and evaluation of the management plan will be the responsibility of the Forest Resources Management Division (FRMD) with the lead taken by CFO, Zhemgang Division.
4. Unforeseen circumstances may warrant deviations from the plan prescriptions and in such an event the CFO, Zhemgang Division must obtain prior written approval from the Head of the Department.

Contents

LIST OF FIGURES

LIST OF TABLES

ANNEXURES

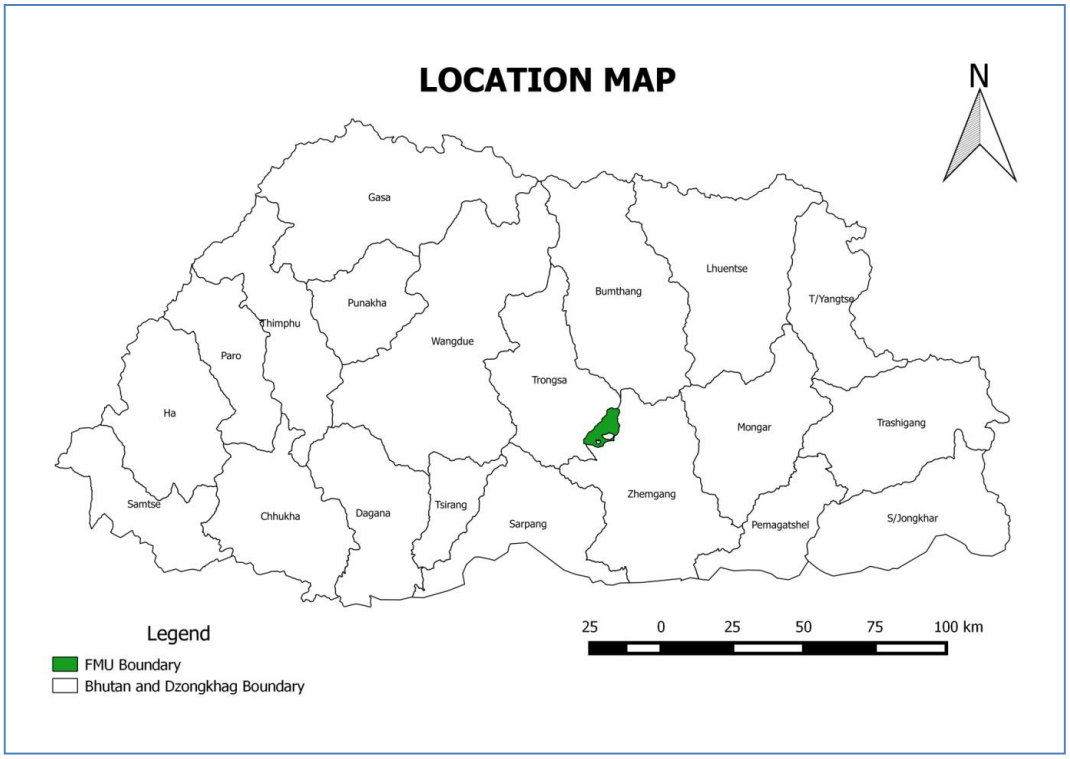
PART ONE: GENERAL DESCRIPTION

1.1 LOCATION AND BACKGROUND

1.1.1 Location and Extent

Wangdigang Forest Management Unit (WFMU) is located in Trong Geog of Zhemgang Dzongkhag in Central Bhutan. The WFMU falls between the longitudes 90º 37'E and 90º 45'E, and latitudes 27º 13'N and27º 20'N. Except for a small eastern portion of the FMU, the boundary of Wangdigang FMU follows the natural watershed boundary of Wangdichu river, which is a tributary of Mangdichu river.

Figure 1: Map of Wangdigang FMU



The Dzongkhag Administration of Zhemgang and Zhemgang town are located within the FMU. The Trongsa – Gelephu National Highway traverses through the FMU.

1.1.2 Historical Background

Before the opening of the forest management unit, the area was used mostly as a grazing land. Cattle owned by the local communities of Dangkhar, Dungbey, Pugling and Zhemgang town used to graze in the Gurpang area which lies in the southeastern region of the FMU. During winter, cattle herders from other neighboring Dzongkhags of Trongsa and Bumthang used to bring their cattle to the area. In the western region of the FMU, the Kangopang Tsamdro (grazing land) is traditionally the grazing ground for cattle of Baling village, Langthel Geog of Trongsa Dzongkhag.

1.1.3 Area Statement

All in all,Wangdigang FMU encompasses an area of 8759 hectares after deducting the total area occupied by Dangkhar Community Forest (156 hectares) and Mithun Breeding Farm (668 hectares). The information has been mostly obtained from LUPP 1994, LCMP 2010 and Topographic maps.

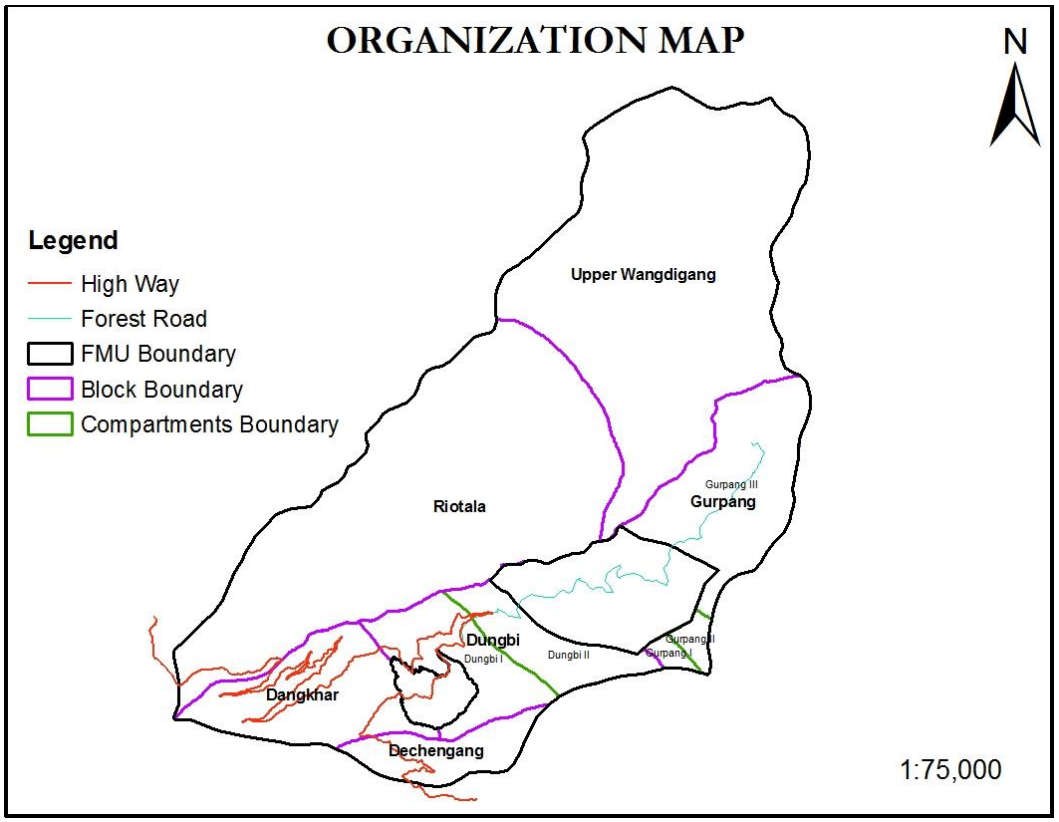


Figure 2: Map of Blocks and Compartments

1.1.4 Legal Status

1.1.4.1 Ownership

As per the Forest and Nature Conservation Rules of Bhutan, 1995, the forested area within the FMU is the Government Reserved Forests (GRF). The Department of Forests and Park Services (DoFPS) has the sole responsibility of managing the forest land within the Forest Management Unit.

There are private lands within the FMU, registered and owned by the local communities comprising mostly of wet farm lands (cultivated terraces), dry farm lands and Tsheris (land under shifting cultivation). Zhemgang town which is under the Trong geog of the Dzongkhag also falls within the FMU. Various private

individuals and government agencies own tracts of land for commercial, residential and office use.

1.1.4.2 Rights and Privileges

The rights and privileges of the local inhabitants with regard to the use of the forest resources are defined in the Forest and Nature Conservation Rules of Bhutan, 1995. According to the Act, the local inhabitants enjoying traditional rights and privileges are permitted to use timber for genuine rural house construction, graze livestock, and collect fuel wood, fodder and leaf mould, etc. for domestic use on payment of nominal royalty or for free.

1.1.4.3 Grazing Rights

There are Tsamdros within the FMU where cattle from the local communities within the FMU as well as those from outside the FMU (from adjacent Dzongkhags of Trongsa and Bumthang) come to graze. However, the cattle belonging to people outside the FMU are migratory and they are in the FMU for a certain period of time only.

Although, grazing has been a part of Bhutan's forests for centuries, it is felt that as more and more forest areas come under management regimes, unchecked grazing is hampering regeneration growth of the harvested area. The DoFPS has been empowered to regulate grazing if the forest management regime finds it necessary for its purpose.

1.1.4.4 Water Rights

The people living within the FMU have the traditional rights to use water for domestic purposes such as human consumption, rearing livestock and irrigating their fields. The people of Trong Geog and Zhemgang town have their supply of drinking water from the Dechengang sub-catchment in the eastern part of the FMU. Dechengang Watershed is a im watershed since it is the source of drinking water

for Zhemgang town for the time being. Previously, the water was diverted from the sub-catchment by water pipes and irrigation channels to supply drinking water to the town and villages below the town and irrigation of farms in the villages. Other water sources include the streams flowing from hills above Dungbey village which supplies water for drinking as well as irrigation to the people of Dungbey area and Dangkhar village.

There are logging activities which took place in the Dungbey water source before the preparation of the first forest management plan for Wangdigang FMU. The villagers are still wary of any such activities since now they are aware that such activities might jeopardize their watershed. In the future, if there is any further expansion of urban settlement in Zhemgang, it is felt that water supply might have to come from Dungbey area.

1.1.4.5 Historical Monuments and Sacred Sites

One of the most important historical sites in the Wangdigang FMU is Zhemgang Dzong built in 1655 AD. It stands on top of the ridge that rises sharply from the Mangdechu facing the village of Trong and Zhemgang town. The dzong now is the residence of Zhemgang Rabdey and serves as a monastic school as well as monks' residence. The Dzongkhag Administration is housed just outside the dzong.

There are a couple of temples build recently above the dzong. They serve the spiritual and religious need of the people in Zhemgang town and surrounding villages.

There are also several Tsoes (lakes) ranging in size from half an acre to one acre in the FMU. Tsoes are considered to be home of water spirits by Bhutanese people and many occurrences outside of the ordinary like a heavier than usual rainfall and flash floods are attributed to the supernatural power of the spirits. Protection of such features in the FMU is of paramount importance for allaying peoples' fear of the wrath of the spirits.

1.2 PHYSICAL FEATURES

1.2.1 Topography

The Wangdigang FMU rises from less than 796 masl at confluence of Wangdichu and Mangdechu rivers in the south to 4143 masl below snowline on its northern border. The terrain is steep in most parts although along the ridges the slope is gentle. There are numerous valleys each formed by the streams flowing into the Wangdichu river.

1.2.2 Geology

Geologically, the Wangdigang area is a part of the Lower Himalayas (Late-Precambrian Meta-sediments and marginal remnants of Gondwana Rocks) and covered by rocks of Wachela Formation. The major rock types are Chlorotic Phyllite Carb, Phyllite Ortho Quartzite, and Siliceous Limestone. The tentative age of the above formation are indicated lower to middle Palaeozoic Era.

1.2.3 Soils

The soil is predominantly loam in the unit although there are patches of clayey loam. The soil is deep in gentle slopes and shallow in steeper areas. In general, the soil conditions are favorable to tree growth.

1.2.4 Hydrology

The major part of the Wangdigang FMU forms the watershed of the Wangdichu which lies in the Mangde catchment. There are several streams which originate from both sides of the valley and drain into the Wangdichu. The Wangdichu and other streams outside the main activity areas are not used for irrigation or domestic purposes. The local inhabitants depend upon Dungbey stream and other streams along the National Highways to irrigate their cultivable lands and for other

domestic purposes. These streams have paramount importance to the local inhabitants and need special protection.

The other smaller watershed forming a part of the FMU is the Dechengang Watershed. This is aimportant watershed since Zhemgang town has its water supply from this watershed. Protection of Dechengang watershed should be accorded highest priority.

1.3 CLIMATE

The climate is subtropical to alpine. At the confluence of the Wangdichu, it is completely different from that of the higher elevations. Summers are pleasant but humid. The upper reaches of the unit become quite cold during the winters.

1.3.1 Temperature

The average minimum monthly temperature ranges from 4.3^0 Celsius in December and January month to 15.9^0 Celsius in the hottest months of July and August. The average maximum temperature ranges from 13.1^0 Celsius to 22.1^0 Celsius. The coldest months are December, January and February where frost occasionally occurs during the night and recedes during day time.

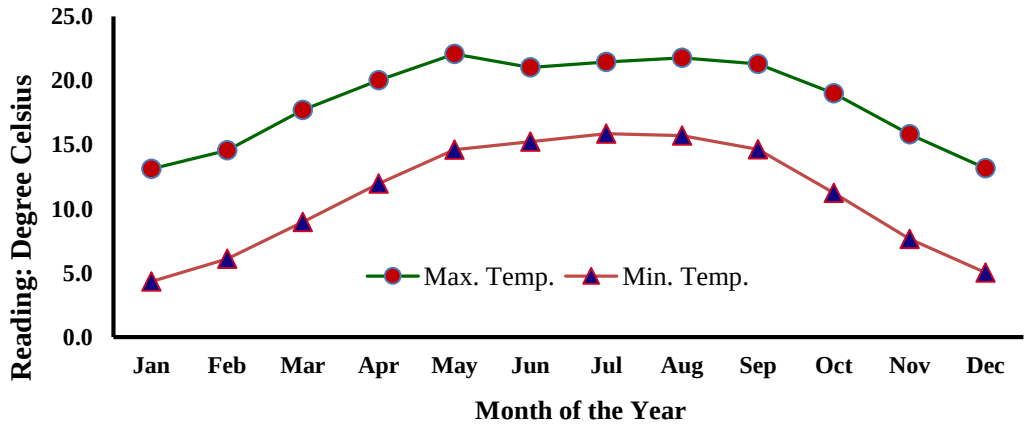


Figure 3:Average Monthly Maximum and Minimum Temperatures

1.3.2 Rainfall

The weather is drier and cooler from December to march, while months with the highest rainfall are from June to September. The south-west slope of the FMU gets more rain since it faces the monsoon winds coming from the south into the Wangdichu river valley.

Average monthly Rainfall (AMR)

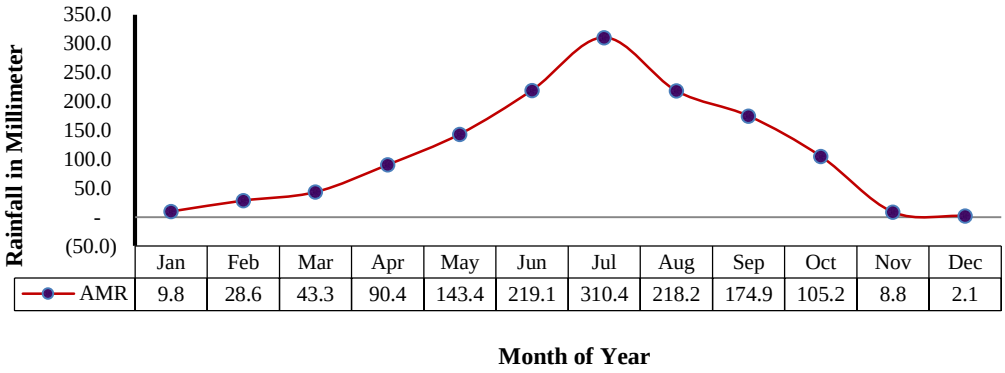


Figure 4:Average monthly Rainfall (AMR)

1.4 SOCIO ECONOMIC FACTORS

1.4.1 Population

The Wangdigang FMU falls within the Trong Geog boundary. The geog with an area of 358 Sq.km has 392 *gungs* with projected population of 7197 (Geog at a glance, 2014, Zhemgang Dzongkhag).

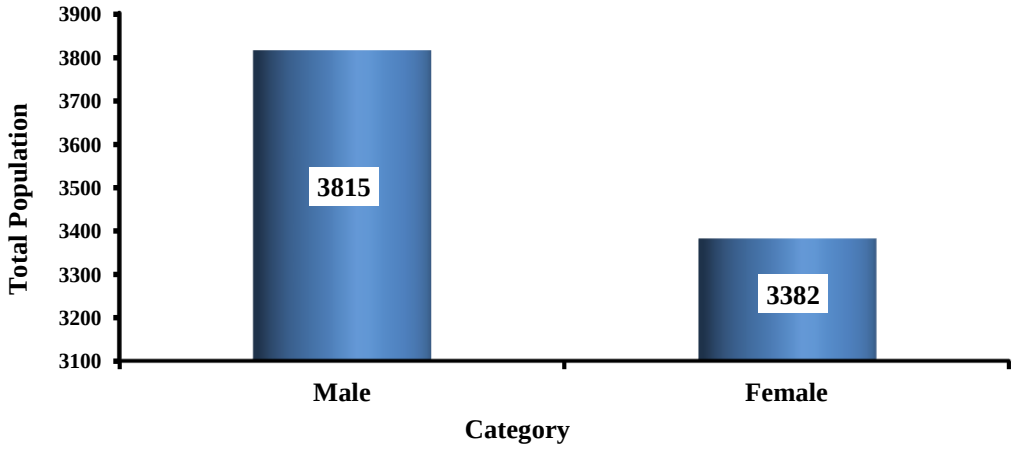


Figure 5:Total human Population (Male/Female) of Trong Geog

1.4.2 Income Source and Expenditure

Income sources: Communities falling within the FMU have varied sources of income. Zhemgang town falling within the FMU tend to skew the socio-economic characterization of the people there. But, we have to know people who are dependent on the FMU for jobs, income, etc. are those in the villages. The sources of income of communities in Dangkhar, Dungbey and Trong include food crops, fruits and vegetables, livestock, labour, remittances, house rent and to some a small scale forest products/produces.

Sources of income include food crops such as paddy, maize (processed into *Tengma* or *Sep*); cash crops like oranges, cardamom and chilly, and livestock products like milk, cheese, butter, eggs and sometimes meat. Income from labour comes from paddy transplanting, logging, power chain saw operation, and dancing allowance. Remittances from relatives with government jobs or private businesses form the main source of income with some households. Generally, the main source of income is derived from livestock and labour. As can be seen, the people in the FMU don't weave or make their own clothes.

The sources of income only shoe the possible avenues from where income is generated and not the amount. We cannot really get the exact amount of household income earned because most of what these people produce is consumed at home. Their products and labours are not really accounted for and the source from forest is very minimal.

Expenditure: Areas where people incur expenses are food, religious ceremonies and education. Although, most households in the FMU are farmers producing their own food, they had to buy salt, sugar, cooking oil, soaps, etc. The entire household interviewed for socio-economic survey responded that they spend or set aside some money for religious ceremonies or rituals. This is no surprise, since all Bhutanese are religious and usually they perform annual rituals. Religious expenditure is incurred when there are sick people in the house (rituals performed to ward off the evil spirit) or rituals after death. The expenditure for education depends on whether the household has school-going children or not.

1.4.3 Education

The literacy rate of the communities residing within the FMU is rather low as compared to national average. This low literacy rate can be attributed to the remote location of the FMU. Zhemgang town falling within the FMU is skewing the socio-economic characteristics of the communities living within the FMU. Most of those who know how to read and write are young people from lower secondary school to some college level degree holders. Still, some children have to walk for hours climbing and descending the steep slopes to reach school.

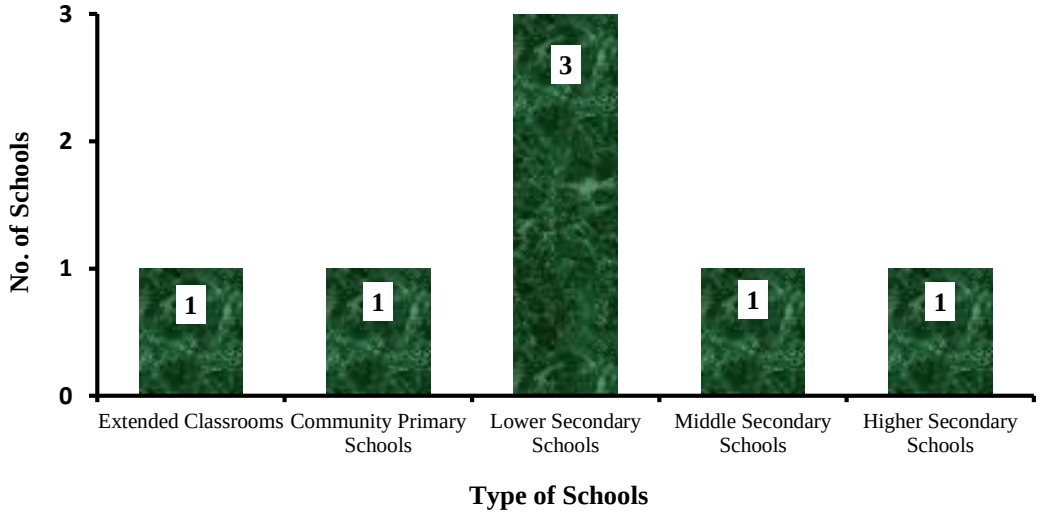


Figure 6:Type and number of Schools under Trong Geog, Zhemgang (Source: Geog at a Glance, 2014, Zhemgang Dzongkhag).

The monastic and religious learning complements western literacy in Bhutan. But unlike in other communities in Bhutan where the religious teachers and students form a considerable portion of the society, in Wangdigang FMU there are very few people engaged full time in religious services. Only a handful of people are earning their living by performing religious rituals. The monks from the Zhemgang dzong perform most of the religious rituals for the people for which substantial expenditure is incurred.

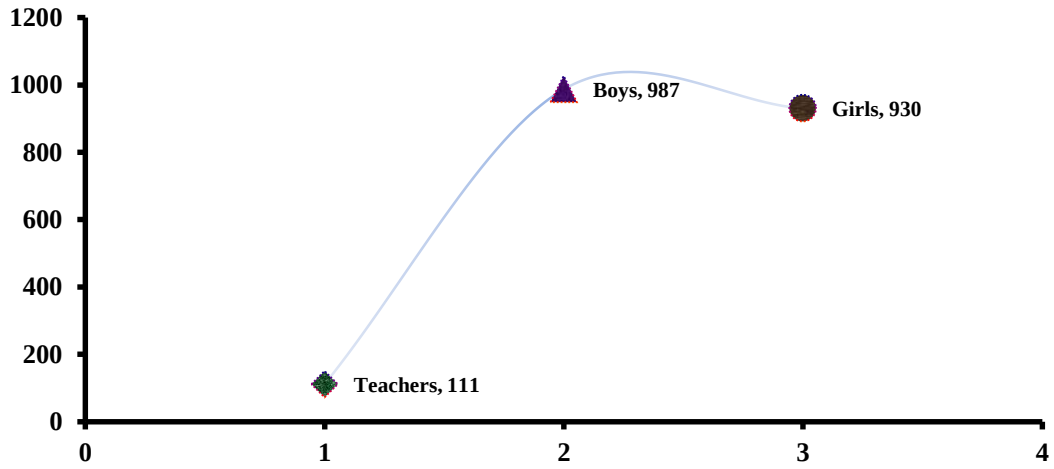


Figure 7:Number of Boys, Girls and Teachers in schools under Trong Geog, Zhemgang (Source: Geog at a Glance, 2014, Zhemgang Dzongkhag)

1.4.4 Agriculture and Farming System

Dungbey, Dangkhar and southern part of Wangdigang FMU are under cultivation. The farmers in the area cultivate cereals like paddy and maize, vegetables like turnip, beans, chillies, etc. For the cultivation of paddy, there are rice terraces in the FMU. These rice terraces are irrigated by water coming from the sub-catchments in upper Dungbey.

In the lower part of the hill, tseri (shifting cultivation) is still practiced by the farmers. This is due to the geo-physical nature of the area which hinders agricultural development. The villages are scattered and located in the steep slopes which make establishment of permanent plots difficult. Most of the lands are not suitable for permanent continuous cultivation. Some of the lands are left fallow for a period while others are cultivated. The fallow lands are brought back to re-cultivation on a rotation basis. The tseri lands are used for growing maize.

1.4.5 Private Forests

Initially in 1993, Save the Children (USA) office in Zhemgang had initiated a programme to raise trees in farmers' land in Dangkhar village to increase their long term income generation capability.

1.4.6 Community Forests

Dangkhar Community Forest falls within the Trong Geog under Zhemgang Dzongkhag and further, it is inside the Wangdigang Forest Management Unit. It was established in 2010 with its approved Management Plan covering the period from April, 2010 to March, 2020. It has an area of 385.59 acres equivalent to 156.04 hac. Dangkhar CF is divided into three main blocks namely:

Zingerpong Block, Bjaro Norbuling Block and Broksar Thang Block with following management objectives:

- To manage forest for sustainable supply of timber, firewood and other NWFPs.
- To rehabilitate forest condition through better protection and development works.
- To ensure equal distribution of resources amongst user group members.
- To protect water catchments to ensure regular supply of water for drinking and irrigation purpose.
- To enhance income generation opportunities for CFMG members.

1.4.7 Traditional Use of the Forests

All timber required for house construction, roofing materials such as shingles and house repair for households in the FMU was extracted from the FMU. Still, the local needs for timber and firewood are met from the FMU. The Unit-Incharge of the FMU marks the trees for local people.

1.4.8 Grazing

The extra income generated from raising livestock forms a major part of the income of the farmers since the steep slope and poor soil limit the yield of the agricultural crops in the field. The local people as well as some people from outside the FMU own registered land for grazing (Tsamdros).

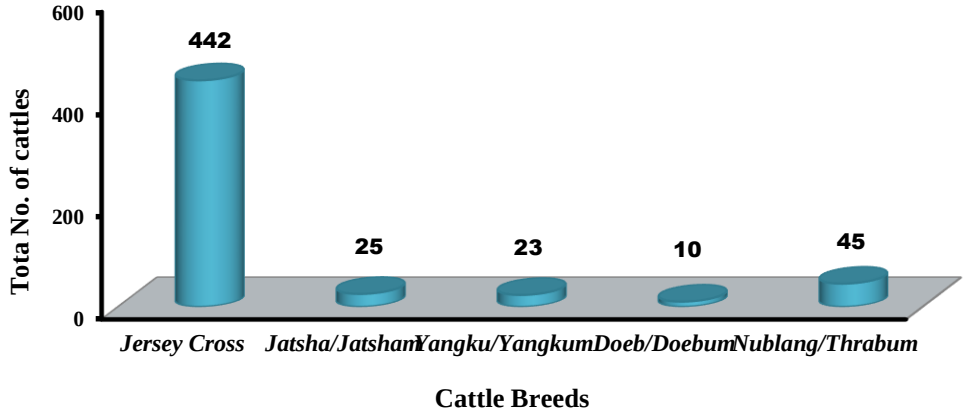


Figure 8:Total nos. and types of cattle in Trong Geog (Source: Geog at a glance, 2014, Zhemgang Dzongkhag).

The cattle belonging to the local communities form a small part of the total cattle grazing in the FMU. The local people allow their cattle to graze in their fields during the off-season and then adjacent forest during the agricultural seasons. Since, the people of Baling village of Trongsa Dzongkhag, outside of the FMU own grazing rights in the western part of the FMU, the communities bring their cattle to graze in the Kangopang pastureland.

Other cattle coming into the FMU for grazing are the Royal Herds of about 150heads that halt over in the FMU for a time while migrating between cooler pastureland in the upper Bumthang and warmer areas of Zhemgang and Gelephu.

1.4.9 Forest Fire

Wangdigang FMU falls in the broad leaf forest with wet climate through most of the year. Therefore, the FMU is not at a great risk of fire. The western portion of the FMU, i.e. the Riotola region is chir pine forest. This region might be more vulnerable to fire outbreaks. But, so far there has been no fire incident in the FMU.

1.4.10 Forest Pest and Disease

There was no major pest or disease outbreak in the FMU. The regular patrolling and monitoring is going to help keep damage from such an outbreak to a minimum if in case there is any. The RNR-RC, Jakar should be informed in case there are any sign of pest or disease.

1.4.11 Non-Wood Forest Products

The portion of Wangdigang FMU that is accessible to the community is for the most part broad leaf forest. As such, there are a lot of non-wood forest products people can utilize from the forest apart from timber and fuel wood. Local people with knowledge on use of plants and their parts extract food, edible fruits, paper and medicine from the forest. The quantity and types of NWFPs harvested during the past Management Plan period is given in the table below:

Particulars	Unit	Year									
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Stone/boulder	T/L	900	300	10	50	20	20	50	30	50	50
Bamboo	No	3000	3000	3000	5000	5000	5000	5000	5000	5000	5000
Top Soil	T/L	10	10	10	5	5	5	5	-	-	-
Kawla Bark	Kg	15000	15000	15000	-	-	-	-	-	-	-
Cane Shoot	H/L	30	50	50	100	100	100	100	100	100	100
Piper leaves	T/L	15	15	15	-	-	-	-	-	-	-
Mushroom	Kg	-	-	20	-	-	-	-	-	-	-
Nakay	Bdls	-	-	30	20	-	-	-	-	-	-
Wood chips	T/L	0	120	-	-	-	-	30	-	-	-

Table 1:Non-wood Forest Products harvested from WFMU

Source: Final Evaluation Report for Wangdigang FMU, December 2014.

The FMU is known for a fruit locally called "Guli" (*Persea fructifera*). This fruit belongs to Avocado family. It is slightly smaller in size and less fleshy compared to avocado. The locals collect the fruit in sacks by going into the forest. With the new forest going deep into the heart of Guli land, people are collecting it in great numbers. Even people from other areas are acquiring the taste of the fruit and the demand is growing bigger. Guli is regular item for sale in Thimphu vegetable markets during its season. There is a concern of Guli stock being depleted since people are likely to over harvest due to the newly gained access and demand for the fruit. Also, the problem is being compounded by the fact that Guli seed are a hunted menu of the cattle grazing in the forest.

The other important non-wood forest products in the FMU are cane and bamboo. Canes and bamboo are used for making handicrafts and other products used in day to day life.

1.5 ECOLOGY AND WILDLIFE

1.5.1 Flora

No detailed classification of the vegetation in Bhutan has been undertaken. However, with minor variations, the classic work of Champion and Seth (1968) on the classification of forest in India which included the Himalayas could be applied to many forest types in Bhutan. Early treatments divided the country into three zones namely:

- A northern belt above 4000masl with only alpine ground shrubs and grasslands and no forest cover.
- A central belt between 2000masl and 4000masl containing the major temperate coniferous and broad leaf forest types, and
- A southern belt between 200masl and 2000masl elevation comprising sub-tropical vegetation.

On this basis, the Wangdigang FMU falls entirely within the Central Belt.

1.5.2 Fauna

Although, there is no wildlife survey carried out in the FMU, the main wildlife species recorded or seen in the FMU include the following:

- Himalayan Black Bear (*Selenarctos thibetanus*)
- Wild Boar (*Sus scrofa*)
- Sambhar Deer (*Cervus unicolor*)
- Barking Deer (*Muntiacus muntjal*)
- Common Langur (*Presbytis entellus*)

Barking deer are found widely in the FMU from 1600masl to 2600masl. They feed on ferns, grasses, wild fruits and bamboo shoots. Sambhars are sighted at a higher elevation, at about 2500masl or above. Wild boars are found between 1700masl to 2500masl. They feed on bamboos, canes, roots and tubers of the plants in the forest as well as on agricultural crops. According to some farmers in the FMU, the wild boar number has significantly increased in the recent years and they have been destroying their crops.

The others wild animal species observed in the Wangdigang FMU are tiger (*Panthera tigris*), leopard (*Panthers pardas*), capped languor (*Presbytis pileata*) and red fox (*Vulpes vulpes*). There are local species of fish in the rivers and streams in the FMU.

The low impact silvicultural prescription in the FMU couples with wide areas in the north of the FMU which fall under inaccessible and protected areas mean that the negative impact to flora and fauna are going to be minimal. Wildlife habitats in the northern and higher altitude areas are going to remain intact since most of the forestry activities in the FMU and human encroachment are going to be confined to Dungbey and Gurpang Blocks, which lies at lower attitude region of the FMU.

1.6 SILVICULTURAL ASSESSMENT

1.6.1 Past Silvicultural Treatment

The earliest commercial activities in record was carried out in 1984 when a coupe of 30 ha. was operated in upper Dungbey valley on selection basis. The timbers so harvested were supplied to Gedu Wood Manufacturing Corporation (GWMC). In total, 550 trees of hardwood species were extracted. The logs were supplied to GWMC for plywood manufacturing and the rest that did not qualify for plywood were used locally or exported to India.

Another coupe of 15 ha. was operated in the same area in 1987-88 and 3500 cft. of mainly Champ (*Michelia champaca*) timber was extracted for construction of National Convention Hall (now housing the National Assembly).

Although scientific methods were employed for extraction of timber resources from the area, due to lack of management plan prior to 1993 the harvesting and past forest management was carried out on *ad hoc* basis. The demand for shingleps, chams, Dangchungs, flag poles and fuel wood from villages in the locality was met from the forest in the vicinity of the communities which forms compartment I in the management plan map.

A 10 year Management Plan for Wangdigang FMU came into effect in 1993 and was to expire in June 2002. But due to road construction activities in the FMU in the first couple of years led to implementation delays and accordingly the extension of the plan period accorded approval till June, 2004.

The Management Plan has prescribed Annual Allowable Cut (AAC) of 650$m^3$for local use onlywhere single tree selection method was followed.

The first management plan (1993 – 2004) clearly prescribed the clear felling system and during the second management plan period (2005 – 2015) the silviculture system adopted for harvesting of commercial timber was Group Selection System.

In both the silviculture harvesting regimes, artificial regeneration through plantation is only the method prescribed to regenerate the harvested coupes. All of the harvesting operations in the FMU during the first management plan period were done in Dungbey Block, Compartment II and Gurpang Block, Compartment I and III. Whereas, during the second plan period, harvesting of commercial timber was concentrated in NRDCL constructed 14.787Km forest road from the national Highway during the plan period. The road runs through the Dungbey and Gurpang blocks.

1.6.2 Plantation

Since the silvicultural system prescribes a clear felling system with artificial regeneration of the logged area, there were several re-plantations in the FMU. According to the policy of the Department of Forests and Park Services (DoFPS), the regeneration of the logged area was to be done with species which are locally available. An area of 11 ha. was planted in 1974 with the following species: *Symintonia populnea, Cryptomeria japonica, Cupressus cashmeriana* and *Pinus roxburghii*. The survival and growth of the plantation was found to be satisfactory during the monitoring and evaluation.

During the implementation of the management plan an area of 30 ha. in Dungbey Block, Compartment I was planted in 1995-96, 30 ha. was planted in Gurpang Block, Compartment I in 2000-2001 and 15 ha. Gurpang Block, Compartment I in 2001-2002.

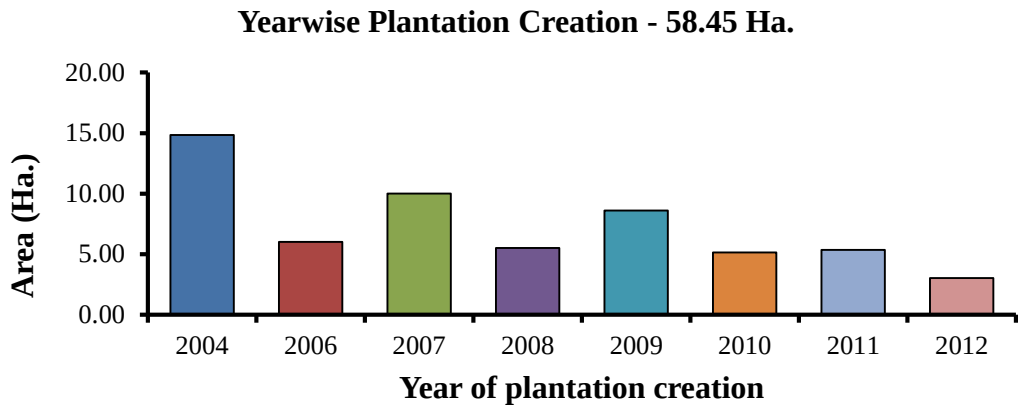


Figure 9:Record of Wangdigang FMU plantation creation

(Source: Regional Office, NRDCL, Zhemgang)

During the past management plan strip clear felling system and group selection system were adopted for commercial logging. As per the recommendations of the FRMD, the logged area were enclosed with fence in order to facilitate successful natural regenerations. The operated coupes were fenced which ran parallel to the cable lines sometimes up to a kilometer along the hill side. However, the fencing caused troubles to cattle grazing as cattle movement was restricted from one side of the fence to the another. The cattle herders used to cut the fence often due to which the very purpose of fencing the area failed. After several meetings with the local herders and the FMU management, they have resolved to fence area in patches with length not more than 300 meters. This arrangement allowed for corridors of about 10 meters between the two fencing for cattle movement.

1.6.3 Nursery

NRDCL has established a half –acre nursery within the production area to produce seedlings for plantation in the already operated cable lines. The nursery produces seedlings such as *Toona ciliata, Schima wallichi, Persea fructifera, Juglans regia,*

Michelia champaca, Bucklandia populnea, etc. All are timber species which are native to the area.

1.6.4 Forest Types

Wangdigang FMU has a huge mixture of forest types since there is a great difference in altitude within the FMU. Only the lower portion of the FMU is populated, with large portions in the north relatively intake and undisturbed. The forestland in the FMU can be categorized into following forest types:

Chirpine Forest: - There is a patch of Chirpine forest in and around Riotala village in the western part of the FMU. The size of the patch comes to around 111.22 Ha. Although, this patch has gentle slopes, it is considered inaccessible since it lays cut off from the road by steep slopes. Due to extensive resin tapping activity within the Chirpine zone, the stands are completely deteriorated in quality.

Mixed Conifer Forest: - In the higher altitudes to the northern parts of the FMU, there are patches of mixed conifer forests which include species like Hemlock, Spruce and Fir. The Fir forest covers 270.70 Ha. Above the mixed conifer forest, there is a small patch at the top of FMU which are mainly highland shrubs which covers an area of 83.68 Ha.

Warm Broadleaf Forest: - This is basically a type of subtropical forest, occurring at higher altitudes in between 1000m – 2000m with a lower rainfall from 230cm – 400cm and contains a mixture of evergreen and deciduous broadleaf trees species. Many of the tropical genera are not represented whereas temperate genera are well represented. The predominant species are: *Castonopsis indica, Macaranga pustulata, Schima wallichi*.

Cool Broadleaf Forest: - Above the warm broadleaf forest on exposed slopes with higher rainfall is the cool broadleaf forest type. It occurs at altitudes between 2000m and 2900m and rainfall between 250cm and 500cm. It is a mixed forest with deciduous and evergreen species like *Symengtonia, Acer, Betula* and those

belonging to Lauraceae family are found mixed with dense shrubs, climbers and epiphytes. Oaks are less common in this type of forest.

Evergreen Oak Forest: -This forest occurs in the drier slopes above the warm broadleaf forests. They are dominated by evergreen species like *Castonopsis* and *Quercus* species.

Sl. No.	Forest and Landuse Type	Area (Ha.)
1	Broadleaved	7128.91
2	Chirpine	111.61
3	Fir	270.70
4	Shrubs	208.70
5	Meadows	123.45
6	Rocky Outcrops	64.08
7	Agriculture	770.01
8	Town Area	81.50

Table 2:Forest Type by area in Wangdigang FMU

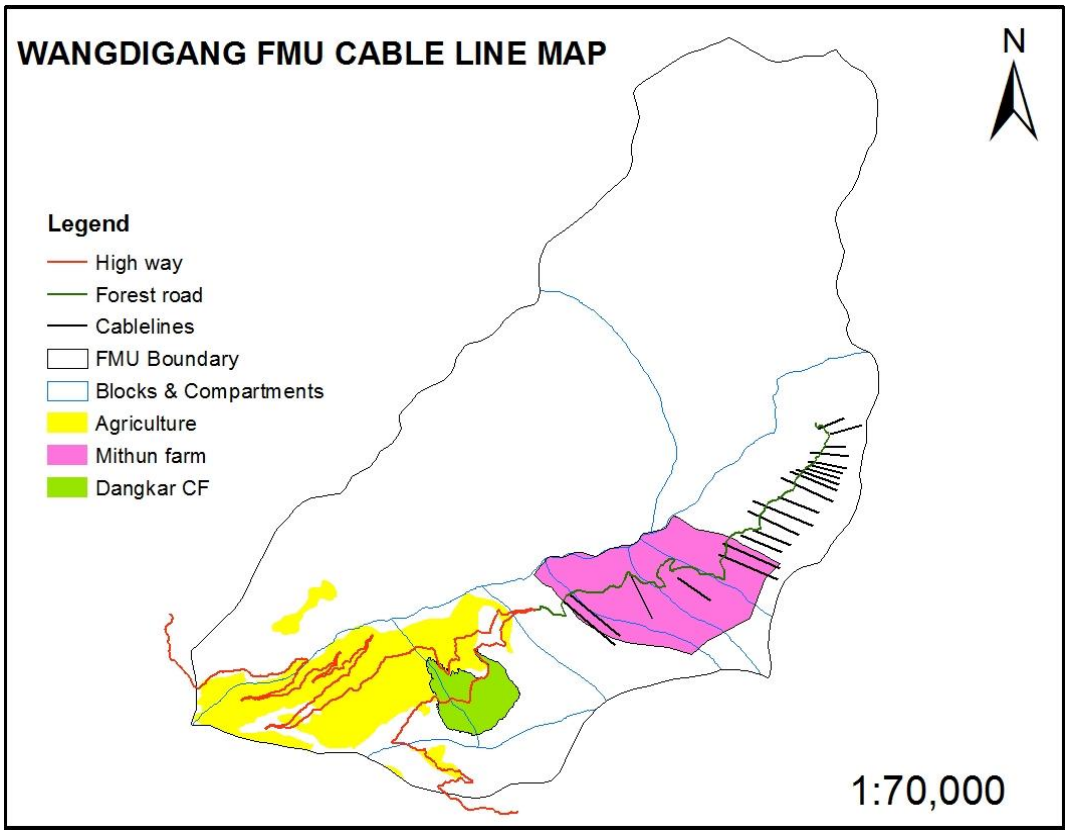
1.7 TIMBER SUPPLY AND DEMAND

1.7.1 Commercial Supply

Proper analysis of timber demand and supply in Bhutan is for the most part inaccurate. This is due to the incomplete recording of the timber operations and allotment. Most of the commercial timbers harvested from the FMU are allotted to the consumers from in and around the Dzongkhags. The volume of the timbers harvested during the previous plan period is given in the table below:

Sl. No.	Year	Volume (Cft.)
1	2005	60,575.15
2	2006	1,05,658.25
3	2007	78,038.45
4	2008	60,862.13
5	2009	62,436.37
6	2010	25,842.69
7	2011	23,852.69
8	2012	Nil
9	2013	Nil
10	2014	Nil

Table :Record of Timber Extraction from Wangdigang FMU.



(Source: RM, NRDCL, Zhemgang Region, 2014)

Figure 10:Cable line Map of Wangdigang FMU

Demand for timber is Zhemgang town forms the major source of demand from within the FMU. Access timbers were sold to outside dzongkhag consumers on lucky dip allotment held on monthly basis. Outside of the FMU, demand comes from various woodcraft and furniture houses from the towns in other Dzongkhag.

1.7.2 Rural Supply

The demand for rural timbers comes from the individual household who are residing within the dzongkhag and FMU nearby communities. The rural timbers are mostly obtained for new rural house construction, renovation, maintenance,

construction of livestock sheds, etc. Mostly rural timber allotments are made on standing tree basis.

Year	Quantity supplied (m3)										Total Quantity Supplied (m3)
	Drashing		Cham		Tsim		Dangchung/ Poles*		Firewood		
	Nos	m3	Nos	m3	Nos	m3	Nos	m3	Nos	m3	
July 1999 to June 2000	68	118.96	150	44.97	550	54.97	700	27.94	0	0	246.85
July 2000 to June 2001	20	34.99	150	44.97	200	19.99	800	31.94	0	0	131.89
July 2001 to June 2002	20	34.99	150	44.97	200	19.99	800	31.94	0	0	131.89
July 2002 to June 2003	78	136.46	9	2.7	22	2.2	256	10.22	0	0	151.57
July 2003 to December 2004	76	132.96	253	75.86	207	20.69	616	24.59	0	0	254.09
January 2005 to December 2005	40	69.98	8	2.4	30	3	1159	46.27	0	0	121.64
Total for 1st plan period (1992-2004)	**302**	**528.34**	**720**	**215.9**	**1209**	**120.84**	**4331**	**172.9**	**0**	**0**	**1037.93**
January 2006 to December 2006	30	52.48	130	38.98	150	14.99	875	34.93	0	0	141.38
January 2007 to December 2007	11	19.24	0	0	0	0	550	21.96	0	0	41.2
January 2008 to December 2008	21	36.74	10	3	0	0	568	22.67	0	0	62.41
January 2009 to December 2009	18	31.49	0	0	0	0	0	0	0	0	31.49
January 2010 to December 2010	20	34.99	0	0	0	0	0	0	0	0	34.99
January 2011 to December 2011	21	36.74	0	0	0	0	0	0	0	0	36.74
January 2012 to December 2012	0	0	0	0	0	0	0	0	0	0	0
January 2013 to December 2013	0	0	0	0	0	0	0	0	0	0	0
January 2014 to December 2014	7	12.25	30	8.99	0	0	0	0	0	0	21.24
January 2015 to December 2015	0	0	0	0	0	0	0	0	0	0	0
Total for 2nd plan period (2005 to 2015)	**128**	**223.93**	**170**	**50.97**	**150**	**14.99**	**1993**	**79.56**	**0**	**0**	**369.45**

Table 3: Rural Timber Supplied during last two Plan Periods Source: Zhemgang Forest Division.

1.8 ORGANIZATION AND ADMINISTRATION

1.8.1 Organization

Wangdigang FMU falls under the overall jurisdiction of the Zhemgang Divisional Forest Office but before it was under the administration of Bumthang Forest Division before the creation of Zhemgang Forest Division. The management of Regional Office of Natural Resources Development Corporation Limited (NRDCL) under Zhemgang Dzongkhag carries out the harvesting and reforestation the areas within the FMU.

1.8.2 Staff

A Territorial Divisional Forest Office was opened in Zhemgang in 2003 to govern and deliver the services in regards to forests and its associated components under Trongsa and Zhemgang Dzongkhags. The Unit Incharge is the focal person in the FMU under the purview of administration of Divisional Forest Office. Likewise, the Unit Manager of the FMU under the direct administration of Regional Manager, NRDCL, Zhemgang Division carries out activities within the Wangdigang FMU in close co-ordination with Unit Incharge of the FMU.

1.9 INFRASTRUCTURES, TRANSPORT AND EQUIPMENTS

1.9.1 Roads

Trongsa – Gelephu National Highway passes through the middle of the FMU. The highway road enters the FMU from the southern part and winds up to Zhemgang town. It exits the FMU after passing through Dechengang sub-catchment.

The National Highway serves little purpose when it comes to forest activities in the FMU as it goes through mostly cultivated areas only. For the purpose of harvesting operations in the FMU, NRDCL has built 13km of forest logging road as of date.

1.9.2 Buildings

At the initial stage after the creation of Territorial Divisional Forest Office in Zhemgang, the offices were housed in the private building. But after the completion of construction of Divisional Office and CFO's quarter, the complete administrations have been shifted to new building. The Range Office of Zhemgang Range is under construction.

NRDCL has Regional Office and Wangdigang FMU office within the FMU. Except for NRDCL office which are rented, the newly constructed FMU office is within the FMU and staff quarters are rented from the local landlords in the town.

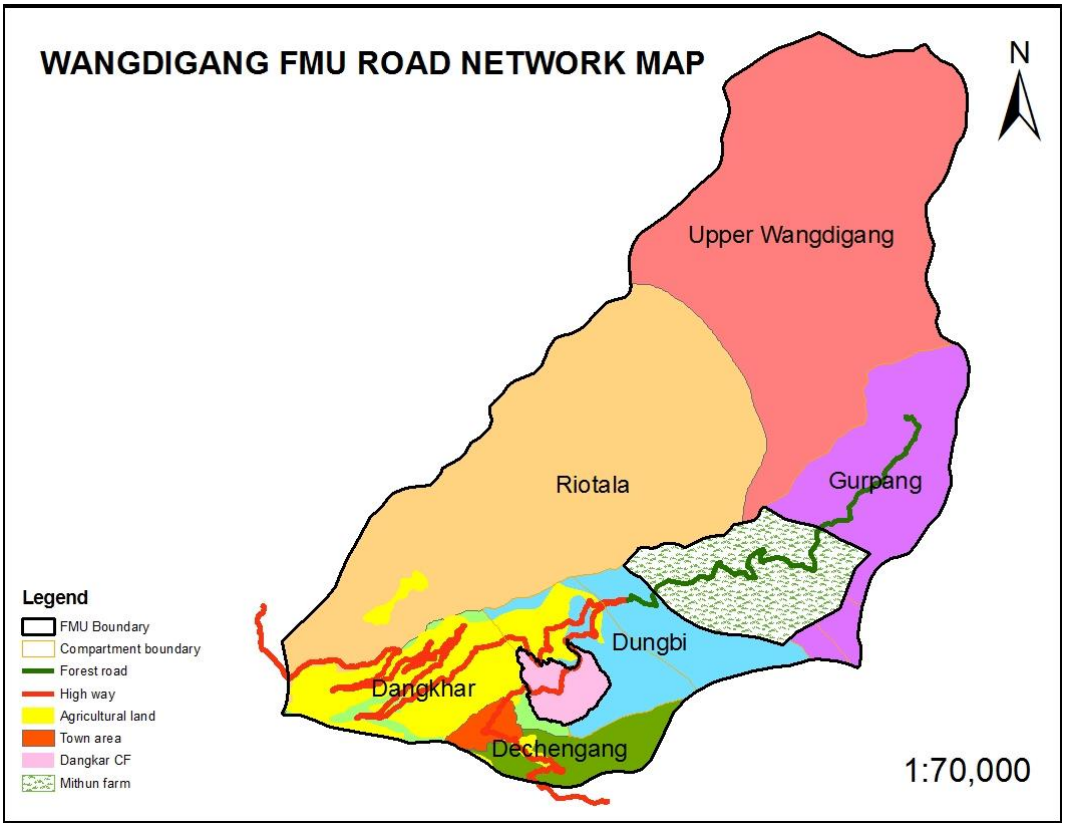


Figure 11:Road Network Map of Wangdigang FMU

1.9.3 Transport

The Zhemgang Divisional Forest Office has one Nos. of 4WD Toyota Hilux that caters for carrying out field activities under its jurisdiction. For any vehicle, it takes almost an hour to reach the inner most part of the Wangdigang FMU.

The Regional Office, NRDCL, Zhemgang Region has only one 4WD Hilux. Through floating of public tenders, NRDCL awards contract for felling, cross-cutting, cable craning and transportation of logs and other associates from the logging sites. This has benefitted the local businesses by engaging them in the harvesting, extraction and transportation of logs.

1.9.4 Equipments

The FMU office has been equipped with computers, printers, fax and telephone. The Territorial Division Office and Regional Office, NRDCL, Zhemgang have been connected with internet facilities from Bhutan Telecom.

For implementation of its day to day activities like logging, extraction and transportation of timbers, NRDCL possesses numerous cable cranes. With almost 17 numbers of operational FMUs scattered over whole of the country, existing cable cranes are not stationed in one location instead they are moved from one location to another under tight schedule. In Wangdigang FMU, operations are done when cable cranes are brought in from other FMUs. Also, there are other private entrepreneurs who own cable cranes and they undertake logging operations as and when NRDCL owned cable cranes are not available at the logging site.

1.10 REVIEW OF THE PREVIOUS MANAGEMENT PLAN ANDIMPLEMENTATION

To be effective, a forest management plan should comprise basic information having direct relevance to the management of a forest, a long-term management goal, and specific prescriptions to achieve each of the objectives. The management

plan structure should be flexible depending upon the characteristics of the forest for which long-term management is being planned. The main objective of the Forest Management Units is that, those areas under FMUs are supposed to be managed sustainably for perpetuity. The review of every management plan (10 years plan period) is very important in order to cross-check the field achievements and the goals set in the management plans. This review gives the opportunity to assess the overall achievement of the activities implemented in the field against the objectives laid out in the previous management plan. The successful approaches can be replicated in the future management plan and for those approaches which proved unsuccessful; we can always provide alternate or remedial measures.

1.10.1 Goals and Objectives of the Management Plan

The goals of the previous management plan was to 'protect the environment and at the same time provide sustained supply of all forest products primarily to meet the needs of the local population and secondly to generate revenue.'

The four main objectives of the previous management plan are laid down as below:

- To maintain and improve the present vegetative cover to protect the environment, soils and water yields.

  Achievement: The forest covers outside the operated areas are still intact. In few cases, there are instances of landslides occurring along the 14.787 km of forest road. Plantations were carried out in the already operated cable lines but the establishment of plantation is very weak and needs additional efforts.
- To provide sustained supply of all the forest produces/products primarily for local needs and secondly for external demand.

  Achievement: All the requirements are met and there are no complaints arising with regards to allocation of forest produces/products to the local communities. The excess timbers were even supplied to meet the external demands.

- To contribute to local and national economy utilizing the forests for sustenance, direct or indirect income generation and creating employment.

  Achievement: From identification, planning and till implementation level, the local communities were involved. The construction of forest roads were done through tendering the works to local contractors. During the felling, cross-cutting and extraction of timbers, the local people are the main labourers. Local transporters were actively involved in transportation of timbers from cable line to the depot.

- To involve the local people more in managing the forest.

  Achievement: Regularly, local people were made aware of the importance of forest through workshops, stakeholder meetings, etc. They were involved during the forest function mapping of the FMU and during the preparation of the Management and Operational Plan of the FMU.

PART TWO: THE FUTURE MANAGEMENT

2.1 INTRODUCTION

One of the core forest policies of the Royal Government of Bhutan (RGoB) is the maintenance of at least 60% of the country's land area under forest cover for perpetuity. This is clearly enshrined in the constitution of Kingdom of Bhutan. This policy stems from the recognition of the country's fragile ecosystem, owing to it being very mountainous and prone to landslides and erosions. The productive forests in the country are to be managed under a sustainable basis to meet the timber and fuel wood needs of the people.

2.1.1 Forest Policy

The Forest and Nature Conservation Act of Bhutan, 1995 requires scientific management plans should be prepared for all forest areas. No commercial harvesting of timbers would be allowed without prior approved management plan. This plan is prepared in accordance with Forest and Nature Conservation Act, 1995 and Forest and Nature Conservation Rules, 2003. The plan reflects the government's policy and commitment to the sustainable management of natural resources in the country.

There are four guiding statements of the national forest policy. The purpose of these guiding statements is to give direction to the forest resources use in the country through sustainable principles, contributing to social justice and equity. The policy is focused mainly at ensuring conservation of the environment and only thereafter aims at deriving economic benefits.

The four forest sector policy goals in the order of priority as set by the RGoB are:

Goal 1: Protection of land, its forest, soil, 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 forest and areas through proper management systems and practices.

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

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

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

Forest and Nature Conservation Act, 1995 provides the legislative framework for the community participation in the forest management and streamlines the preparation of supporting forest rules and regulations.

The participation of the local communities within the Wangdigang FMU is encouraged. The formation of Divisional Level Forest Management Committee and FMU Level Forest management Committee for Zhemgang Territorial Division will provide a platform for the local communities' representation in the management of the FMU. The management planning process also involved the *Gups, Mangmis* and *Tshogpas* who represented the local communities. Key informants were also extensively and actively involved during the planning stage.

2.1.2 FMU GOAL

The main goal of the Wangdigang Forest Management Plan is to:

"*Manage the Wangdigang FMU on a multiple use, sustainable basis for the production of timber, fuel wood and other forest products and for conservation of watershed, wildlife and environment*."

2.1.3 FMU OBJECTIVES

Wangdigang Forest Management Unit is divided into four different management circles, namely Production, Protection, Non Production and Non Wood Products (NWFPs) (Overlapping) management circles. The objectives in each one of these management circles differ from one another, although one or two of the objectives may overlap.

Production Management Circle

- To provide the local population on a priority basis, with continuous timber and fuel wood supply.
- To enhance and improve forest conditions and productivity.
- To involve the local people in the management of the FMU.
- To regulate grazing with the consensual support of the local people for regeneration of forests.

Protection Management Circle

- To protect important watersheds and other water catchment areas.
- To meet the local needs for NWFPs sustainably.
- To protect the forest from grazing, fire and illegal activities.
- To raise awareness of biodiversity areas and conserve biodiversity.
- To respect the sanctity of religious places and protect historical sites.
- To minimize soil erosion.

Non Production Management Circle

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

Non Wood Products (NWFPs) (Overlapping) Management Circle

- To carry out inventory of NWFPs species and approximate yield of specific species within the FMU.
- To study and improve the proper management of NWFPs.
- To enhance the productivity of major NWFPs in the FMU through NWFPs yielding species propagation technologies.
- To involve local population in proper harvesting and management of NWFPs.

2.1.4 Management based on Forest Function

2.1.4.1 Introduction

Various socio-economic functions are ascribed to forests, based on the differentiated needs of the human population. Apart from the defined forest functions, human welfare benefits from the diverse environmental effects of forests. The capacity of an ecosystem to sustain a specific function depends on the characteristics of its individual dynamics.

Sustainable forest management concepts must take into account the compatibility between forest function and ecosystem characteristics. Incompatibility causes either dysfunction and ecosystem degradation or the need of corrective management interventions which may exceed tolerable economic limits. A detailed understanding of the de-stabilizing and stabilizing processes intrinsic to the ecosystem is necessary, for their regulatory interactions, and their responses to exogenous disturbances and perturbations, which emerge from forest management and environmental conditions.

Forest Management Code of Bhutan describes that forest function defines for all the forest areas within the FMU ecological, environmental and social functions and as such serves to balance the often diverging interests of commercial logging, local forest use and nature conservation. Most of the forests can have many potential uses

or functions – biodiversity conservation, soil conservation, watershed conservation and other resources conservation. The values and ranking of such functions are dependent on location, site, forest type, accessibility, slope, flora and fauna, human settlement and many other factors.

For effective assignment of forest functions, the forest is mapped. Forest function mapping is an essential tool for forest management planning. The forest function map provides the information on the total commercially operable area, identifies which areas have to be reserved for local use and provides the management planner and the implementer with information on management restrictions for particular areas.

2.1.4.2 Forest Functions

Forest Management Code of Bhutan, 2003 lists five main groups of functions. Each one includes a number of sub-functions. For the sub-functions term "protection" is used if commercial use is prohibited and term "conservation" if the function only imposes some management restrictions on commercial use. Some of the functions used in this management plan are listed in Table No .5.

Code	Function Group (Bold) and Functions
S	**Soil 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 Sites Protection
RB	**Road Buffer**

Table 4:List of different forest function groups and sub-functions

2.1.4.3 Mapping Forest Function

Forest function mapping is one of the most important tasks set for management planning. The process is also vital for commercial planning because it is the basis for determining the net operable area from which timber may be harvested. The operable area is the foundation of the commercial operation, designing the forest inventory, assessing total commercial volume available, calculating the estimated allowable yield and allocating compartments. The criteria used in forest function mapping in this plan are given in Table No.6.

Function group & codes	Criteria for Mapping
Soil Conservation (Map)	**SP**: Soil Protection for areas with slope greater than 100%. Very steep areas. **SC**: Soil Conservation for areas that are steep (76% - 100%), exposed sites like ridges and sites with moderate soil erosion.
Water & Watershed Conservation (Map)	**WSh**: Watershed Conservation – areas with slope steeper than 25%. Also upper catchment areas and poorly drained or waterlogged sites, moist areas and swamps, and all other sites serving as water retention or water feeding bodies. The whole of Wangdigang FMU is Watershed Conservation area. **WRR**: Riparian Reserve Protection includes the stream bed and extends to the top of the entrenchment slope. Along perennial rivers and streams the width of the Riparian Reserve is 30 meters. **WLS**: 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. In Wangdigang FMU, Dechengang is delineated as the importmantl water catchment area for Zhemgang town.
Nature Conservation (Map)	**NWP**: Wildlife Protection – alpine areas, ecosystem of high conservation values.

Function group & codes	Criteria for Mapping
Social Function (Map)	**SocL**: Local Use Only – Forest areas which were traditionally used intensively by the local community. **SocRS**: Regligious Site Protection – Religious sites are Lhakhang, Goenpas, Gneys, sacred lakes and all other places used by people to practice religion.
Road Buffer (Map)	**RB**: Road Buffer – Road Buffer is the zone 200m uphill and 100m downhill of a motorable public road. Forest activities within these zones are strictly prohibited.

Table 5:Criteria for Mapping Forest Functions

2.1.4.4 Restrictions of Forest Function

The specific restrictions to be applied to forest in the various function categories are summarized in Table No. 7.

Code	Function	Restriction on Commercial Use	Restriction on Local Use
SP	Soil Protection	No commercial use	No tree felling, minimize human interference
SC	Soil Conservation	No clear cutting, no conversion into plantation, extension of rejuvenation period	Low impact local use
WLS	Local Water Supply Protection	No commercial use	No tree felling, minimize human interference
WSh	Watershed Conservation	No clear cutting, no conversion into plantation, minimize disturbance to under storey vegetation	Low impact local use, single tree selection
WRR	Riparian Reserve Protection	No commercial use	Only collection of NTFPs, no boulder collection, no Tsamdro, no Sokshing
NWP	Wildlife Protection (Alpine Area)	No commercial use	Restriction to activities that do not change habitat quality and disturb wildlife, minimize grazing activities where possible
RB	Road Buffer	No commercial use	No tree felling

Table 6:. Impact of Forest Function Classification on Commercial Forest Management and Local Use.

QUANTITATIVE RESOURCE ASSESSMENT

2.2 Forest Management Inventory

The Forest Resources Management Division had carried out two forest management inventories in the past. The third inventory for Wangdigang Forest Management Unit was carried out in early 2015-2016. The general objective of the inventory was to provide essential background information for revising the Haa East Forest Management Plan. More specifically the objectives of the inventory were:

- To study the changes in growing stock
- To provide relatively accurate overview of the growing stock and regeneration potential of natural forest in the area, according to major forest types
- To give an overview of the general site characteristic of the natural forest, in terms of soil, non-green vegetation and the use by local population
- To provide an indication of timber quality in different forest type
- To furnish essential data on tree height to enable construction of local volume table for main species

The standard FMU inventory technique was used, with data being collected for the trees >10 cm DBHOB. A total of 244 plots were laid throughout the HEFMU area at the spacing 200 m x 250 m. The inventory was designed with target sampling error of +/- 10% and the coefficient of variation of 80%. Every fourth plot in the line were measured as special plots.

2.3 Forest Management Inventory Results

A total of 244 plots were measured were used in the calculation of the AAC and the 'zero' plots were data are missing are also included in the analysis.

Stratum name	Gross area (ha)	Net area (ha)	Number of plots	Stems per Ha	ME* % of stems per Ha	Gross Volume per Ha	ME* % of Volume per Ha	Basal area per ha	ME* % of basal area
Broadleaf	1326.06	1248.02	244	153.85	8.72	237.7	10.61	21.48	9.5

The summary of the inventory results.* ME = sampling error (95% level of probability)

** Note that the area sampled is less than the area of the FMU. The inventory results are only calculated for the operable/accessible areas of the FMU.

It should be noted that the above figures are for the stratum as a whole, and include all species recorded in the inventory plot.

2.4 AREA ORGANIZATION

2.4.1 Spatial Organization

For ease in visualizing and analyzing the problem, for clearness and definiteness in describing the forest growing stock, and for convenience in allocating operations and in keeping records of action taken, Forest Management Units are sub-divided into blocks, compartments and sub-compartments. The block is a large division of a management unit usually with topographic boundaries consisting of a group of compartments or an undivided area distinguished from other areas by a marked difference in silvicultural treatments or otherwise. The block is a division of convenience. It is not necessarily permanent and there need be no hard and fast rules to govern its use. For the sake of simplicity, its use should be restricted to situations where a real need is to be served.

The compartment is a permanent division of a block and its boundaries should be located with care and a full realization of the very practical purpose which it is to serve. Compartment boundaries should be plainly and permanently marked on the ground and clearly shown on all maps. Wherever available, natural topographic

features such as ridges, streams, cliffs, lakes, etc, should be used to mark compartment boundaries.

In Wangdigang FMU, one of the main boundary forming natural features is Wangdigang Chu (River). The river has been running its course for thousands of years cutting the mountain and defining landscape. The right bank of the river is very steep, uninhabited and inaccessible.

Wangdigang FMU is divided into six blocks namely Dechengang, Dangkhar, Dungbey, Gurpang, Riotala and upper Wangdigang. Dungbey Block is further divide into two compartments and Gurpang Block is divided into three compartments.

Sl#	Block	Compartment	Area (Hac.)	Major Use
1	Dangkhar	-	689.82	Permanent & Shifting Cultivation
2	Dungbey	Compartment I	444.25	Local Multipurpose Forestry/Cultivation
		Compartment II	340.33	Protection
3	Gurpang	Compartment I	41.46	Multipurpose Forestry
		Compartment II	58.40	Protection
		Compartment III	835.74	Multipurpose Forestry
4	Riotala	-	2997.08	Cultivation/Protection
5	Upper Wangdigang	-	3036.70	Protection
6	Dechengang	-	315.72	important Watershed Protection

Table 7:Areas by Blocks, Compartments and Sub-compartments in the FMU.

Dechengang Block: It forms the main water catchment area for Zhemgang town. It also forms a small watershed of its own. Following its function as the crucial water catchment for the town, it is designated into a block.

Dangkhar Block: It is mainly made up of cultivated fields and human settlements. Most of the villages within the FMU are located in this block.

Dungbey Block: Because of its identical functions within the block, it's divided into two compartments. Compartment I is mainly for local use forestry and watershed protection. Compartment II is steeper and forest road joining the national highway is zigzagging in this compartment. So, this compartment is for protection and cattle grazing.

Gurupang Block: It's divided into three compartments. Compartment I and III has a similar objective which is meant for multipurpose forestry use and Compartment II is set aside strictly for protection since these areas are very steep.

Upper Wangdigang Block: This block is inaccessible. The lower boundary is very steep and the northern parts comprise of high elevations. It is mainly for protection of the Wangdigang Watershed.

Riotala Block: The block has couple of houses in it but the area bordering with the national highway is rocky and very steep. In the upper part, there is a stand of chirpine. However, that stand has been subjected to resin tapping and the stand quality has deteriorated. The area remains inaccessible and it is designated for protection. Very little management activity is undertaken in this block.

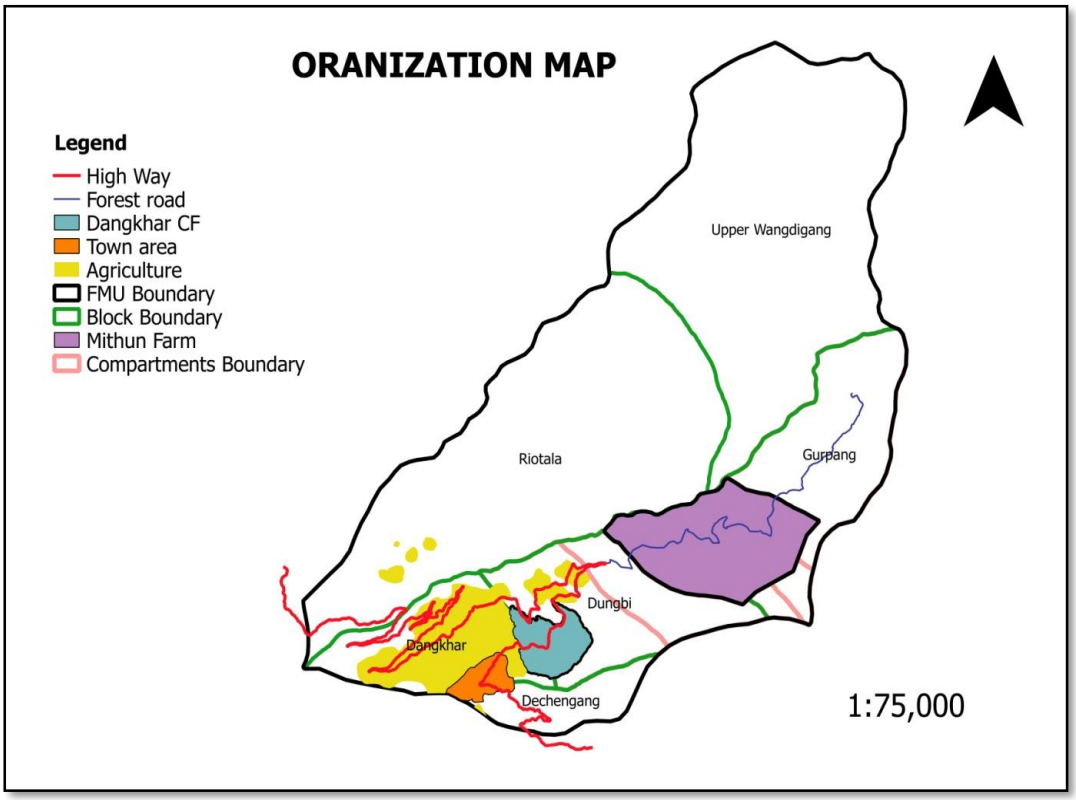


Figure 12: Ogranization Map of Wangdigang FMU

2.4.2 Determining Operable Area

Operable areas are areas left for commercial and local use forestry after other critical functions are mapped and deducted from the map using GIS information, inventory data and local peoples' information. Large areas in the Wangdigang FMU have been designated as in accessible since most areas fall on the steep side of the riverbank. National Highway traverses the FMU in the southern portion only leaving mostly the Riotala and Upper Wangdigang Blocks inaccessible.

The functions that take precedence over rural and commercial forestry activities are:

- Riparian Buffers and Zones
- High Altitude Zones (above 4000 masl)

- Soil protection Areas (slope greater than 100%)
- Biodiversity Sites (wildlife conservation and protection)
- Special Ecological Niche Protection
- Religious Sites
- Agricultural land and human settlements
- Road Buffers

2.4.3 Organization into Management Circles

As part of the forest function mapping exercise, the area has been mapped into three main management circles and one overlapping Non-Wood Forest Product Management Circle. The objectives in each of these management circles are different. The four management circles in the FMU are **Protection, Non-Production, Production** and **Non-Wood Forest Product (Overlapping)** Management Circles. The Protection Management Circle includes areas demarcated for soil protection, stream and road buffers, religious sites and sacred lakes, important watershed protection, wildlife protection and alpine areas. The Production Management Circle includes areas that are suitable for harvesting both local and commercial. In Wnagdigang FMU, since the forest type is entirely broadleaf, there is no sub-division into working circles. Non-Production Management Circle includes all the remaining areas made up of private and cultivated lands, *Sokshings*, and inaccessible areas. Non-Wood Products Management Circle overlaps with all the above three management circles which include areas where Non-Wood Forest Products can be collected.

2.4.4 Management Circles

2.4.4.1 Protection Management Circle

The Protection Management Circle or Protection Forest is an area that is set aside for total protection of the natural environment. It includes areas of soil protection,

stream and road buffer, religious sites and lakes, wildlife and special ecological niche protection, alpine zones and important watershed protection.

In the Protection Management Circle, commercial exploitation is strictly prohibited. However, depending on the function Protection Management Circle might be subjected to local use of trees and firewood, collection of NWFPs, *sokshings* and light animal grazing. Other activities like salvage logging in case of pest and disease in the protection area can be allowed with prior approval of the concerned CFO and Head of the Department. The management objectives and management options concerning Protection Management Circle is given in the table below.

Management Objectives	Management Options	Responsibility
To protect important watersheds and water catchment areas.	Minimal intervention in important watershed areas.	Territorial Division, NRDCL, Dzongkhag and Local Communities.
To meet the local needs for NWFPs sustainably.	Regulate NWFPs harvesting. Resource assessment.	Territorial Division
To protect the forest from grazing, fire and illegal activities.	Involve local people. Raise awareness.	Territorial Division
To raise awareness of biodiversity areas and conserve biodiversity.	Public meetings/field visits. Information dissemination.	Territorial Division
To respect the sanctity of religious sites and sacred lakes.	Non intervention.	All parties.
To minimize soil erosion.	Protection of steep slopes. Awareness among local people.	Territorial Division, NRDCL, Local People.

Figure 13:Protection Management Circle

2.4.4.1.1 Watershed Protection

Dechengang Block forms the water catchment of the drinking water source for the whole of Zhemgang town. In such areas, low impact and limited local use of forest might be permitted. But other larger scale logging operations and its infrastructure are strictly prohibited. Cattle grazing in the area should be restricted for hygienic reasons.

2.4.4.1.2 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. The majority of fish food organisms come from overhanging trees and shrubs while the nutrients from organic materials that fall or wash into the streams are the basic of aquatic ecosystem productivity.

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

So, within the buffer zone, any forestry activity except those for improving the forest stand shall not be allowed. The improvement activities include reforestation of the open areas, beating up, weeding and tending. All these activities should be done manually. The local use in this zone is limited to collection of NWFPs only.

2.4.4.1.3 Soil Protection

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

2.4.4.1.4 Wildlife Protection

This area includes habitats of rare and endangered animals and birds. Local forest use is permitted on alimited scale if the habitat quality and structure is not altered and disturbance to the protected animal is short and minimal.

2.4.4.1.5 Religious Site Protection

To respect the local beliefs is one of the very important steps in involving people in the participatory management. Therefore, we have to pay due reverence to the local religious sites that people are considering sacred. No forestry activity should be allowed at such sacred sites.

2.4.4.1.6 Road Buffers

A road buffer is the zone 200m above and 100m below road where the implementation of forestry activity may have firect negative impect on the road itself or on the security of the traffic. The main objective of the road buffer is to protect the road from rock fall, land and snow slides, surface runoff of precipitation and erosion and to safeguard traffic.

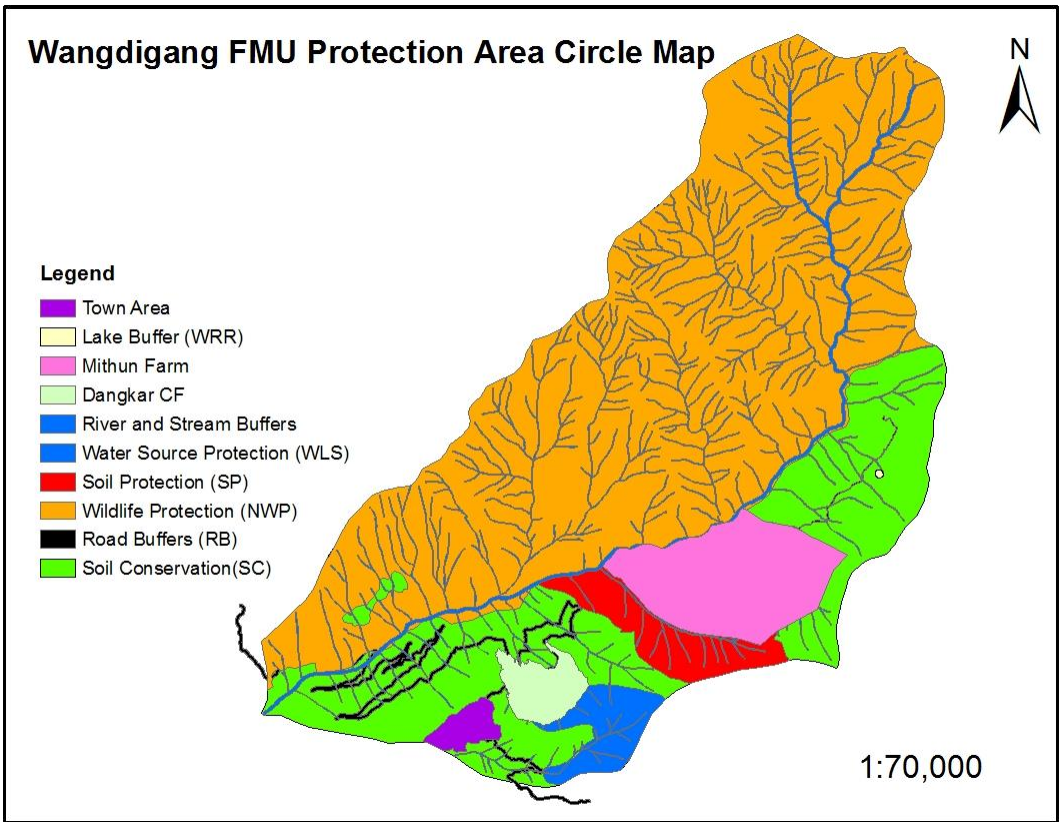


Figure 14:Wangdigang FMU Protection Area Circle Map

Commercial and local use felling of trees within the buffer zone is prohibited. However, trees that are deemed dangerous to the road or traffic should be felled. This refers to dead, decayed or single tree which might fall due to storm or strong wind. Removal of trees in case of epidemic or for silvicultural reasons can be permitted.

Note: The road buffer does not apply for forest road.

2.4.4.2 Non-Production Management Circle

This area is mostly made of inaccessible areas, private lands and sokshings. The use of the forest other than timber harvesting is allowed in this management cirlcle. One of the fundamental objectives is the maintenance of biodiversity and watershed functions.

Management Objectives	Management Options	Responsibility
To maintain and improve the forest condition.	Regenerate degraded areas. Control illegal logging.	Territorial Division/NRDCL
To meet local demand for NWFPs.	Regulate NWFPs harvesting. Resource assessment.	Territorial Division
To manage grazing for livestock.	Fodder species planting. Invlove local people.	Territorial Division
To conserve and enhance biodiversity.	Promote research. Regulate patrolling.	Territorial Division
To conserve the water catchment functions.	Control felling in water catchment areas.	Territorial Division/NRDCL

Table 8: Non-Production Management Circle

In Wangdigang FMU, most of the Non-Production areas are inaccessible. One of the new developments in the FMU has been the establishment of private forests. It was started by Save the Children (USA). Now, Social Forestry and Extension Division through Dzongkhag Forestry Office have taken over the development of private forestry.

2.4.4.3 Non-Wood Forest Products (Overlapping) Management Circle

The Non-Wood Forest Products Management Circle is constituted of various major non-wood forest products species that are collected from the FMU namely Bamboo overlapping management circle, resin tapping overlapping management circles, Guli (*Perseaspp*.) overlapping management circles, Cane overlapping management circles, etc.

There is no effective organization for the management, collection, harvesting, processing and marketing of most of the non-wood forest products. Except for resin tapping in Riotala Block, which is done by a private business enterprise, other non-wood forest products are collected by the villagers free of cost. The problem with

Non-Wood Forest Products is that it is difficult to quantify since different parts are used for different purposes.

2.4.4.4 Production Management Circle

The Production Management Circle is made up of the operable areas where timber harvesting will take place. Since the entire production management circle falls in the broadleaf area, it is not subdivided into smaller blocks. Single Tree Selection System will be applied as blanket system covering the whole production management circle of the FMU.

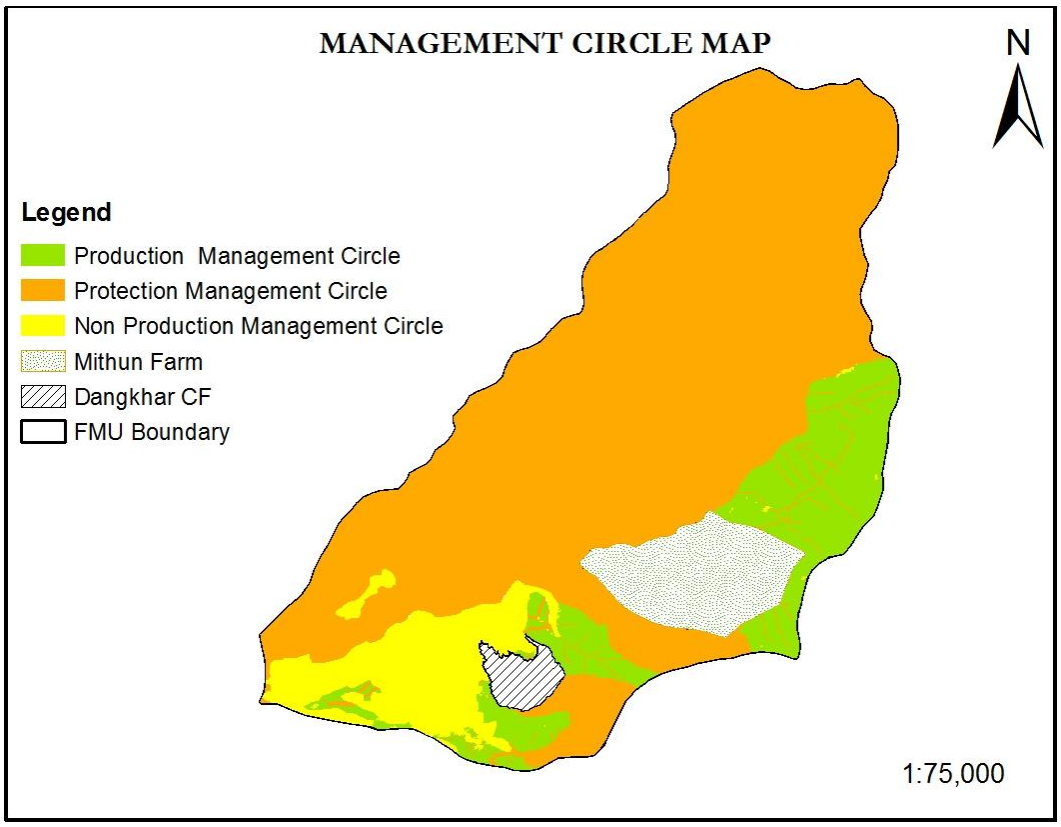


Figure 15: Management Circle Map

Management Objectives	Management Options	Responsibility
To provide local population with continuous supply of timber and fuel wood.	Allow closely monitored marking of trees for rural use. Encourage firewood contractors to clean up entire lines, not just lower parts.	Territorial Division Territorial Division/NRDCL
To involve the local people in the management of the FMU.	Include local representation in Divisional Level Forest Management Committee. Local consultation through community meetings.	Territorial Division Territorial Division/FRMD Planner
To regulate grazing with the consensual support of the local people.	Local people involvement. Develop acceptable grazing arrangement.	Territorial Division/NRDCL Territorial Division/NRDCL

Table 9:Production Management Circle

The Production Area in Wangdigang FMU has been made accessible with the construction of 14.787 km of forest road during the first management plan period.

2.4.4.5 Implementation of the working Circle Management

Forest Function Planning concept has been used in the plan to distribute and allocate the best land uses in the FMU. But the problem remains in the implementation of the management prescriptions on the ground. The Forest Management Plan is broad spanning for 10 years. Implementation on the ground requires breaking down of this broad plan into smaller bite-size morsels of Operational Plan.

Operational planning has been greatly simplified with the Forest Management Code of Bhutan. Detailed information on an area earmarked for thatparticular year is collected through operational inventory, discussion with stakeholders, market

situations. Operational plans are perfect for incorporation of changes that occur during the Management plan period, be it in the new scientific understanding of forest management or amendments in the forestry law in the country.

Forest Function Mapping is usually done on a map that is derived from the 1:50,000 topographi maps. In spite of field truthing, the maps may have some errors due to mapping error or time span after the preparation of forest functions. Some streams are small and might not be reflected in the map. Therefore, the Unit Incharges has the responsibility to carefully field truth the maps and incorporate necessary minor changes.

2.5 YIELD REGULATION AND HARVESTING

2.5.1 Determination of Annual Allowable Cut (AAC)

One of the fundamental prerequisites of the sustainable forest management is that the extraction from the forest should not exceed the rate of increment or growth of that forest. This balance in the extraction from the forest and forest replenishment is going to be maintained by proper yield regulation. Without this basic balance provided by yield regulation, sustainable forest management is impossible and the forest resource will gradually be depleted and degraded.

Yield regulation is the practice of calculating and controlling the quantities of forest products removed from the forest each year to ensure that the rate of removal does not exceed the rate of replacement. If the main product being harvested is timber, yield regulation is often defined by the Annual Allowable Cut (AAC). The AAC can be volume-based or area based. In simple terms the AAC is the volume (or area) of timber which ia available divided by the number of years required until the next harvest. The production area is divided into annual coupes for harvesting; in theory, by the time the last block has been cut, the first block should be ready for harvesting again. The number of years into which the area can be divided and hence

the annual volume or area for harvesting depends on the re-growth rate and the harvest intensity.

Yield regulation, or allocation, involves making decisions that lead to clear specifications of where and under what conditions a harvest may be cut using AAC and technical information about a forest. It is a critically important part of sustainable forest management. It is irrespective of the silvicultural system being applied provides a basis for deriving a log harvest which is in balance with forest increment and for controlling the output to ensure that the cut is neither exceeded nor undercut (Armitage, 1998).

During the earlier year in Western Bhutan, most of the FMUs have prescribed Annual Allowable Cut more than what the forest could sustain. The reasons for larger AACs ranged from field work quality to optimistic rotationperiod. Therefore, like all such indicators, AACs need to be calculated correctly, applied thoughtfully and reviewed regularly. Nonetheless, many decades of use in far-flung and diverse forests have cemented and not detracted from its utility. The fact that it continues to receive regular mention in forest management texts (e.g., Buongiorno and Gilless 2003; Higman *et al* 2004; Bettinger *et al* 2009) attests to its utility.

From the total of 8759.23 hac area of the FMU 6639.63 hac (75.80%) had been designated as wildlife protection area since it falls under the Biological Corridor linking Jigme Singye Wangchuck National Park and Phrumshingla National Park. Another, 871.54 hac (9.95%) of the area is under nonproduction management circle. The final production area is only 1248.06 hac comprising only 14.25 % of the total area of the FMU. This small production area had been managed for the past 20 years and all the areas had been logged. Due to lack of proper establishment of the plantations and regenerations with many adverse factors like intense grazing and weed growth the current plan will have no AAC for commercial harvest, instead the plan is focused on regenerating the harvested areas. To enable the proper

establishment of natural regeneration, the rotation period for the broadleaf working circle during this plan period has been increased to 140 years.

Thus, the entire production area of the FMU shall be used for Rural Timber Extraction purpose based on the Single Tree Selection System. However, allotment and marking of trees from the past harvested area should be avoided as far as possible.

AAC by Volume

Although the practice in Wangdigang has been that AAC was calculated based on area, for planning reason, AAC by volume is desirable. In the AAC based on area, there are no indicative timber volumes. This poses a problem to logging agencies like NRDCL in practical planning and computing operational viability. However, the inventory data are available we could make use of it to derive AAC in terms of volume.

2.5.2 Recording and Accounting for AAC

AAC will be monitored through the records of trees marked (Tree Marking Register) for local use production areas. The AAC as has been calculated as the gross bole volume will be totaled on an annual basis from the Tree Marking Register. This AAC compiled over the years will give a picture of the production from the area for the plan period.

2.5.3 Allocation of the AAC

The allocation of the AAC is an important part of the yield regulations, since one of the objectives of the FMU is to benefit the local public by meeting the demand for timber and firewood through available AAC. The allocation has to take into account the need of the local people (rural) and the local industries.

Calcultaion of AAC for Wangdigang FMU

The overall AAC for Wangdigang FMU will be **2100m^3**.Calculation

$$AAC = \frac{\text{Net operable area}}{\text{Rotation}} \text{ x average standing vol./ha}$$

- Net operable area =1248 hac
- Rotation = 140 years (40 years for seedling establishment period)
- Average standing volume per Ha = 237.7 m^3/Hac

AAC = 2100m^3/year in standing volume

Thus, the overall Rural AAC for Wangdigang FMU will be 2100m^3. The available resources will be allocated only for rural use, there will be no commercial harvesting in the FMU during the current plan period.**It doesn't necessarily apply that total AAC should be harvested every year, amount of timber extraction should be guided by rural demand.**

2.6 SILVICULTURAL SYSTEM

2.6.1 Single Tree Selection System

Since the FMU shall cater only Rural Timbers to the public for rural use, single tree selection system will be adopted in the Production area of the FMU for Rural Allotments. No commercial timber harvesting will be done in the FMU during this plan period. However, if sanitation operations need to be carried out during the course of this plan period, the CFO shall seek prior approval from the Head of the Department (DoFPS) and execute the same.

Single tree selection is a silvicultural system where individual trees are selected for harvesting in all size classes more or less uniformly throughout the stand. Individual trees are harvested with the intention of maintaining a continuous canopy without significant gaps. This system is most suitable for shade-bearing species because gaps created by removal of single trees are too small for regeneration of strong light

demanders. It is a silvicultural system that most closely mimics nature in gap driven forest typesand it results in a stand that is uneven-aged i.e. not dominated by a single size-class or age class.

2.7 FOREST PROTECTIONS

2.7.1 Fire

Fire is not a major problem in most of the broadleaf forests. In Wangdigang FMU, the forest which are closer to settlements and where cattle graze is wet and there are rains throughout the year. Other forests like mixed conifer and chirpine are susceptible to fire. But these forests are far away from human settlements and there is not much threat of fire. Forest fires are mainly anthropogenic cause.

In Wangdigang, the cable lines once harvested are kept barren for a year. This is to allow the local firewood contractors to extract lops and tops from the operated cable lines. But this practice makes the forest vulnerable to forest fires. Firewood contractors usually do not extract lops and tops beyond 500 meters of the cable lines. Then in the barren soil, grasses and shrubs invade the open space. The shrubs and grasses combined with dried lops and tops are a dangerous combination for fire. This puts the trees in the inter-cable lines at a higher risk of fire damage. Areas adjoining the villages have been demarcated as local use areas. This arrangement has been helpful in involving the local people in protecting the forest. There is a sense of ownership of the forest and they would help to protect it. The concerned Unit In-charge and counterpart from NRDCL has to regularly monitor the above mentioned susceptible areas in the FMU. Local community should be actively involved in prevention of forest fire.

2.7.2 Pest and Disease Management

Insects and diseases are a continuing menace to the forests. Various insects devastate forests extensively by defoliation. Others insects serve as carriers for the

causative agents of diseases that destroy trees. Parasitic tree diseases may be caused by bacteria, fungi, viruses and nematodes or by such parasitic plants like mistletoe or dodder. Noninfectious diseases of trees include sunscald, drought injury, root drowning or suffocation, nutritional excesses or deficiencies, winter injury and injury from smoke, gases and fumes.

The forest should be periodically monitored to detect any outbreak of pests and diseases. Most pests and diseases when detected earlier in the stage, their damage to the forest are minimized substantially. Regular inspection of the FMU is to be conducted by the FMU staff to detect and report any pest or disease outbreaks. The report should be made immediately to the CFO and relevant research specialist should be contacted in RNR-RC.

NRDCL should fell the trees from the affected areas. It is possible to extract the timber from affected areas on a commercially viable operation. Otherwise, to maintain the long-term health and productivity of the forest, combating pest and disease should be given priority. One of the preventive ways to reduce disease outbreaks in the plantation and later when plantation develops into forest is the practice of planting mixed tree species. The pest and disease spreads very quickly in monocultures. In heterogeneous plantations, the pest of one species does not attack another species, hence providing natural check to the pest and disease outbreaks.

Another important recommendation is that replanting stock should be selected from the native or endemic species only. Exotic species without its natural enemies in the new territory might prove disastrous to the ecology.

2.7.3 Grazing

Over the centuries, various communities in Bhutan have developed their own rights to graze in certain areas. Grazing is one of the important ways the villagers are utilizing the forest and the income from cattle and their products contribute to the

community's economy. The government laws have protected the grazing rights of the people even though the grazing maybe on the government land.

Though grazing has an adverse impact on forest regeneration, research shows that regulated grazing facilitates better regenerations on the forest floor than those which are not disturbed at all.

During the earlier plan periods, the plantations carried out in the harvested areas were fenced at regular intervals with an objective of having better regenerations. The interrupted fencing also facilitated easy cattle movements while in the forest. However, it was observed in the field that fencing doesn't display beneficial role for seedling establishment. Infact, it was observed that fenced area were dominated with profuse bamboo regeneration. Therefore, it is recommended to carry out the research on negative and positive impact of fencing for regeneration in Wangdigang FMU and implement accordingly. Further, since single tree selection system adopted in the FMU will create only small openings, natural regenerations needs to be encouraged as far as possible.

2.8 ENVIRONMENTAL STATEMENT FOR ENVIRONMENTAL IMPACT ASSESSMENT

2.8.1 Introduction

Environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse.

Environmental Impact Assessment (EIA) as a tool is used to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the

local environment and present the predictions and options to decision-makers. By using EIA both environmental and economic benefits can be achieved, such as reduced cost and time of project implementation and design, avoided treatment/clean-up costs and impacts of laws and regulations.

The Environment Assessment Act, 2000 of Bhutan requires that all the development proposals in Bhutan meet a series of environmental criteria outlined in Section 18, Chapter III. For the purpose of implementation of Forestry, the national Environment Commission has prepared Forestry Sectoral Guidelines and recommends more specific set of criteria. These guidelines have been thoroughly screened to ensure that the best practices are being adopted to meet the requirements laid down in the guidelines. This environmental Statement includes possible effects of activities within the FMU along with their mitigating measures.

The goal of Wangdigang FMU is to manage the Wangdigang FMU on a multiple use, sustainable basis for the production of timber, fuel wood and other forest products alongside conservation of watershed, wildlife and environment. The FMU has been in operation for 20 years and is the only FMU catering the needs of the Zhemgang Dzongkhag and other nearby Dzongkhags and Dungkhags. Timbers are in constant demands and are mostly bought by sawmills and furniture houses in the locality. With the operationalization of FMU and harvesting in full swing, there is not much change in forest structure or environment as a whole.

2.8.2 Method

The Environmental Statement is based on the personal observations by the evaluator, interviews with key stakeholders and forestry personnel working in the FMU representing both territorial and NRDCL staffs. A detailed review of the existing management plan and other reports were also made during the evaluation. Scoping exercise of the site was conducted to identify the most significant impacts

on the environment by the activities within the FMU. The stakeholders of the FMU were involved in identifying all the potential impacts they might pose as significant.

The Forestry Environmental parameter checklist developed by NEC was completed by identifying the environmental effects and their mitigating measures. In accordance with the Environmental Assessment Act, 2000, NEC Secretariat will be responsible for ensuring that the recommendations within this document are implemented if the environmental clearance is granted. It is also the responsibility of NECS as stated in Section 23 that 'Environmental Clearance' for the project shall be reviewed and may be revised at least every five years.

There are impact management recommendations in the Forestry Sectoral Guidelines covering all the activities taking place in the FMUs. All of the recommendations in the sectoral guidelines are basically a reflection of the Forest Management Code of Bhutan, which is closely followed for writing and implementing forest management plan. This shows that forest management practices in the FMUs in Bhutan follow the ethics of sustainable forest management and conservation of environmental integrity of forest in Bhutan while at the same time extract economic benefits from the forest resources.

2.8.3 Monitoring and Evaluation

Monitoring and Evaluation (M&E) is a process that helps improving performance and achieving results. Its goal is to improve current and future management of outputs, outcomes and impact. M&E exercises are very important in FMUs to make sure that the field implementation is in line with the prescriptions of the Forest Management Plans. Otherwise, the whole purpose of having a scientifically written and environmentally sound forest management plan will be defeated if it is not matched with strict implementation in the field.

Subsequent management plan prescribed the monitoring and evaluation to be carried out on annual basis by FRMD but due to manpower shortage and

incapability of the field offices to carry out the exercise, it could not be done as planned. The M&E for Wangdigang FMU was carried out by the technical team formed by the DoFPS during December, 2014.

2.8.4 Environment Performance of the FMU

Evaluation of Wangdigang FMU should have taken place as per the Forest and Nature Conservation Rules of Bhutan, 2000, Section14, "the DoFPS shall on a regular basis evaluate the effectiveness of implementation of the Management Plans". However, the monitoring and evaluation of Wangdigang FMU was carried out only in December, 2014.

The management plan objectives of the previous plan were:

- ✓ To maintain and improve the present vegetative cover to protect the environment, soil and water yields.
- ✓ To provide sustained supply of all the forest produce primarily for local needs and secondly for external demand.
- ✓ To contribute to the local and national economy utilizing the forests for sustenance, direct or indirect income generation and creating employment.
- ✓ To involve the local people more in managing the forests.

The objectives of the Forest Management Plans address beside the requirement to fulfill the timber needs, the importance of environment and other functions of the forests. Most of the objectives have been met and the intensive forestry activities are only confined in small areas of the FMU, other areas are still intact.

The objective have been reviewed and changed to incorporate the new knowledge developed over the previous management plan period. The environmental issues and the mitigating measures that would be employed to meet the future objectives of the management plan are discussed below:

2.8.5 Checklist of Environmental Parameters for Forestry Projects

The checklist is designed to check the adequacy of the information in the Environmental Statement for decision making and consultation. Forest Management Plans are in fact prepared based on the principle of sustainable forest management with application of the best code of practices and scientific knowledge. As such the Forest Management Units are normally designed not to have much adverse environment impacts.

Wangdigang FMU has been scientifically managed for the last 20 years. Till date, 14.787 km of forest road has been constructed to allow accessibility for smooth transportation of timbers from the operated coupes. Extensive grazing occurs in the FMU. Based on the checklist, the effects of activities are listed below with mitigating measures briefly described.

I. LOGGING

A. Environmental Consideration regarding Project Sitting

Watershed Areas: Siltation and water quality

***Small Effect*:** Wangdigang FMU as a whole is a watershed that drains its water into the Mangdechu. Therefore, any harvesting in its catchment would have adverse effect on the water quality. However, since the commercial logging is going to occur in s small area and also there is no settlement downstream using the water coming from logging area, the impact is very negligible. Other important drinking water catchment like Dechengang which provides the Zhemgang town with drinking water is protected with no logging or activities are allowed.

***Proposed Mitigating Measures*:** Dechengang watershed would be completely protected with no human activity in the whole of the compartment. Cable craning for timber extraction and reduced logging impact would be strictly applied in the FMU.

Traditional Forest Uses: Impairment of Benefits

***Small Effects*:** Traditionally, the forest in Wangdigang FMU has been used as grazing land by the ocal herders and cattle from nearby Dzongkhags especially Trongsa and Bumthang. Though grazing has an adverse impact on forest regeneration, research shows that regulated grazing facilitates better regenerations on the forest floor than those which are not disturbed at all.

***Proposed Mitigating Measures*:** The consultative and or stakeholder meetings with the local communities including the cattle herders have been fruitful over the years in creating the understanding and respect for aims and goals of each other. Such meetings should be continued to explore mutually beneficial ways to address issues and avoid future conflicts.

B. Consideration regarding Planning and Design

Operations and Maintenance: Diminished Efficiency due to Lack of Funds

***Major Effects*:** For any project to take off, the availability of funds is a bottleneck which results not accomplishing the planned activities. This ultimately results in loss of efficiency and effectiveness of the plan. After coming under Druk Holdings and Investment, NRDCL has tremendously cut down on the operating cost of the FMU thereby resulting into many planned activities not being implemented thus undermining the forest management plan.

***Proposed Mitigating Measures*:** During the preparation of budget for implementing the planned activities of the FMU, a joint sitting from NRDCL and concerned territorial division is a must. Only then, the prescribed developmental activities can be carried out. The budget requirement which is not under the purview of NRDCL should be sought from the Finance Ministry.

Database for Decision Making

Major Effects: Decision making for sound and sustainable forest management should be based on scientific knowledge and experience of best practices. However, in Bhutan there is unavailability of data to learn from experience since there is poor maintenance of records. Poor record maintenance leads to poor supervision and accountability which is disastrous in the long run.

***Proposed Mitigating Measures*:** For any decision to materialize, sufficient and relevant data should be available to rely on. Therefore, maintenance of records is found to be very important and useful. So, maintenance of standard records is recommended in line with the Forest Management Code of Bhutan.

Road Network Design: Erosion, Landslide, Siltation, Water Quality Degradation, etc

***Small Effects*:** Forest roads have big implication on environment. Thus, proper design is very important to minimize negative impacts like soil erosion, landslides, siltation, etc. All in all, 14.787 km of forest road had been constructed in Wangdigang FMU and during the construction period, excavator was used adopting environmental friendly road construction methodology. Labourers from the local communities were engaged during the construction thereby reducing impact to the environment. Wherever necessary culverts, retaining walls, breast walls and hume pipes were used to allow smooth flow of runoff. Over a period of time road had stabilized.

***Proposed Mitigating Measures*:** Future construction should adopt environmental friendly road construction methodology. Wherever required, culverts should be built, breast and retaining walls constructed and side drains properly maintained to allow flow of water.

Design of Logging Activities: Affected Residual Stands and Interlines

***Medium Effects*:** Use of cable cranes during the logging is very important and most environment friendly timber harvesting technology. Equally, proper tree felling

techniques and cable line layout are also important components for effective implementation in reducing the logging impacts. As observed in some cases, the cable lines are laid out too close to one another or sometime, the cable lines are not running parallel to each other which pose difficulty to operate the interlines in the future.

***Proposed Mitigating Measures*:** Tree felling should be carried out by the competent and certified individuals and close supervision and monitoring should be carried by concerned territorial division. To the maximum possible, encroaching or damage to interlines and residual saplings should be minimized. Lay out of cable lines should follow standard set out in the management plan.

C. Consideration regarding Project Operations

Log Conveyance: Soil Erosion and Soil Compaction

***Small Effects*:** During the extraction, logs are being dragged over the forest floor to cable lines from either side. The rural timbers are dragged till forest road head. These practices expose the surface soil to monsoon rain and the areas form gullies due to runoff and there is soil erosion and water siltation formation.

Proposed Mitigating Measures: Branches and leaves from the trees should be used to cover up the soil before dragging the timbers to the centre of cable lines. This will certainly protect the soil from exposure and reduce log conveyance damage. Rural people should be made aware on how to transport the timber without disturbing the soil and at the same time the concerned forestry field staffs should closely supervise the timber extraction activities.

Rural Allocation: Over Cutting of the Coupe

***Medium Effects*:** Timber allocations from Wangdigang FMU for some years is sometimes more than the AAC allocated.

***Proposed Mitigating Measures*:**Proper records of rural harvesting of timbers should be maintained so as to trace the total volume of timber extraction from the FMU and also not to exceed the allocated total AAC. Regular patrolling should be carried out by the concerned staffs of the FMU to curb the illegal timber extraction. Without any clemency, fines and penalties should be levied for any illegal activities inside the FMU.

Logging in Riparian Zones: Degradation of Water and Aquatic Life

***Small Effects*:** Intentional or unintentional, sometimes the cable lines are laid out in the riparian zones affecting the water quality and aquatic life. With the excess of forest road, sometimes people are collecting the stone/boulders from within the riparian zones. This may lead to siltation of the streams and ultimately affect the aquatic life.

***Proposed Mitigating Measures*:** Whatsoever, there should be no human intervention inside the riparian zones that will have negative adverse impact to streams and to aquatic life. Stringent action should be taken against the defaulters by the concerned territorial and unit staffs.

II. REFORESTATION/AFFORESTATION

A. Environmental Consideration Regarding Project Sitting

Past Forest Utilization in Wangdigang FMU: Without Plan

***Medium Effects*:** In the past, local communities used to collect firewood, fodder and other forest produces/products without any supervision. The scientific forest management in Wangdigang FMU came into force only some 20 years ago. The un-operated forest stands are still intact. During the first and second management plan period, extensive harvesting of timber took place which is dangerous to degrade the forest unless regeneration takes place.

Proposed Mitigating Measures: All the areas within the FMU should be brought under strict management regimes. It should be regularly monitored so that no illegal logging takes place within the FMU.

B. Consideration Regarding Planning and Design

Selection of Tree Species: Monoculture and Vegetation Structure Alteration

***Medium Effects*:** Silvicultural prescription of artificial regeneration, if natural regeneration fails has a high chance of creating a monoculture. There is a probability of altering the structure of the forest due to introduction of new and exotic tree species.

***Proposed Mitigating Measures*:** No new or exotic tree species should be planted in the already harvested coupes. The harvested areas must be restocked with natural regenerations as far as possible. Artificial regeneration to be carried out only to supplement the natural regenerations in case of regeneration failures.

Allocation of Benefits to Locals: Training

Small Effects: The training of the local communities in regards to raising of seedlings, grazing issues, illegal activities, etc. would immensely benefit the local as well as the forestry staffs.

***Proposed Mitigating Measures*:** Actively and in increased numbers, involve the local people in forestry related and other associated activities to knowledge sharing and understanding of the importance of the forest.

Allocation of Benefits to Locals: Non-Wood Forest Products

***Small Effects*:** From the very early, the local people were collecting various non-wood forest products to meet their basic day today needs. There is an increased in accessibility within the FMU with the construction of 14.787 km of forest road. Priorities in the forest products, people are collecting Cane, Pan (Beetle leaves) and Guli (*Persea fructifera*) on regular basis and as such it is depleting.

***Proposed Mitigating Measures*:** Identifying the forest products and its in-depth study need to be carried out for prescribing the appropriate management strategies.

Operation and Maintenance: Diminished Project Effectiveness due to Inadequate Funds

***Major Effects*:** Due to high presence of wild and domestic animals within the Wangdigang FMU, the artificial regeneration has not been very successful. So, to restock the harvested areas artificial plantations have to be done with proper fencing. To put it straight way, there is a requirement of sufficient funds to carry out plantation and if the funds are short coming then, it will be a challenge to concept of sustainable forest management.

***Proposed Mitigating Measures*:** Both the parties (NRDCL & Territorial) should sit together while preparing the Operational Plan to work out enough provision for budget allocation for carrying out plantation and beating up activities. The shortfall in fund allocation will directly have direct implication on creation and maintenance of plantation.

Monitoring and Evaluation of Plantation: Lack of Regeneration Survey

***Major Effects*:** Almost all the plantations carried out in the already operated coupes are not at all satisfactory. There is no appropriate regeneration surveys carried out in the operated coupes as of date.

***Proposed Mitigating Measures*:** Timely regeneration survey should be carried out to ascertain the regeneration status in the harvested areas. Henceforth the CFO, Zhemgang, should play a lead role in carrying out regeneration surveys at regular intervals.The Divisional Forest Office, Zhemgang, may contact FRMD, DoFPS, for any technical assistance required in carrying out the survey.

C. Consideration Regarding Project Operations

Socio-Economic Benefits: Employment Opportunities and Income Generation

***Moderate Effects*:** Regeneration activities like fencing, plantation and weeding involve local people either as manual labourers in daily wage basis or on contract. Some local people can be involved on seedling raising while others can opt to look after the plantation. Through these measures, the local people will have opportunity to understand the importance of forest and protect it from destruction.

***Proposed Mitigating Measures*:** The communities should be encouraged and actively involved from seedling raising to plantation, weeding, fencing and finally protection and conservation of forests.

Forest Stock Improvement: Better Stocking

***Moderate Effects*:** Most of the forests in Bhutan are experiencing negative increment meaning that the stocks are old and decaying. Therefore, logging and regeneration would put in fresh and vigorously growing stock. This would ensure quality stock for future commercial utilization of the forests.

2.8.6 Forest Management Unit Planning and Zoning

Forest Management Unit Planning and Zoning was carried out through extensive involvement of key stakeholders. Vital data and statistics were gathered from important sources for land use planning of the FMU. The key stages in Forest Management Planning and Zoning are given as below:

a) An initial screening process using GIS techniques was used to identify and locate areas of well-stocked forests accessible from the road head. Field truthing was done with consultation with the local communities to make sure that there were no conflicting resources use issue would arise in the future.
b) A forest management inventory was carried out to provide data on forest stocking, standing volumes, regeneration, and site characteristics and species composition. For the third period of Forest Management Plan, forest management inventory was conducted in early, 2015.

c) Zoning or function mapping within the FMU was then based on the above data. Identifying forest types and matching it was appropriate management prescriptions. The FMU areas were zoned into Blocks and Blocks were further sub-divided into compartments.

d) The rotation age has been prescribed at 140 years. The AAC has been calculated based on the rotation age. The Annual Allowable Cut (AAC) is based on the standard international formula. It uses both the volume which has been obtained out by the forest management inventory and the area to check that log extracted is within the sustainable limits of forest growth within that period.

2.8.7 Road Construction and Maintenance

Most of the forest roads in our country are in the mountain region, characterized by steep terrain, with a dense stream network which favours the instability of slopes and landslides. Thus a large volume of works, consisting mainly in the construction of supporting retaining and breast walls, culverts, laying of hume pipes and causeways are required for the protection and consolidation of roadbeds. Forest roads are also cause of one of the most environmental damages of all operations in the FMU. Forest roads expose the soil and silt the waters in the area. It also makes remote inner forest areas accessible to the general public who come to gather non-wood forest products. Forest road also encourages illegal activities.

Within the period of past two management plans, 14.787 km forest road has been constructed in the Wangdigang FMU by NRDCL. Excavators and manual labourers were engaged during the construction of the forest road. Culverts, causeways and cross drains were laid out along the road to minimize the impacts of water flowing. During the current plan, there is no provision of further construction of forest road instead road maintenance will be carried out as and when deem necessary.

2.8.8 Harvesting and Extraction

The allotment of Rural Timbers from the FMU will be carried out using single tree selection system. The trees will be marked selectively based on the phenotypic characteristics of the trees. The best trees with good phenotypic characteristic shall be retained as seed trees for better seeds and regenerations in the area. As far as possible, environmental damages to the surrounding environment must be kept at the minimal during the extraction of the felled trees. Rolling of logs must be not accelerate soil erosions and damages to regenerations.

AAC should be followed strictly according to the Forest Management Plan. Operational Plan and cable line survey conducted accordingly would yield an accurate volume for extraction. The total volume of timber to be extracted in a year must be reflected clearly in operational plan.

2.8.9 Stream and Riparian Protection

The term "riparian" is defined as vegetation, habitats, or ecosystems that are associated with bodies of water (streams or lakes) or are dependent on the existence of perennial, intermittent, or ephemeral surface or subsurface water drainage.

Put more simply, riparian areas are the green ribbons of trees, shrubs, and grasses growing along water-courses. Riparian areas occur in a wide range of climatic, hydrologic and ecological environments. Different latitudes and altitudes can support very different riparian communities. This is caused primarily by changes in precipitation and temperature. Riparian areas are ecosystems. An ecosystem is a functional system that includes both a biotic part in the organisms, such as the plants and animals, and an abiotic part which factors in their immediate environment such as soil and topography. These organisms interact both with each other and with their environment. Each ecosystem is unique because the organisms and the environment differ significantly from other ecosystems.

Riparian areas are the transition zones, or ecotones, between aquatic (water-based) systems and terrestrial (land-based) systems, and usually have characteristics of both. These characteristics and location make it habitat for a larger number of species of plants and animals. Riparian areas are found at every elevation and in all landforms, and differ depending on local physical conditions (water, soil, temperature, etc.) and their location (elevation, valleys, etc.). Although riparian areas can differ greatly, they all have several things in commons. They are shadier, cooler, and moister than the adjacent upland environments. A wide variety of animals are attracted to these areas including insects, amphibians, reptiles, fish, birds, and mammals. Suitable habitat (food, water, and shelter) is often provided in riparian areas to support these animals which may not occur in surrounding drier areas.

Wangdigang FMU forms one of the many tributary watersheds of the Mangdichhu River. Within the FMU, Dechengang watershed is the drinking water source for Zhemgang Town. For other perennial streams and rivers within the FMU, 30 meters on either side should be maintained as buffer and the implementers should initiate the action in the field to protect the riparian zones or areas.

So within the buffer zone no forestry activity except those for improving the forest stand should be allowed. The improvement activities include reforestation of the open areas, beating up, weeding and tending operations. All these activities should be done manually without engaging any mechanical devices. Even, cattle grazing are strictly restricted in the riparian zones.

2.8.10 Community Forest Selection and Management

A total of 156.04 ha forms Dangkhar Community Forests (Dungbey Block, Compartment I: 118.72 ha and Dangkhar Block: 37.29 ha). It was established in 2010 with its approved Management Plan covering the period from April, 2010 to March, 2020. It is divided into three main blocks namely: Zingerpong Block, Bjaro

Norbuling Block and Broksar Thang Block. This community forest will serve the need of the local communities as per the prescriptions in the management plan.

2.8.11 Landscape and Aesthetic Consideration

Landscape and aesthetic considerations have become one of the important factors in forest management. In Wangdigang FMU, although the production area is out of sight from the national highway, the area is going to be maintained with optimum forest cover for landscape and aesthetic values. Silvicultural prescription of harvesting of commercial timbers is Group Selection System and the operated areas will be regenerated with artificial planting. The small group openings are not so visible.

2.8.12 Health and safety Issues

Forestry continues to be one of the most hazardous industrial sectors in most countries. However, clear evidence shows that good safety and health performance in forestry is feasible. It deals with the protection of workers' health through control of the work environment to reduce or eliminate hazards. Safety is not an afterthought and it cannot be retrofitted.Workplace accidents and unsafe working conditions can result in temporary or permanent injury, illness or even death. They also take a toll in reduced efficiency and loss of productivity.

In Bhutan, now the Ministry of Labour and Human Resources (MoLHR) has adopted acts and rules in place to guide the employers to make the work environment safer which is less costly than making a huge compensation or paying for a lengthy court battles.

Table 10:CHECKLIST OF ENVIRONMENTAL PARAMETERS FOR FORESTRY PROJECTS

	Adverse Environmental Impacts	Preliminary Evaluation			
		No Significant Effect	Small Effect	Moderate Effect	Major Effect
I. COMMERCIAL LOGGING					
A. Environmental Considerations Regarding Project Siting					
Watershed Areas					
erosion	*downstream economic losses*	×			
siltation	*downstream economic losses*		×		
hydrology	*increased peak and flood flows*	×			
water quality	*loss of downstream beneficial uses*		×		
Relation to other dedicated land uses					
conservation areas	*impaired ecological and recreational opportunities*		×		
economic ventures	*possible economic loss*	×			
Traditional forest uses	Impaired beneficial uses		×		
Re-habilitation	Social problems	×			
Relation to regional/ national forestry plans	Possible conflicts with established management policies	×			
Critical environmental areas	Downstream economic losses	**NA**			
erosion	*downstream economic losses*				

	Adverse Environmental Impacts	Preliminary Evaluation			
		No Significant Effect	Small Effect	Moderate Effect	Major Effect
siltation	*downstream economic losses*				
hydrology	*increased peak and flood flows*				
water quality	*loss of downstream beneficial uses*				
Precious ecology	Loss of ecological values	**NA**			
B. Considerations Regarding Planning and Design					
Cost/benefit analysis		×			
Operations and maintenance	Diminished project efficiency and objectives if lack of funds				×
Data base for decision making			×		
Road network design					×
erosion	*downstream economic losses*				×
siltation	*downstream economic losses*			×	
hydrology	*increased peak and flood flows*			×	
water quality	*loss of downstream beneficial uses*		×		
Design of logging activities	Unnecessary damage to residual stand		×		

	Adverse Environmental Impacts	Preliminary Evaluation			
		No Significant Effect	Small Effect	Moderate Effect	Major Effect
Critical environmental areas		**NA**			
erosion	*downstream economic losses*	**NA**			
siltation	*downstream economic losses*	**NA**			
hydrology	*increased peak and flood flows*	**NA**			
water quality	*loss of downstream beneficial uses*	**NA**			
Precious ecology	Loss of ecological values	**NA**			
Appropriate technology	Diminished project objectives if inappropriate		×		
C. Considerations Regarding Project Operations					
Road construction					
erosion	*downstream economic losses*	×			
siltation	*downstream economic losses*	×			
hydrology	*increased peak and flood flows*		×		
water quality	*loss of downstream beneficial uses*	×			
Felling					
erosion	*downstream economic losses*	×			

	Adverse Environmental Impacts	Preliminary Evaluation			
		No Significant Effect	Small Effect	Moderate Effect	Major Effect
siltation	*downstream economic losses*		×		
hydrology	*increased peak and flood flows*		×		
water quality	*loss of downstream beneficial uses*	×			
Log conveyance and allocation					
erosion	*downstream economic losses*		×		
soil compaction	*increased runoff*		×		
log floatation	*impede navigation*	×			
allocation	*less than optimum economic benefits*	×			
Logging in riparian zones	Degradation of waterways/ fisheries	×			
Socio-economics					
employment opportunities				×	
loss of traditional forest use	*economic and cultural losses*			×	
D. Considerations Regarding Post-Project Activities					
Rehabilitation and conservation			×		
Road shutdown		×			
II. REFORESTATION/AFFORESTATION					
A. Considerations Regarding Project Siting					
History of forest abuse	Negation of project goals if		×		

	Adverse Environmental Impacts	Preliminary Evaluation			
		No Significant Effect	Small Effect	Moderate Effect	Major Effect
	not effectively controlled				
Relation to other dedicated land uses		×			
conservation areas		×			
economic ventures	*Interference with more profitable ventures*		×		
regional/national forestry plans					
Rehabilitation	Social Problems		×		
Siting in degraded forest	Possible unnecessary loss of ecological values	×			
B. Considerations Regarding Planning and Design					
Cost/benefit analysis			×		
Selection of tree species	Diminished project objectives		×		
Precious ecology		×			
wildlife		×			
fisheries		×			
plants			×		
soil and water			×		
Allocation of benefits to locals			×		
employment opportunities	*social conflict if local people not significantly involved*		×		
training		×			
non-wood products				×	

	Adverse Environmental Impacts	Preliminary Evaluation			
		No Significant Effect	Small Effect	Moderate Effect	Major Effect
Operations and maintenance	Diminished project efficiency and objectives if lack of funds			×	
Data base for decision making			×		
Project financing and reservoirs			×		
Appropriate technology	Diminished project objectives if inappropriate			×	
Relation to other dedicated land uses	Potential social and economic conflicts			×	
extensive land use modification					
10. Road network design	10. Increased erosion			×	
11. Use of grasslands				×	
C. Consideration Regarding Project Operations					
Commercial logging	Same as in Commercial Logging A and B		×		
Reduced water supplies	Socioeconomic losses	×			
Chemicals and fertilizers	Impaired fisheries and aquatic systems	×			
First-year operations	Increased erosion due to soil disturbance		×		
Soil conservation benefits					
erosion				×	
sedimentation				×	

	Adverse Environmental Impacts	Preliminary Evaluation			
		No Significant Effect	Small Effect	Moderate Effect	Major Effect
soil capacity			×		
soil surface moisture			×		
soil nutrients			×		
Socioeconomic benefits					
employment opportunities				×	
fuel-wood				×	
enhanced fisheries		×			
enhanced recreation/ tourism		×			
Water resources benefits			×		
minimized overland flows			×		
reduced flood peaks			×		
water quality		×			

Source: ADB (1987) and Forestry Sectoral Guidelines NEC (1999)

2.9 FINANCIAL AND ECONOMIC APPRAISALS

A 10-year financial forecast (cash flow) and economic appraisal has been developed for the Wangdigang FMU. This is intended to identify revenue to NRDCL and the Treasury (via royalties) and the costs and royalties paid by NRDCL. Overhead costs to NRDCL are not included. Some of the figures are estimates based on the assumptions listed and the information made available to the planner. The assumptions for the forecast are listed in Table 18.1. A summary of the forecast is presented in Table 18.2 and the forecast itself in Table18.3.

Assumptions	
m^3 to cft	35.31
Recover Volume NRDCL (%/AAC)	40
Length of proposed new road (km)	0
Length of existing road (km)	14.78
Road maintenance (Nu/km/yr)	12000
Distance to Depot (km)	7
Royalty from Rural Allotment is paid by DBH. However an average was used for this calculation (Nu/yr) (Based on previous plan and adjusted for the new AAC allotment)	19992
Rural Allotment (m3)	2100
Regeneration maintenance (for cable lines) (Nu/ha)	3000
Hectares of cable lines that require planting per year (approximate)	4
Coupe regeneration establishment	19000
Creation of plantations (Nu/ha) (including cable line regeneration)	19000
Plantation maintenance (Nu/ha) (for first five years of plantation only)	3000
Hectares of existing plantations in the FMU	58.45

Table 11: Assumptions used for Financial Forecast

This forecast is for ten-year period of the plan, therefore does not include profitability of the FMU for the rotation length. The potential income from the investment in regeneration is not represented in this forecast. However, it is important to remember that all development activities within the FMU will be beneficial in the future. It is also important to understand that the income generated from previous plan period would have been much higher (due to the AAC and the minimal amount of money spent on regeneration of harvested cable lines) and should be kept in mind when dealing with expenses during this plan period.

Financial Summary for Plan Period	
Total Revenue NRDCL	Nu. 0
Total Costs NRDCL	Nu.3819350
Total Royalty NRDCL	Nu.0
Total Revenue less Royalty less Costs NRDCL	Nu. -3819350
Total Revenue of FMU (All Revenue and Royalties)	Royalties from Rural Timbers only

Table 12:Summary of Financial Forescast

Note: It was assumed that there will be no commercial harvest and revenue generated form sanitation logging is not accounted.

This financial forecast is based on indicative figures and is a projection of a possible cash flow scenario. This is financial forecast should only be used as a guide.

					2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	10 years
	AAC	Rec. Vol													
	(m3)	(m3)	Nu/ cft	Nu/ m3	Nu	Nu	Nu	Nu	NU	Nu	Nu	Nu	Nu	Nu	Total (Nu)
Revenue: NRDCL															
Timber-Commercial	0	0	107.3	0	0	0	0	0	0	0	0	0	0	0	0
Timber-Rural	2100	840		0	0	0	0	0	0	0	0	0	0	0	0
Total Revenue: NRDCL					0	0	0	0	0	0	0	0	0	0	0
Costs: NRDCL															
Bridge construction															
Road construction					0	0	0	0	0	0	0	0	0	0	
Road maintenance		Nu.12000 /km/yr			177360	177360	177360	177360	177360	177360	177360	177360	177360	177360	1773600
Marking cost					0	0	0	0	0	0	0	0	0	0	0
Inventory cost			**0.08**	2.83	0	0	0	0	0	0	0	0	0	0	0
Felling and crosscutting cost			**2.49**	87.9	0	0	0	0	0	0	0	0	0	0	0
Debarking			**0.45**	15.9	0	0	0	0	0	0	0	0	0	0	0
Cable craning			**10.01**	353	0	0	0	0	0	0	0	0	0	0	0
Transportation to depot			**7**	247	0	0	0	0	0	0	0	0	0	0	0
Stand tending (spacing etc.)															
Regeneration maintenance(Nu/ha)		Nu 3000/ha													
Creation of plantation		Nu 19000/ha													
Plantation maintenance		Nu 3500/ha			204575	204575	204575	204575	204575	204575	204575	204575	204575	204575	2045750
Total Cost: NRDCL					381935	381935	381935	381935	381935	381935	381935	381935	381935	381935	3819350
Total revenue less Total cost: NRDCL					-381935	-381935	-381935	-381935	-381935	-381935	-381935	-381935	-381935	-381935	**-3819350**

Table 13:Financial Forecast

Note:

- It was assumed that there will be no commercial harvest and revenue generated form sanitation logging is not accounted
- It is recommended that a contingency fund be established for these activities due to the uncertainty of the occurrence of bark beetle during the plan

2.10 RESEARCH

Research programs need to be implemented in close collaboration with the RNR-RC. The management plan is based on several assumptions since not enough research data is available. Since there is a need for localized data generations, research issues will be decided by Divisional Level Forest Management Committee for Zhemgang Division and submitted to RNR-RC.

Some of the research subject includes:

- Impact of fencing for regeneration in Wangdigang FMU
- Success of Clear Cutting in Broadleaf Forest.
- Effect of grazing in broadleaf forests.
- Site Index.
- Regeneration with local species.
- Product development from locally available species.
- Non-Wood Forest Product use.
- Water productivity of local watershed.

PART THREE: IMPLEMENTATION OF THE PLAN

3.1 IMPLEMENTING AGENCY

The Department of Forests and Park Services (DoFPS) is vested with the responsibility for protection and management of the country's forest resources which it executes through the Territorial Divisions. The Divisional Forest Office in Zhemgang shall be the responsible agency for the management and implementation of the plan of Wangdigang FMU. The Chief Forestry Officer (CFO), Zhemgang will be responsible for plan implementation with the help of Unit In-charge and its staffs.

3.2 HEALTH AND SAFETY

Health and Safety of the workers has become one of the important means to assess the quality of modern workplace. It deals with the protection of workers health through control of the work environment to reduce or eliminate hazards. Workplace accidents and unsafe working conditions can result in temporary or permanent injury, illness and or even death. They also take a toll in reduced efficiency and loss of productivity.

In Bhutan, health and safety is not accorded its due importance due to lack of any legal labour provision in the country. But the scenario might change in the future and employers will find that making the work environment safer is less costly than making huge compensations or paying for lengthy court battles.

Harvesting and extraction activities have been identified as the areas that need to be addressed in earnest. The practice has been observed to be poor in the whole of Bhutan. The following are the main activities that need to be addressed:

- Chainsaw operations
- Felling practices
- Lack of understanding if personal safety by workers

Some safety measures can be initiated with very little financial resources. These measures are going to make a marked improvement in the safety of the workers.

- Always make workers wear helmet in the field.
- Ensure that chainsaws are equipped with a fully functioning chain break.
- Always ensure that tree fellers are two tree lengths apart.
- Do not make timber pile too high.
- Always dismantle a timber stack top down rather than bottom up.
- Educate the workers involved in timber harvesting.
- The job and the worker should be appropriate matched because there are huge differences in physical and physiological competence of different people.

It is recommended that system approach be used for identification and minimization of work hazards. Because accidents arise from the interaction of workers and their work environments; both must be carefully examined to reduce the risk of injury. Injury can result from poor working conditions, the use of improperly designed equipment and tools, fatigue, distraction, lack of skills and risk taking. The systems approach examines the following areas: all work locations to eliminate or control hazards, operating methods and practices, and the training of employees and supervisors. The system approach moreover demands a thorough examination of all accidents and near misses. Key facts about accidents and injuries are recorded along with the history of the worker involved, to check for and eliminate any patterns that might lead to hazards.

The system approach also plays special attention to the capabilities and limitations of the working population. It recognizes large individual differences among people in their physical and physiological capabilities. The job and the worker therefore should be appropriately matched whenever possible. NRDCL should take the lead role in training contractors in the proper work practices with the possibility of

initiating a certification system. The DoFPS should back this and it should aim at penalizing contractors who do not abide by the set policy (Stark, 2003).

3.3 PLANNING OF OPERATION

3.3.1 Operational Plan

Within the framework of a long-term Forest Management Plan, the concerned Territorial Division and Unit In-charge (UIC) of a Forest Management Unit prepares Operational Plans (OP) of that particular unit. During the first and second plan period , CFO, Zhemgang Division and UIC, Wangdigang FMU prepared OP to facilitate the implementation of this Management Plan. Operational Plan describes in detail the timber harvesting, access development, and forest renewal activities proposed. They clearly identify where the activities will take place and how they will be carried out. The OP also identifies, in lesser detail, proposed activities for the following two years to provide a general projection of where the proposed operations will proceed.

The Plan is based upon the preparation of harvesting block maps and an analysis of the potential yield, which is determined by the commercial stock within each block and inventory data from the forest compartment. The Plan details the road and other infrastructure construction and maintenance, and hence the operational activities to be undertaken.

In the past years, the rolling concept in operational planning was causing problem since period of the rolling plan was thought to be two years. With the simplification brought about by the new Operational Planning Guidelines, annual preparation of operational plan has become clear and easier. It is also used to estimate the cost of carrying out the activities and identify funding sources. Operational plan also provides opportunity for making changes in the Management Plan arising from newer opportunities or problems in the field.

General principles of a good operational plan as given in the Operational Plan Guidelines 2003 produced by FRMD are simple structure and format, objective led, site specific and quantitative and participatory. Operational Plans are prepared annually. Therefore, for ten years of Management Plan, there should be ten Operational Plans..

For Wangdigang FMU, operational plans shall be prepared by the CFO, Zhemgang three months before the starting of the operating year. The operational plan is going to give detail about the exact operational activities and their timing. It is also going to deal with the unseen phenomena like forest fire, outbreak of pests and diseases, floods or landslides. Operational plans are to be reviewed immediately when such unforeseen events occur.

The Operational Plans are going to be written in close consultation with all the relevant agencies and parties who will be using the forest. Consultative process with local communities is particularly important so that potential issues concerning the communities are worked out well in advance of the operation.

3.3.2 Tree Marking Rules

Marking Guidelines for the Single Tree Selection System

Description

Single tree selection is a silvicultural system where individual trees are selected for harvesting in all size classes more or less uniformly throughout the stand. Individual trees are harvested with the intention of maintaining a continuous canopy without significant gaps. This system is most suitable for shade-bearing species because gaps created by removal of single trees are too small for regeneration of strong light demanders. It is a silvicultural system that most closely mimics nature in gap driven forest types (**Error! Reference source not found.**) and it results in a stand that is u neven-aged i.e. not dominated by a single size-class or age class.

Single tree selection is used to harvest timber and to develop and improve mixed forest stands (with mixed species and age-classes). It allows further growth to be concentrated on the best individual trees of the most desirable species whilst improving the vitality and health of the stand. It avoids too much forest disturbance and provides suitable conditions for natural regeneration of shade bearing species in the selected forest types.

Single-tree selection system -- before cut

Single-tree selection system -- after cut

Implementing single tree selection requires considerable skill by forest managers. It requires a good knowledge of the silvicultural and growth requirements of different species (especially in broadleaved forests) and it requires careful monitoring over time. However, it does allow for timber to be harvested 'on demand' i.e. if only small quantities are required at one time, although usually it is better to treat an entire stand at one time to avoid excessive disturbance.

3.3.3 Implementation

1. Visit all parts of the stand to be harvested so that a good overall impression is obtained.
2. Plan how much timber can be harvested from the stand. This should be no more than 10-20% of the standing volume for single tree selection.

3. Follow these marking guidelines for single tree selection:

   - Where ever possible, mark trees evenly distributed throughout the stand,
   - Mark up to 25% of the stand volume,
   - Mark trees that are malformed, dead, diseased and dying trees as a priority including those that are less than 50 cm dbh,
   - Mark larger trees for timber (above 50 cm dbh) that will promote the growth of nearby saplings of desired species when they are removed and that have utilisation value,
   - Ensure that no large openings are created in the stand,
   - Ensure that an even distribution of suitable species remains after harvesting,
   - If using cable cranes the extraction lines should be as narrow as possible (no wider than 3-5 m).

4. Do not mark trees if they are:

   - On steep slopes with more than 45 degree (100%)
   - Closer than 30 m to a water course or water source
   - In and around the sacred places (consult local people)

5. Harvesting operations shall start only after marking has been completed for the particular stand. This will give you an opportunity to check whether the right volume has been marked.

6. During harvesting, trees should be carefully felled to avoid damaging neighbouring trees and regeneration. Trees should be felled across the slope if possible.

7. Marking and harvesting should normally be carried out between October and March

8. All marked trees should be harvested and extracted within 2 years of marking

9. After harvesting, the stand should not be visited for harvesting again for at least 10 years. This will allow the stand to recover and to allow the regeneration to develop and grow.

10. In broadleaved forest types, single tree selection can be used to increase the stocking of the most valuable timber species such as *Michelia, Nyassa, Alnus, Castanopis* and *Juglans*. Stems of less preferred species or with poor form adjacent to good quality individual stems of the preferred timber species can be marked for harvesting so that these remaining trees continue to grow and the overall quality of the stand improves. However, harvesting operations must be carried out carefully so that these valuable stems are not damaged.

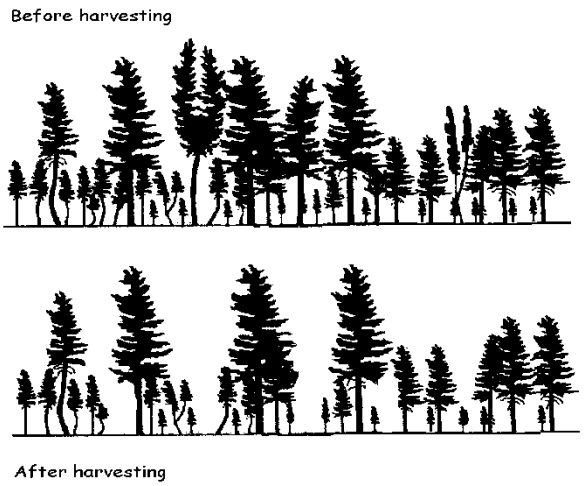


Figure 16 Single tree selection
Note that only a few trees have been removed (about 15%) of all sizes and evenly across the stand so that no large gaps are created.
Priority it to remove less desirable species or trees that are over-mature and poor quality.

3.3.4 Reforestation of Harvested Sites

Since single tree selection system will be adopted as the prescribed silvicultural system for rural allotments in the FMU which will create only small openings, natural regenerations of the harvested area must be encouraged as far as possible. Artificial regenerations to be done only as a supplement to natural regeneration in case of failures.

3.3.5 FMU Level Forest Management Committee

The Divisional Level Forest Management Committee chaired by CFO, Zhemgang Forest Division has been constituted to oversee the implementation of the Management Plan. This committee comprises of stakeholders from Trongsa and Zhemgang Dzongkhags. But for the issues pertaining to Wangdigang FMU, CFO will call a meeting of the stakeholders from Zhemgang Dzongkhag only. The eligible members from the Divisional Level Forest Management Committee for the Wangdigang FMU would comprise of the following:

- CFO, Zhemgang Forest Division
- Regional Manager, NRDCL, Zhemgang Region
- Representative from FRMD
- Unit In-charge, Wangdigang FMU
- Unit Manager, NRDCL, Wangdigang FMU
- DzFO, Zhemgang Dzongkhag
- Gups and Mangmis of Toong Geog, Zhemgang Dzongkhag

The committee meeting for Wangdigang FMU can co-opt any person as a member as required for example, from the local community, Dzongkhag Livestock Officer, Dzongkhag Agriculture Officer, NGOs, Dratshang or others.

Gups and Mangmis should be included in the committee meetings because they represent the local community within the FMU boundary. Their participation is important for the education of the local community of the activities within the FMU while at the same time their inputs are important to plan these activities.

The committee will meet before the preparation of the Operational Plan every year. They are going to review the past year and then set new activities for the new operational year. The activities for the new operational plan will be guided by the Management Plan objectives and prescription wherever possible. Budgets for the Wangdigang FMU Committee Meeting will be borne by the implementing agency.

3.3.6 Staff

The Chief Forestry Officer, Zhemgang Forest Division is the overall controlling officer of the FMU. Under the administrative supervision of the CFO, the Unit In-charge, Wangdigang FMU will be working as the representative of the Department of Forests and Park Services in the field. The FMU In-charge will have the direct responsibility in the control and management of the FMU.

3.3.7 Responsibility

For the smooth implementation of the forest management plan, the following staff is the required numbers:

Unit In-charge - 1

Forester - 4

The Unit In-charge will be responsible for the day to day implementation of the plan under the overall supervision of the CFO, Zhemgang Forest Division. The Unit In-charge will keep all the records for the activities in the FMU, supervise and initiate the silvicultural assessment as per the plan prescriptions. In the FMU, there should be constant monitoring even during off hours. The road has made the FMU very accessible. Publicly accessible area naturally needs regular monitoring.

3.3.8 Buildings

One storeyed RCC building has been constructed that houses the Wangdigang FMU office which is just above the existing Divisional Forest Office. It is constructed in complete traditional style.

3.3.9 Computer and Peripherals

The FMU office is equipped with desk top computers, printer, fax and photocopying machines.

Presently, the available computer and its peripherals are enough to run the day-to-day activities of the FMU.

3.3.10 Vehicles and Equipments

Almost all the required field equipments are available with the FMU office. There are one 4WD Hilux with the Divisional Forest Office which are used on official duty. At present, it seems there is not much problem since the FMU office can use the division vehicles as and when required for field works.

3.4 MONITORING AND EVALUATION

In the Forest Management Planning Code of Bhutan, monitoring is described as the examination of whether project inputs, activities and outputs are successfully supplied and carried out according to the planned schedule. In the context of FMU implementation, 'inputs' include machinery availability, staff skills, funds availability, etc. while 'outputs' include operational plan completion, road construction, timber production, collection of lops and tops, etc. Monitoring is short term. Evaluation on the other hand is the examination of whether the project objectives are being achieved. It is long term since it requires enough time to provide a realistic assessment of progress in fulfilling objectives.

Monitoring and evaluation are needed because we have to ensure that the primary objective of forest management in Bhutan like conservation of forest is met. Then only the exploitation of forest for economic gain comes into picture as a goal. To ensure that this policy is being carried out in the management of the FMU, monitoring checks that the ground activities are carried out according to plan and evaluation checks that the objectives of the plan are being achieved. The monitoring and evaluation process was developed in 1999 with the fund from World Bank.

3.4.1 Record Keeping

Proper record of the timber volumes extracted should be maintained in the FMU office. already harvested areas. Details of tree marked and allotted for rural use must be maintained with the FMU office and should be available for cross checking.

3.4.2 Mid-Term Review of the FMU Plan

Mid-Term Review of the implementation activities in the FMU should be conducted based on a monitoring and evaluation system developed as an activity. The evaluation team shall be constituted by the Hon'ble Director, Department of Forests and Park Services and will comprise of following team members (minimum five).

- FRMD
- PPD, MoAF
- CFO, Territorial Division
- RM, NRDCL.
- UWICER
- Local community leaders of Toong Geog and Mangmi from Dungbey village within the FMU

Mid-Term evaluation should take place during the last quarter of the fifth year of the existing Forest Management Plan (FMP) period that is in the year 2020. Final evaluation is to take place during the last quarter of the ninth year of its operation that is during the year 2024. The final evaluation should directly inform the preparation of the FMP for the subsequent 10 years period.

3.5 CONSTRAINTS AND RISKS

Forest management in Bhutan is not an easy activity. There are many factors which are not under our control. The risks and constraints are as follows:

- Lack of trained manpower.
- Inadequate funds for forest management.
- Uncertain natural regeneration due to grazing.
- Inadequate monitoring to determine whether objectives are being met or not.
- Communication gap between field and office.
- Lack of proper depot stocking and marketing.
- Lack of research information.

Prerequisite for effective implementation of this plan seeks for enough funds and manpower. Along with the financial resources, the technical capability of the staff should be strengthened to implement the plan. There should be a plough back mechanism of revenues earned from forest into the restocking of forest for long term sustainability.

Training of both the territorial and NDRCL staffs should be conducted from time to time. The training once conducted by FRMD in Chelaila, Paro in 2003 removed the differences in understanding of what operational planning was all about. Such divergence and differences in perception and understanding are going to occur is refresher course or trainings are not conducted from time to time.

Reforestation failure risks can be reduced by close monitoring of the regeneration survival rate, use of quality seedlings and proper fencing with required strand of barbed wire. Grazing is a traditional practice and it is enshrined in the Forest and Nature Conservation Rules, 2003. The only way to deal with it is to fence the logged areas till the saplings reach a certain height where their survival is ensured. Blaming grazing for regeneration failures is not an option for excuse.

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ANNEXURES

*Annexure 1:**Compartment Review and Prescription***

For better management, Wangdigang Forest Management Unit is divided into six (6) blocks mainly, Dangkhar, Dungbey, Gurpang, Riotala, Upper Wangdigang and Dechengang. The blocks are further divided into compartments based on prominent natural features and similar forest stand conditions.

1. Block: Dangkhar

Total Area : 727.11 Ha (Old), 689.82 Ha (New)

Altitude : 796 masl – 2250 masl

Protection : 29.10 Ha

Non-Production : 587.98 Ha

Production : 72.73 Ha

Forest Type : (Broadleaf: 99.80 Ha, Agriculture: 525.28 Ha, Rocky Outcrops: 0.34 Ha, Town Area: 60.52 Ha, Shrubs: 0.40 Ha and Meadows: 2.20 Ha)

Past Management: Most of the villages are located within this block and in the past, rural timber allotments were done through single tree selection system.

Future Management: No commercial timber harvesting shall be carried out and rural allotment may be accorded on case by case basis.

2. Block: Dungbey Compartment: I

Total Area : 562.97 Ha (Old), 444.25 Ha (New)

Altitude : 1130 masl – 2570 masl

Protection : 134.73 Ha

Non-Production : 145.88 Ha

Production : 163.64 Ha

Forest Type : (Agriculture: 144.02 Ha, Broadleaf: 298.03 Ha and Shrubs: 1.90 Ha)

Past Management: Rural timber allotments were done from this compartment and no commercial harvestings were carried out.

Future Management: There shouldn't be commercial harvesting whatsoever and the compartment should be protected for watershed. Rural timber allotments may be made on single tree selection basis.

3. Block: Dungbey Compartment: II

Total Area : 429.53 Ha (Old), 340.33 Ha (New)

Altitude : 1340 masl – 2570 masl

Protection : 304.87 Ha

Non-Production : Nil

Production : 35.45 Ha

Forest Type : (Broadleaf: 340.44 Ha)

*Past Management:*In the past, the area was kept aside as watershed catchment area.

Future Management: As the area is very steep, no harvesting shall be prescribed and shall be protected for watershed catchment.

4. Block: Gurpang Compartment: I

Total Area : 282.84 Ha (Old), 41.46 Ha (New)

Altitude : 1380 masl – 2680 masl

Protection : 5.55 Ha

Non-Production : Nil

Production : 35.91 Ha

Forest Type : (Broadleaf: 41.46 Ha)

Past Management: Commercial harvesting was prescribed in this compartment.

Future Management: As the compartment was commercially operated, the area should be brought under forest cover through natural regenerations. Rural timber allotments may be made on single tree selection basis and harvested areas to be avoided as far as possible.

5. Block: Gurpang Compartment: II

Total Area : 226.43 Ha (Old), 58.40 Ha (New)

Altitude : 1490 masl – 2680 masl

Protection : 3.64 Ha

Non-Production : Nil

Production : 54.76 Ha

Forest Type : (Broadleaf: 58.40 Ha)

Past Management: As the area is very steep, it was accorded protection without any anthropogenic interventions.

Future Management: The area should be set aside for full protection.

6. Block: Gurpang Compartment: III

Total Area : 1001.55 Ha (Old), 835.74 Ha (New)

Altitude : 1508 masl – 2800 masl

Protection : 60.68 Ha

Non-Production : 5.30 Ha

Production : 769.76 Ha

Forest Type : (Broadleaf: 827.05 Ha, Shrubs: 5.55 Ha and Meadows: 3.13 Ha)

Past Management: Commercial timber harvesting was prescribed in this compartment with artificial regeneration.

Future Management: The area should be restocked with by encouraging natural regenerations and rural allotments can be made on single tree selection basis by avoiding markings on harvested areas as far as possible.

7. Block: Riotala

Total Area : 2997.08 Ha

Altitude : 796 masl – 3850 masl

Protection : 2920.32 Ha

Non-Production : 76.76 Ha

Production : Nil

Forest Type : (Broadleaf: 2605.91, Chirpine: 111.22 Ha, Agriculture: 76.74 Ha, Meadows: 58.60 Ha and Rocky Outcrops: 36.74 Ha)

Past Management: The bottom part of the block is very steep and rocky with extensive resin tapping have deteriorated the Chirpine stand. The upper part of the block is also steep and inaccessible and has been designated for protection.

Future Management: As whole of the block is steep, rocky and inaccessible, the area should be designated for protection.

8. Block: Upper Wangdigang

Total Area : 3036.70 Ha

Altitude : 1510 masl – 4143 masl

Protection : 3036.70

Non-Production : Nil

Production : Nil

Forest Type : (Broadleaf: 2604.40 Ha, Fir: 270.70 Ha, Shrubs: 83.68 Ha, Meadows: 52.06 Ha and Rocky Outcrops: 25.86 Ha)

Past Management: During the past management, the block was designated for protection due to steep slope and high altitude.

Future Management: Due to steep slope and high altitude, no management shall be prescribed in this block instead shall be kept for protection as Wangdigang important Watershed Catchment Areas.

9. Block: Dechengang

Total Area : 315.72 Ha

Altitude : 1700 masl – 2250 masl

Protection : 144.05 Ha

Non-Production : 55.49 Ha

Production : 115.92 Ha

Forest Type : (Broadleaf: 257.61 Ha, Meadows: 3.53 Ha, Shrubs: 9.95 Ha, Agriculture: 23.98 Ha and Town Area: 20.65 Ha)

Past Management: No commercial harvesting has been prescribed during the earlier management plans.

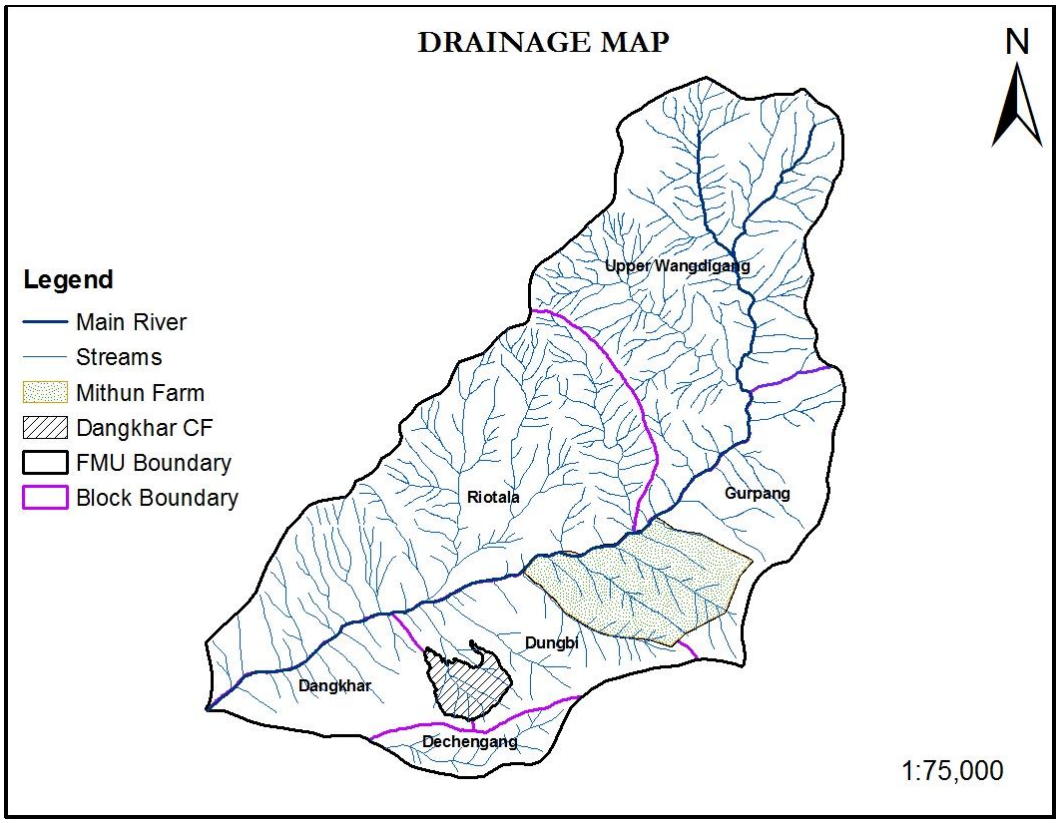
Future Management: As the area forms green zone to Zhemgang town and serves as main water catchment so no activity should be carried out that will have detrimental effect.

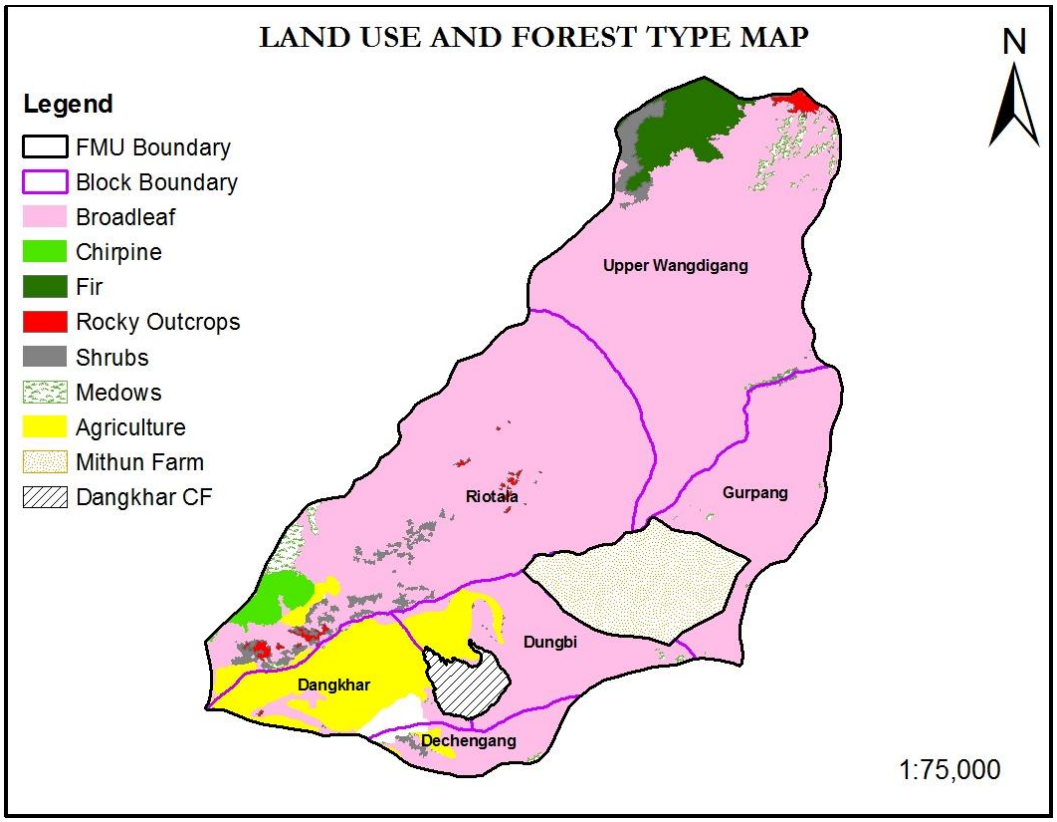
Annexure 2: *Compartment Record Sheet*

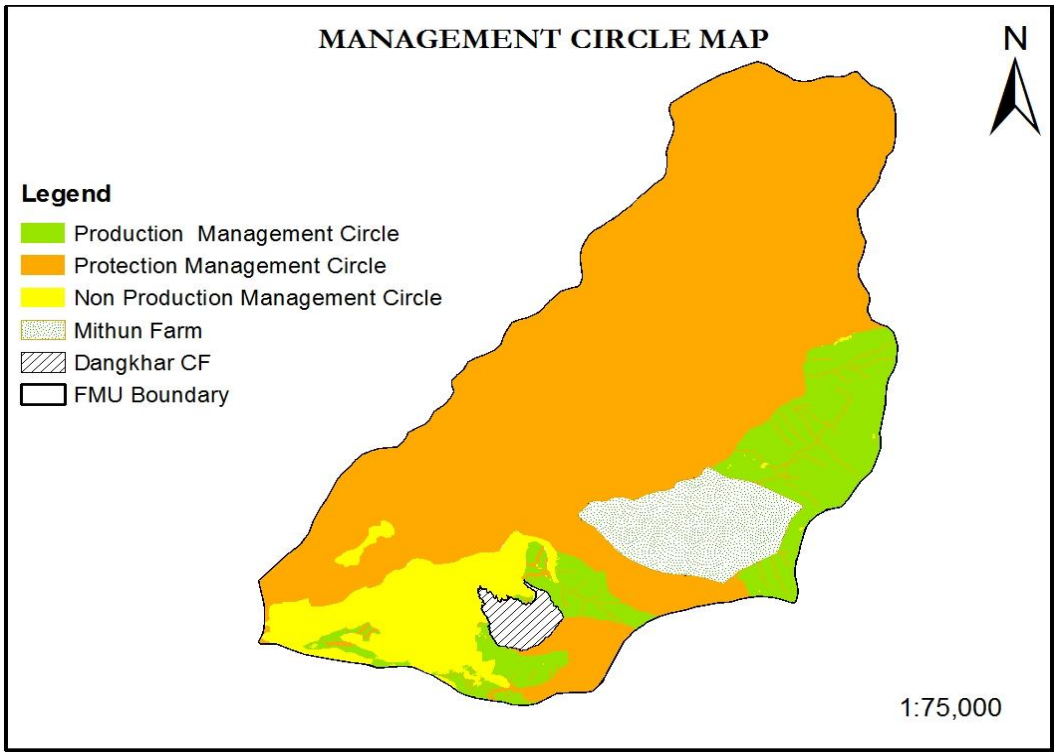
BLOCK: **COMPARTMENT NO:** **Sub-Compartment No.**

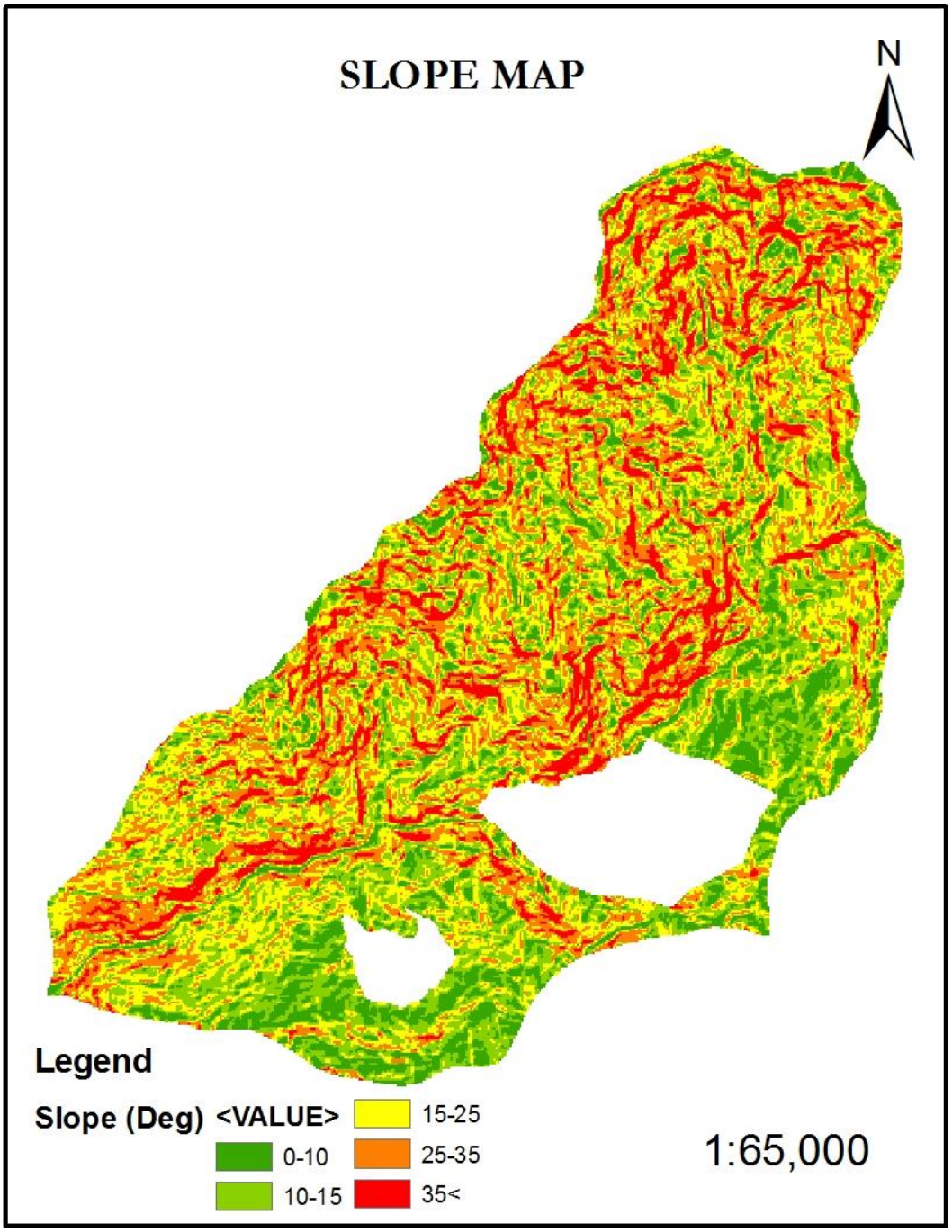
Year	Harvesting					Planting		Others	Remarks
	Rural		Commercial		Total	Area(ha)	Species		
	Area (ha)	Vol (m^3)	Area (ha)	Vol (ha)					
2015									
2016									
2017									
2018									
2019									
2020									
2021									
2022									
2023									
2024									

Annexure 3:Additional Maps




LAND USE AND FOREST TYPE MAP
N
Legend
FMU Boundary
Block Boundary
Broadleaf
Chirpine
Fir
Rocky Outcrops
Shrubs
Medows
Agriculture
Mithun Farm
Dangkhar CF
Upper Wangdigang
Riotala
Gurpang
Dungbi
Dangkhar
Dechengang
1:75,000


MANAGEMENT CIRCLE MAP
N
Legend
Production Management Circle
Protection Management Circle
Non Production Management Circle
Mithun Farm
Dangkhar CF
FMU Boundary
1:75,000


SLOPE MAP
N
Legend
Slope (Deg) <VALUE>
0-10
10-15
15-25
25-35
35<
1:65,000

Annexure 4: Inventory Results

Inventory results at the whole FMU level

Total area : 1248.02 ha
Number of plots: 244
Area of the plot: 0.05 ha

Volume (m^3) at whole FMU level	**Estimated volume (m^3) (whole FMU level)**
Estimated total volume proration to Big A	296649.47
Sample variance of total volume of trees among Big A proration plots	88597930398.99
Estimated variance of total volume based on Big A proration plots	363106272.13
Margin of error (%) of total volume at Big A proration plots	10.61
Lower limit of estimate at 95 % confidence interval	265186.26
Upper limit of estimate at 95 % confidence interval	328112.68
Percent coefficient of variation	100.34
Standard error percent	6.42

Volume (m^3) per hactare at whole FMU level	**Estimated volume (m^3) per hectare (whole FMU level)**
Estimated total volume per hectare	237.70
Sample variance of total volume per hectare	56882.74
Estimated variance of total volume per hectare	233.13
Margin of error (%) of total volume per hectare	10.61
lower limit of volume per hectare	212.49
upper limit of volume per hectare	262.91
Percent coefficient of variation	100.34
Standard error percent	6.42

Volume (m^3) at plot level at whole FMU level	**Estimated volume (m^3) at plot level (whole FMU level)**
Estimated total volume per plot	11.88
Sample variance of total volume among plots	142.21
Estimated variance of total volume based on the plots	0.58
Margin of error (%) of total volume at plot level	10.61
Lower limit of estimate at 95 % confidence interval	10.62
Upper limit of estimate at 95 % confidence interval	13.15
Percent coefficient of variation	100.34
Standard error percent	6.42

Basal Area at whole FMU level	**Estimated Basal area (whole FMU level)**
Estimated total number of basel area proration to Big A	26812.17
Sample variance of total basel area of trees among Big A proration plots	580664590.08
Estimated variance of total basel area of trees based on Big A proration plots	2379772.91
Margin of error (%) of total basel area of trees at Big A proration plots	9.50
Lower limit of estimate at 95 % confidence interval	24265.03
Upper limit of estimate at 95 % confidence interval	29359.32
Percent coefficient of variation	89.87
Standard error percent	5.75

Basal Area per Hactare at whole FMU level	Estimated Basal Area Per Hectare (whole FMU level)
Estimated basel area of trees per hectare	21.48
Sample variance of total basel area of trees per hectare	372.81
Estimated variance of total basel area of trees per hectare	1.53
Margin of error (%) of total basel area of trees per hectare	9.50
lower limit of basel area of trees per hectare	19.44
upper limit of basel area of trees per hectare	23.52
Percent coefficient of variation	89.87
Standard error percent	5.75

Number of Trees per Hactare at whole FMU level	Estimated number of trees per Hectare (whole FMU level)
Estimated number of trees per hectare	153.85
Sample variance of total number of trees per hectare	16118.67
Estimated variance of total number of trees per hectare	66.06
Margin of error (%) of total number of trees per hectare	8.72
lower limit of number of trees per hectare	140.43
upper limit of number of trees per hectare	167.27
Percent coefficient of variation	82.52
Standard error percent	5.28

Number of Trees at whole FMU level	Estimated number of trees (whole FMU level)
Estimated total number of trees proration to Big A	192010.95
Sample variance of total number of trees among Big A proration plots	25105698978.66
Estimated variance of total number of trees based on Big A proration plots	102892208.93
Margin of error (%) of total number of trees at Big A proration plots	8.72
Lower limit of estimate at 95 % confidence interval	175262.39
Upper limit of estimate at 95 % confidence interval	208759.50
Percent coefficient of variation	82.52
Standard error percent	5.28

Number of trees at plot level	Estimated number of trees at plot level (whole FMU level)
Estimated total number of trees per plot	7.69
Sample variance of total number of trees among plots	40.30
Estimated variance of total number of trees based on the plots	0.17
Margin of error (%) of total number of trees at plot level	8.72
Lower limit of estimate at 95 % confidence interval	7.02
Upper limit of estimate at 95 % confidence interval	8.36
Percent coefficient of variation	82.52
Standard error percent	5.28

*Annexure 5:***Road Standards**

No new forest road will be constructed during the current plan period however the road standards are given for general reference and information. As stated before, the road standards developed in the east by TFDP will be implemented for design, drainage and construction of all forest roads in the Wangdigang FMU. Following are the standards:

Road Design

- Road lengths and density should be minimized, consistent with access requirements to reduce environmental impacts and enhance access economics.
- Where possible locate roads in areas with low side slopes, the maximum side slopes allowed in all areas except rock is 100%.
- Roads must be constructed in such a way that no earth works or soil spill into water courses or watercourse buffer areas. Care should also be taken to ensure that no earth works or soil is allowed to spill onto agricultural land, near houses or main roads.
- Roads should be planned in such a way as to balance cut and fill to minimize transport of construction materials.
- Roads should not be constructed in steep and unstable areas where there is the possibility of landslide. A thorough survey of any area suspected of being unstable should be undertaken prior to work commencing.
- Roads should be kept as narrow as possible to reduce damage to the environment and to reduce costs.
- Where possible, box cuts should be avoided, however they are acceptable for short distances (up to 300 m), if they reduce the length of the road, reduce environmental damage and are properly drained.
- Minimum radius formed by curves or corners should be 15 m and should where possible fit the topography of the land.

- Roads should be located on elevated areas where possible to minimize side cutting, width of clearing and drainage problems.
- Side cutting should be carried out leaving a stepped batter, each step no more than 3 m in vertical height and no more than 100% gradient with a 1.5 m horizontal step.
- Convex road surface should be maintained at all times with the centre line 30 cm higher than the edges.
- Stabilize and re-vegetate cut and fill slopes with shrubs, grasses and legumes as soon as possible after construction.
- Ensure proper maintenance of roads and enforce road use restrictions during critical weather conditions such as monsoon seasons.

Drainage

Road planning should ensure that roads are located in such a way as to minimize stream river crossings.

Roads should not be constructed in areas, which are prone to flooding in the monsoon seasons.

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 40 cm deep and 65 cm wide and should drain into culverts of sufficient size and frequency.

All culverts must have stone or concrete aprons at their exit points to prevent erosion by water. These aprons should be of suitable width and design to prevent any erosion, taking place and should extend down the slope for at least the length of the spill. They should divert the water back into the stream if the water came from a stream.

Culverts of appropriate diameter (not less than 30 cm) 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 be reduced by 50%.

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

Culverts should be laid at 2 to 5 % gradient across the road to enable water to flow but should not exceed 6 % as damage from erosion will result.

Culverts pipes (Hume pipe) should be buried a minimum of 700 mm below the surface of the road.

In areas of high seasonal rainfall, catch drains should be constructed above the road to collect surface runoff and prevent it reaching the road.

Drains should not be allowed to directly enter a watercourse but should be diverted into surrounding vegetation at least 50 m before a watercourse.

Sumps or silt traps should be places in drains every 50 m in erodible soils and must be cleaned regularly.

Road Construction

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).

Primary excavation should be done in such a manner as to remove the topsoil and place it on the downward slope of the road. This will allow vegetation to regenerate and stabilise the slopes.

Where side slopes of 70% or more extend more than 100 m downhill no side casting of spoil should be allowed. In this situation end haul methods must be used.

Forest roads should only be constructed on stable soil types where there is no possibility of slippage.

All road construction on side slopes of over 50% or difficult terrain, such as boulder fields, must be carried out using excavators.

Batter and fill slopes should not exceed 100%

Where road construction is carried out on side slopes of over 90% rock or concrete wall should be built to support both batter and fill (this is not required in solid rocks).

On side slopes of over 70% all of the load carrying surface of the road must be built on stable ground. The road should not be supported by fill.

The adverse gradient should not exceed 10%. However, grades of up to 12% will be allowed for distances of up to 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.

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 6: **Marking guidelines**

Marking guidelines for Single Tree Selection System

1. Visit all parts of the stand to be harvested so that a good overall impression is obtained.
2. Plan how much timber can be harvested from the stand. This should be no more than 10-20% of the standing volume for single tree selection.
3. Follow these marking guidelines for single tree selection:
    - Where ever possible, mark trees evenly distributed throughout the stand,
    - Mark up to 25% of the stand volume,
    - Mark trees that are malformed, dead, diseased and dying trees as a priority including those that are less than 50 cm dbh,
    - Mark larger trees for timber (above 50 cm dbh) that will promote the growth of nearby saplings of desired species when they are removed and that have utilisation value,
    - Ensure that no large openings are created in the stand,
    - Ensure that an even distribution of suitable species remains after harvesting,
    - If using cable cranes the extraction lines should be as narrow as possible (no wider than 3-4 m).
4. Do not mark trees if they are:
    - On steep slopes with more than 45 degree (100%)
    - Closer than 30 m to a water course or water source
    - In and around the sacred places (consult local people)
5. Harvesting operations shall start only after marking has been completed for the particular stand. This will give you an opportunity to check whether the right volume has been marked.

6. During harvesting, trees should be carefully felled to avoid damaging neighbouring trees and regeneration. Trees should be felled across the slope if possible.
7. Marking and harvesting should normally be carried out between October and March
8. All marked trees should be harvested and extracted within 2 years of marking
9. After harvesting, the stand should not be visited for harvesting again for at least 10 years. This will allow the stand to recover and to allow the regeneration to develop and grow.

In broadleaved forest types, single tree selection can be used to increase the stocking of the most valuable timber species such as *Michelia*, *Nyassa*, *Alnus*, *Castanopis* and *Juglans*. Stems of less preferred species or with poor form adjacent to good quality individual stems of the preferred timber species can be marked for harvesting so that these remaining trees continue to grow and the overall quality of the stand improves. However, harvesting operations must be carried out carefully so that these valuable stems are not damaged.

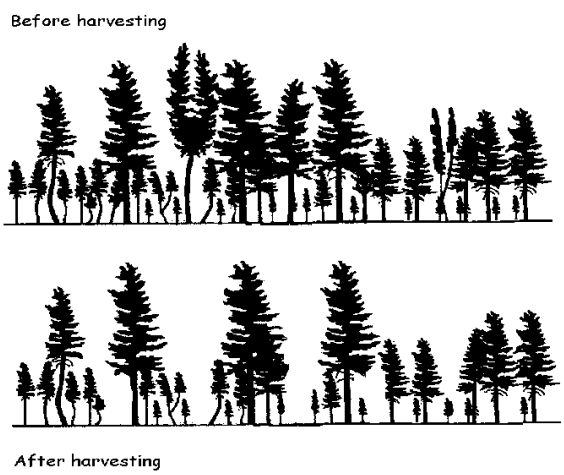


Figure 17 Single tree selection

Note that only a few trees have been removed (about 15%) of all sizes and evenly across the stand so that no large gaps are created.

Priority it to remove less desirable species or trees that are over-mature and poor quality.

Annexure 7: **Record Keeping Forms**

Rural Allotment

Block: Compartment:

Sub-compartment:

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

Stand Tending and Regeneration

Block: Compartment:

Sub-compartment:

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

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